# A Method for Measuring Internal Fraud Risk (IFR) of Business Organisations with ERP systems

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# ABSTRACT

ERP system has shaped the way modern organisations design, control, and execute business processes. It has not only paved the way for efficient use of organisational resources but also offered the opportunity to utilise data logged in the system for ensuring internal control. The key contribution of this research is that it has resulted in a method which can practically be employed by internal auditors for measuring internal fraud risk of business organisations with ERP systems, by utilising process mining technique and evidential reasoning in the form of Bayesian theorem, in a much more effective way compared to conventional frequentist method. The other significant contribution is that it has paved the way for combining process mining technique and evidential reasoning in addressing problems prevalent within organisational contexts. This research has contributed in developing IS theories for design and action especially in the area of soft systems methodology as it has relied on business process modelling in addressing the issue of internal fraud risk. The chosen method has contributed in facilitating incorporation of design science method in problem solving.

Researchers have focused on applying data mining techniques within organisational contexts for extracting valuable information. Process mining is a comparatively new technique which allows business processes to be analysed based on event logs. Analysis of business processes can be useful for organisations not only for attaining greater efficiency but also for ensuring internal control inside the organisation. Large organisations have various measures in place for ensuring internal control. Measuring the risk of fraud within a business process is an important practice for preventing fraud as accurate measurement of fraud risk provides business experts with the opportunity to comprehend the extent of the problem. Business experts, such as internal auditors, still heavily rely upon conventional methods for measuring internal fraud risk way by of random check of process compliance. Organisations with ERP systems in place can avail themselves of the opportunity to use event logs for extending the scope of assessing process conformance. This has not been put into practice as there is a lack of well researched methods which can allow event logs to be utilised for enhancing internal control. This research can be proved to be useful for practitioners as it has developed a method for measuring internal fraud risk within organisations.

This research aimed to utilise process mining technique that allows business experts to exert greater control over business process execution by allowing the internal fraud risk to be measured effectively. A method has been developed for measuring internal fraud risk of business originations with ERP systems by using process mining and Bayesian theorem. In this method, rate of process deviation is calculated by conducting process mining on relevant logs of events and then that process deviation rate is applied in Bayesian theorem along with historic internal fraud risk rate and process deviation rate calculated manually for arriving at a revised internal fraud risk rate. Bayesian theorem has been relied upon for the purpose of developing this new method as it allows evidential reasoning to be incorporated. The method has been developed as a Design Science Research Method (DSRM) artefact by conducting three case-studies. Data has been collected from three case companies, operating in readymade garments manufacturing industry, pharmaceuticals industry, and aviation industry, regarding their procurement process for conducting process mining. The revised internal fraud risk rates were then evaluated by considering the feedback received from respective business experts of each of the case company. The proposed method is beneficial as it has paved the way for practitioners to utilise process mining using a soft system methodology. The developed method is of immense significance as it has contributed in the field of business intelligence and analytics (BI&A) and the big data analytics which have become significantly important to both academics and practitioners over the past couple of decades.

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# DEDICATION

To my Dad, Mom, Wife, Grand Dad, my Children, and the entire humanity

# ACRONYMS AND ABBREVIATIONS

ACFE- Association of Certified Fraud Examiners

AICPA - American Institute of Certified Public Accountants

APICS - American Production and Inventory Control Society

BAM - Business Activity Monitoring

BPI - Business Process Intelligence

BPM - Business Process Modelling

BPMN - Business process model and notation

BPR - Business Process Re-engineering

COSO - Committee of Sponsoring Organizations of the Treadway Commission

CPN - Coloured Petri-Net

CRM - Customer Relationship management

DFD - Data Flow Diagrams

DSR - Design Science Research

DSRM - Design Science Research Method

ERP - Enterprise resource planning

ER - Evidential Reasoning

IDEF - Integrated Definition for Function Modelling

IFR - Internal Fraud Risk

IS - Information Systems

IAASB - International Auditing and Assurance Standards Board

ISA - International Standards on Auditing

IT - Information Technology

QMS - Quality Management Systems

MRP - Manufacturing Requirements Planning

PCAOB - Public Company Accounting Oversight Board

PO - Purchas Order

RAD - Role Activity Diagram

WFM - workflow meta model

UML - Unified Modelling Language

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# 1.0 Introduction

## 1.1 Overview

This chapter includes a brief discussion on the research domain and the context in which the study is being carried out. This is a research in the field of Information System (IS) which aims to address the phenomenon of internal fraud within business organisations by using Information Technology (IT). Section 1.2 focuses on research domain and context where the role of IS in fraud risk measurement, the scope of utilising process mining, and the applicability of Evidential Reasoning (ER) in measuring internal fraud risk have been considered. The aim and the objectives of this research have been clearly set out in Section 1.3. The aim of the research is to develop a method for measuring internal fraud risk of business organisations with Enterprise Resource Planning (ERP) systems by using Bayesian theorem, a probability theory that allows ER to be incorporated, and process mining technique. The associated objectives include reviewing relevant literature, developing a preliminary method, applying the method on real life cases, and evaluating various aspects of the developed method. Section 1.4 includes statement regarding the research approach that has been embraced for conducting the case studies. The research has been conducted in light of Design Science Research (DSR) for attaining the aim and objectives. Section 1.5 sets out the structure of the thesis.

## 1.2 Research Domain and Context

### 1.2.1 Information Systems and Fraud Risk Measurement

Enterprise resource planning (ERP) is the extended version of manufacturing Requirements Planning (MRP II) and has been promoted by the American Production and Inventory Control Society (APICS) since 1980 (Berchet & Habchi, 2005). ERP system has come a long way since its inception and currently overall resources of an organisation can be integrated through ERP systems. ERP system has been defined as "*a tool assembling and integrating all data and management skills which represent the firm's activity, in a unique database: from finance to human resources, going through the elements of the supply chain that permanently link the production to purchasing and sales*" (Guffond & Leconte, 2004). ERP systems offer complete automation of the business processes and activities of an organisation (Islam, et al., 2010). This has been implemented by many companies in recent years due to having the potential of lowering operating costs, shortening cycle times, and ensuring higher customer satisfaction.

The benefits gained by implementing of ERP systems can be evaluated more effectively by measuring them at the levels of activities areas rather than across the entire system within an organisation (Gefen & Ragowsky, 2005). ERP systems can enhance transparency of business processes, effectiveness of supply chain management, and financial performance of business organisations (Usman, et al., 2014). It has been commented that one of the main objectives of business organisations for adopting ERP systems is to tighten internal control (Berchet & Habchi, 2005). ERP systems have created new opportunities for internal auditors by paving the way for enhancing transparency by allowing use of an integrated system (Saharia, et al., 2008). Numerous researches have been undertaken for assessing practicality and feasibility of alternative architectures that can support continuous auditing (Kuhn & Sutton, 2010). According to Islam et al (2010), ERP systems can provide organisations with better control over possible fraudulent activities although such systems will remain ineffective in detecting frauds unless appropriate tools are being embraced and put in action.

It is important to understand how fraudulent activities affect an organisation's bottom line. It has been reported by Association of Certified Fraud Examiners (ACFE) that organisations

across the globe lose US$ 3.7 trillion of revenue annually due to fraudulent activities (Tschakert, et al., 2016). The definition of fraud is quite broad as it has been defined as "*Any intentional false representation, including failure to declare information or abuse of position that is carried out to make gain, cause loss or expose another to the risk of loss*" (CIPFA, 2011). Fraudulent activities which an organisation can be subject to are primarily divided into two types: external fraud – where an external agent is involved in swindling money or valuables and internal fraud – where an internal agent, such as an employee, is involved in swindling money or valuables (Vilar, et al., 2016). Internal fraud is less frequent compared to external fraud and as such this peculiarity has an impact on fraud detection methods that are capable of effectively dealing with internal fraud. It is therefore of great importance to focus on utilising mining and machine learning techniques in dealing with internal fraud.

Auditors are increasingly examining transaction log files for detecting suspicious user activities within the ERP systems in the recent years as ERP systems generate millions of transaction records. The enormous amount of data, often referred to as big data, creates interference in detecting all suspicious behaviours efficiently. Islam, et al. (2010) mentioned that appropriate policy and internal controls within the ERP system play an important role in preventing fraudulent activities. Many other researchers have focused on the fraud prevention approaches by utilising ERP systems (Khan, et al., 2010). However, it is commented that fraud prevention techniques are only capable of detecting simple fraudulent transactions and often not on their own (Bolton & Hand, 2002). It is argued that an increased reliance upon service oriented architecture has created a demand for better fraud detection techniques as such those architectures have paved the way for having increased number of entry points often resulting in decreased number of human checks (Khan, et al., 2010).

It is important to comprehend the theories which have been put forward by those who are involved in studying and dealing with the ERP systems with a view to tackling internal fraud. Generally, auditors and other fraud examiners must review a large number of logs for detecting fraudulent activities. The overarching objective of this research is to develop a method that will allow internal fraud risk to be measured effectively by utilising the data available in ERP systems of business organisations with the help of information technology. This research aims to tackle a specific type of fraud, which is internal fraud, by developing a

method which can potentially assist in measuring the internal fraud risk involved in business processes and it aspires to introduce evidential reasoning for arriving at more accurate outcomes by utilising information extracted using process mining. This study is being conducted as an IS research and as such relevant literature, methodologies, and tools have been considered from an IS perspective.

### 1.2.2 Process Mining in Fraud Risk Measurement

Examination of old logs of an ERP system can serve several purposes such as probing compliance with prescribed methods, investigating any incident involving breach of security, and any suspected behaviours of a system user (Tarzey, 2015). At the advent of technological advancement in the field of computer science and information technology, storing event logs digitally has been a widely embraced practice. The practical usage, which involves extraction of knowledge from the information stored by information systems, can be evidenced in Business Process Intelligence (BPI) and Business Activity Monitoring (BAM). These have been possible because most information systems support logging of events in some form (Ciardo & Darondeau, 2005). ERP systems like SAP, PeopleSoft, Oracle, and JD Edwards are all designed for logging transactions. The adoption of ERP software by businesses in the past decade has assisted in making a significant progress in the corporate world as the implementation of ERP system has made it possible to manage business processes digitally in a unified manner (Debreceny, et al., 2005).

Process mining is primarily utilised to diagnose processes by mining the logs of events for acquiring knowledge (Jans, et al., 2011). It is now possible to discover, analyse, and improve businesses processes based upon event data owing to the recent developments in the field of process mining (Aalst, 2012). The aim of process mining is to extract information about various processes from the recorded event logs which can be turned into specific knowledge (Ciardo & Darondeau, 2005). Application of process mining has revealed that managers and users of systems often overestimate their knowledge about business processes (Aalst, 2012). Therefore, the application of process mining technique in the chosen business process of this research, i.e. the procurement process, has been relied upon as an X-ray of the business process which highlighted the discrepancies and led to a way for measuring internal fraud risk of business organisations with an ERP system. The main objective for using process mining has been to quantify process deviation using IT.

### 1.2.3 Bayesian Theorem in Fraud Risk Measurement

It is important to consider probability theories for developing a new method for measuring risk as risk is measured in terms of odds. There are IT tools and artefacts which can be relied upon for conducting diagnosis of an ERP system but the information obtained by utilising such technologies must be translated into comprehendible outcome for specific users. Bayesian probability, which is based on the theorem, allows posterior probability to be calculated and the methods derived from this theorem have been widely relied upon in measuring risks (Alexander, 2000). Developments in Bayesian literature focused on propagating probabilities in a network of variables through local computations have paved the way for development of analytical models for complex problems such as measurement of internal fraud risk (Shenoy & Shafer, 1990). It has been showed that Bayesian inference can be employed in the Evidential Reasoning (ER) paradigm where ER is used to combine multiple pieces of evidence in random order without affecting the final outcomes (Yang & Xu, 2014). This research aspires to introduce an elegant ER approach in fraud risk measurement.

Evidential Reasoning (ER) is a multi-criteria decision-making method which describes each criteria for any alternative by way of a distributive assessment using a belief structure and is relied upon under uncertainty (Zhou, et al., 2015). Such ER approach has been developed and implemented in business settings for assessing IS security risk assessment (Sun, et al., 2006). The suitability of evidential reasoning approach for multi-attribute decision making with uncertainty has been discussed in detail by Yang and Singh (2006). Similarly, Bayesian theorem or Bayesian inference has already been relied upon in evaluating the effectiveness of control structures within computer systems (Cascarino, 2017). Bayesian inference is a rigorous probabilistic reasoning process and it has been showed that generalisation of Bayesian inference to evidential reasoning is possible (Yang & Xu, 2014). In this research, Bayesian inference has been used for developing a method for measuring internal fraud risk of business organisations with an ERP system by employing process mining for identification of process deviation. This approach is novel as Bayesian inference has not been included as evidential reasoning in any method for measuring internal fraud risk.

## 1.3 Research Motivation

Business intelligence and analytics and the associated filed of big data analytics have come to the forefront of information systems over the past two decades as their importance has been reiterated by both the academics and the practitioners (Chen, et al., 2012). 'Big Data' has undoubtedly become one of the most discussed topic within the world of information science. However, it has been commented that the importance of process-orientation should not be undermined while focusing on data analysis as effective processes are invaluable to any organisation (Aalst, 2015). The key motivation for conducting this research is to contribute in developing a new method that will allow process mining to be utilised in analysing business processes and thus pave the way for large volume of data to be processed without undermining the process orientation of business organisations. It has been commented that a significant number of research, which will focus on practical and theoretical analysis to provide new methods, is needed to be conducted in order for having distributed versions of mining methods (Fan & Bifet, 2014). A great deal of research have focused on using mining and machine learning techniques in dealing with external fraud but internal fraud has created challenges to practitioners due to it being less frequent and peculiar in nature (Vilar, et al., 2016). This research aspires to develop a method that will allow internal fraud risk to be measured by employing process mining technique and evidential reasoning and ultimately assisting business organisations in tackling the complex problem of internal fraud.

## 1.4 Research Aim and Objectives

It has been highlighted that ERP systems are in need for an effective method that is comprehensive, manageable, and creative in measure the internal fraud risk within business organisations. The aim and key objectives of this research have been set out below considering the need for addressing a problem in the field of IS by developing an artefact:

**Aim:**

To develop a method that will allow internal fraud risk to be measured effectively by utilising the data available in ERP systems of business organisations with the help of information technology.

**Objectives:**

In fulfilling this aim, a number of objectives are considered important to be achieved which are as follows:

Objective 1: To comprehend the literature regarding prevalence of internal fraud, role of process mining in ERP systems, and applicability of Bayesian theorem for introducing evidential reasoning in measuring internal fraud risk

Objective 2: To develop a preliminary method of internal fraud risk measurement based on process mining and Bayesian theorem

Objective 3: To evaluate the applicability of the method against multiple case studies

Objective 4: To analyse the effectiveness of this new internal fraud risk measurement method across organisations with ERP systems

Objective 5: To represent the developed method as a potential artefact for being used in measuring internal fraud risk of business organisations with ERP systems

## 1.5 Research Approach

This research adopts the Design-Science Research (DSR) paradigm to attain its aim along with the objectives. The aim of the research is to develop a method for measuring internal fraud risk of business organisations with ERP systems and hence Design Science Research (DSR) paradigm has been employed as a general methodological framework in this study (Henver, et al., 2004). A research based on design science should create artefacts where two key characteristics of such artefacts would be relevance, i.e. solving an important problem, and novelty, i.e. differentiating the design science research from routine design (Geerts, 2011). The artefacts created by any Design Science Research (DSR) have been classified into four different types: concepts, models, methods and instantiation (March & G., 1995). The chosen artefact that has been developed in this research is a method that is comprised of a set of steps for addressing an issue. The research design is comprised of four successive phases: (1) awareness of the problem; (2) solution selection and suggestion; (3) application; and (4) evaluation.

The first phases focus on comprehending the problem by considering a wide body of existing literature. The aim of the research is to develop a method for measuring internal fraud risk using Bayesian theorem and process mining and thus literature available on fraud, risk measurement, fraud risk measurement methods, probability theories, evidential reasoning (ER), Bayesian theorem, process mining, and ERP systems are to be scrutinised. The next phase involves considering relevant research methodologies and coming up with suggestions for developing a method for measuring internal fraud risk. The proposed method has been applied on selected cases in order to assess the functionality of the method. The final phase focuses on evaluating the effectiveness of the developed method. The study has been divided into seven chapters which collectively contain the four phases of the research. The research approach has been presented in Figure 1.1 below:

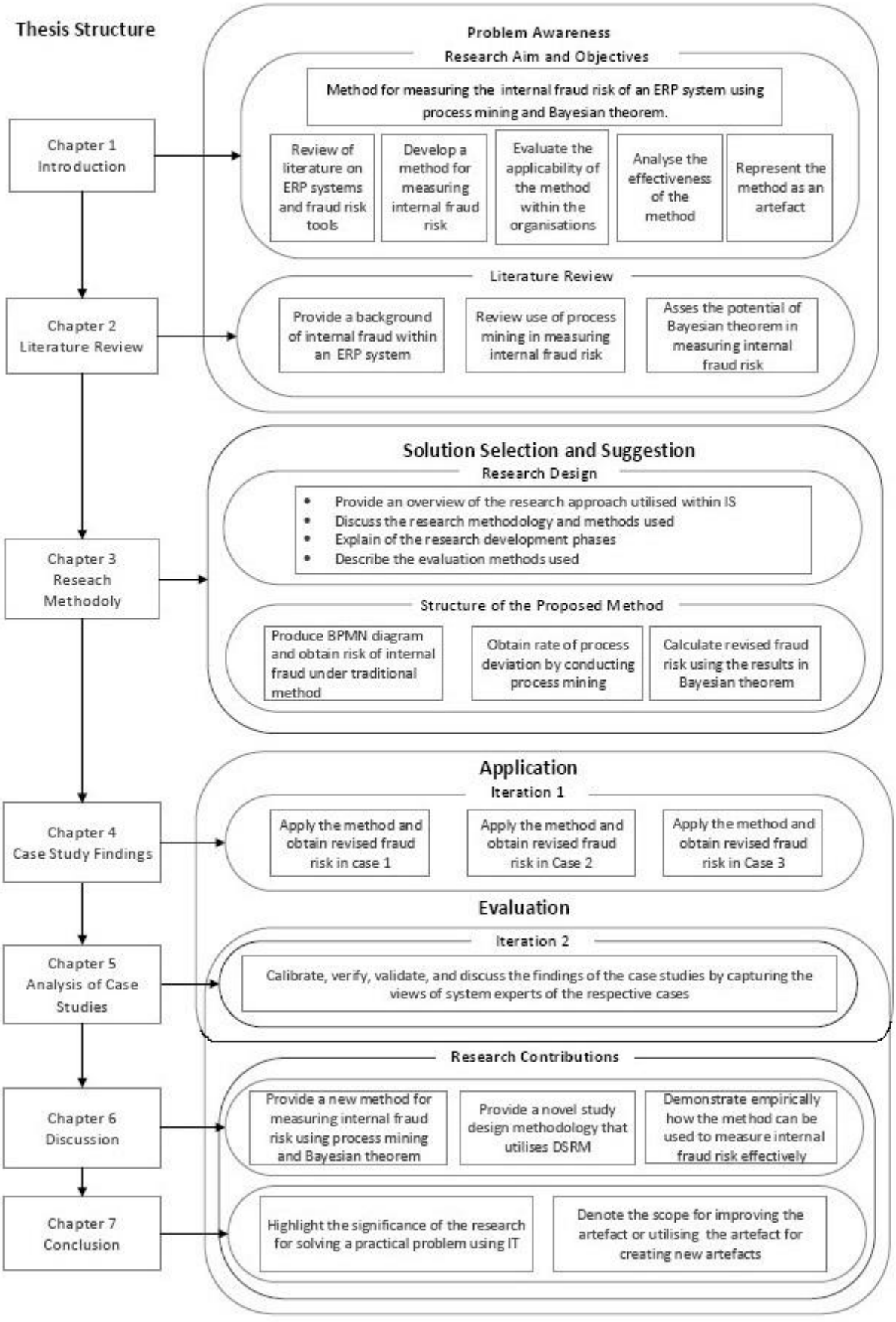


Figure 1.1: Overview of the research approach

## 1.6 Structure of the Thesis

The research has been broken down into seven chapters. A brief description of the content of each chapter is as follows:

Chapter 1 – Introduction:

The first chapter contains introductory statements regarding the research. It highlights the problem that the research aims to address. This chapter introduces the key areas of studies which the research will involve followed by a concise discussion about the existing literature of those arenas. This chapter also highlights the aim and objectives of the research and an outline of the research methodology which are employed throughout.

Chapter 2 – Literature Review:

This chapter reviews the existing literature of the aspects understanding of which are significant for conducting this research without fundamental errors. The chapter is comprised of existing literature of several arenas of study such as internal fraud, business process analysis, business process modelling, process mining and internal fraud risk measurement framework. A diverse range of scholarly article and research papers have been relied upon due to the multi-disciplinary nature of the research.

Chapter 3 – Research Methodology:

This chapter sets the approach which has been adopted for the purpose of conducting this research. There are analysis of relevant research methodologies and the reasoning behind choosing design science research. There are detailed discussions regarding design science paradigm and design science processes.

Chapter 4 – Case Study Findings:

This chapter consists of three case studies conducted on three companies operating within three different industries. Each company is regarded as an individual case study. Data is collected about the business process, internal control mechanism, and prevalence of fraud risk by interviewing internal auditor and system experts. Process mining is conducted for

collecting data which are applied in Bayesian theorem to obtain results of revised fraud risk level.

Chapter 5 – Analysis of Case Studies:

The results obtained through the proposed method with respect to measuring fraud risk within the companies are analysed in this chapter. The results are compared with the historic data about prevalence of fraud risk which were measured by the respective companies in absence of process mining.

Chapter 6 – Discussion:

This chapter consists of detailed synthesis of the analysis of case studies where frequentist method and the applied method have been compared and the key attributes of the applied method have been discussed. The method which has been applied in the case studies has then be critically evaluated where its shortcomings have been discussed in detail. The new method which has been developed as a result of this research has then be set out. Then each step involved in the new method have been described so that it can be applied with respect to other business organisations.

Chapter 7 – Conclusion:

This chapter contains detailed discussion on contributions and limitations of the research with specific focus on the achievement of deliverables and attainment of objectives. The key contribution and all other contributions made by this research have been set out. Attainment of research objectives have been discussed against each objective. The limitations of the research have also been critically evaluated in this chapter. It also denotes how this research can be extended in the future and its role in incremental creation of new knowledge.

# 2.0 Literature Review

## 2.1 Overview

This chapter includes a detailed review of a wide body of literature relevant to the research area. The objective of this research is to develop a method for measuring internal fraud risk within organisations with ERP systems using IT. The research falls within the realm of IS as the research and as such the aim was to develop a method by relying upon tools available within that area. The chapter begins with the review of literature on fraud, in Section 2.2, with specific focus on fraudulent activities taking place within organisational context. A wide range of literature focused on internal fraud has been considered that revealed the importance of ensuring internal control system within organisations. In Section 2.3, a wide body of literature available on the role of IS in tackling fraud in organisational settings have been considered. This led to a deeper research into the area of process mining and its role in tackling internal fraud within business organisations with ERP systems.

Section 2.4 focuses on aspects related to business process. It is important to comprehend business process and to be able to map the business process of an organisation for conducting process mining. Review of internal fraud literature revealed the importance of susceptibility of procurement process to fraudulent activities and therefore further literature related to procurement process and business process modelling was reviewed. Then Section 2.5 focuses on the body of literature available on various way for measuring internal fraud risk. It was revealed that one of the ways for measuring fraud risk was to quantify process deviations and it also transpired that Evidential Reasoning (ER) had the potential to be utilised in internal fraud risk measurement. Process mining techniques were then carefully considered in light of the researches that have been undertaken in that field in Section 2.6. Then literature with regards to Bayesian theorem for incorporating ER in measuring internal fraud risk and its application have been considered in Section 2.7.

## 2.2 Comprehending Fraud within Organisational Settings

In this section the phenomenon of fraud will be considered with specific attention to nature of fraudulent activities, how fraud affect organisations, and relevant theories that focused on comprehending fraud. Then a detailed discussion on internal fraud within the context of business organisations has been included with a view to understanding the need for a method for tackling with this specific type of fraud. A range of activities which can be classified as internal fraud has then been discussed with examples within organisational context. The suitability of procurement process for testing the proposed method has also been discussed. Then the role of internal control in managing fraud risk has been discussed.

### 2.2.1 Fraud and Organisations

Fraud is any deceptive activity carried out by a perpetrator which causes financial or personal gain for the perpetrator while at the same time depriving the victim in some way. It has been stated that, "*Fraud always involves one or more persons who, with intent, act secretly to deprive another of something of value, for their own enrichment*" (Davia, et al., 2000). One of the defining characteristics of fraud which distinguishes it from other types of criminal or tortuous wrongful activity is the deception factor. There is a sense of deceit and fear of disclosure working within the perpetrators of fraud. Among the many types of fraud committed, corporate fraud is the one which is of interest for the purpose of this research. Corporate fraud gets its name through identifying the victim, in this case the companies. It is classified as a corporate fraud when the ultimate victim is the company.

International Auditing and Assurance Standards Board (IAASB), an affiliate body of International Federation of Accountants, developed the International Standards on Auditing (ISA). Among its many standards, the standard focused on fraud is ISA 240, and it is titled 'Auditor's Responsibility to Consider Fraud in an Audit of Financial Statements.' ISA 240 requires auditors to "*perform procedures to obtain information that is used to identify the risks of material misstatement due to fraud*" and to "*design and perform audit procedures to respond to the risk of management override of controls*" (IAASB, 2004). Public Company Accounting Oversight Board (PCAOB), a standard-setting body in the United States created with a mandate from Sarbanes–Oxley Act of 2002, also provided for a separate standard for corporate fraud in its standard AS 2401, titled 'Consideration of Fraud in a Financial

Statement Audit'. Another standard by PCAOB directly deals with the assessment of fraud risk: AS 2110, titled 'Identifying and Assessing Risks of Material Misstatement.' Within AS 2110, Section 46, it states that "*The auditor should perform analytical procedures that are designed to… identify areas that might represent specific risks relevant to the audit, including the existence of unusual transactions and events, and amounts, ratios, and trends that warrant investigation*" (PCAOB, 2010) These standards directly require or suggest use of analytical procedures in audit to assess risk of fraud. Hence any artefact or method developed in this paper for the assessment of Corporate Fraud should fall within the scope of requirements or suggestions of Audit Standards around the globe. The concept of corporate fraud, however, should be further analysed and narrowed down for any model to tackle without reaching unnecessary complexity. Hence a further discussion on the nature of corporate fraud follows.

### 2.2.2 Relevant Fraud Theories

Sutherland (1940) famously addressed corporate and occupational fraud as 'white collar crime', refining the criteria later as "*a crime committed by a person of respectability and high social status in the course of his occupation*" (Sutherland, 1983). Since then the term has captivated minds of financial journalists and even has enjoyed renewed popularity after early 2000s high-profile accounting fraud cases and 2008's financial meltdown. More importantly the criminality of corporate fraud had been established together with the immoral aspects of it becoming more prominent, be it breach of fiduciary duty when committed by executives or misleading minority-interest parties when committed by major shareholders. The malicious intent of deception is present in all these cases. A cornerstone in the literature of corporate fraud, the concept of Fraud Triangle (Figure 2.1) was formulated by Joseph Wells, CPA, inspired by arguments and counterarguments produced by Sutherland and one of his doctoral students Donald R. Cressey (Morales, et al., 2014, p. 176).

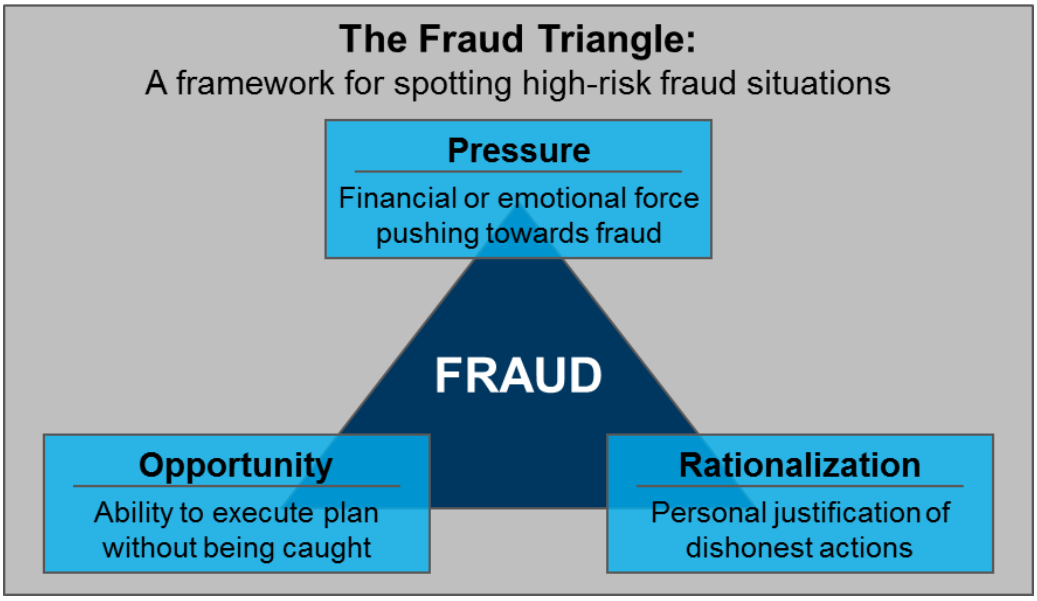


Figure 2.1: Fraud triangle (Morales, et al., 2014)

Study of cases of corporate embezzlement by Cressey (1953) has been credited to be a classic study on occupational offenders and has been credited by Wells to be the foundations for the concept of Fraud Triangle. In its simplest form, Fraud Triangle states that for occupational fraud to occur three factors must be present, namely, incentive (or pressure), opportunity and attitude (or rationalisation). That is, given, for example, that an employee has incentive to carry out fraud, that is he or she will be benefited through that process; he or she also has the opportunity to commit fraud, and he or she has developed a neutral or positive attitude towards fraud, provides for an environment that is more likely to have fraudulent activities committed compared to a situation where not all the factors are present. While describing fraud requires three main elements, namely, a perpetrator, a victim and a deceptive act; facilitation of fraud, on the other hand, requires three more things for the perpetrator to have: opportunity, incentive and attitude. The use of process mining to identify excessively or infrequently deviated processes to indicate need for further investigation, which is the premise of this research, turns the focus of the research mainly towards the perpetrator and the opportunities that he or she might have for committing fraud.

### 2.2.3 Internal Fraud in Organisations

Corporate fraud can be analysed across multiple distinct perspectives. One such perspective is the dissection of corporate fraud into internal and external fraud. Distinction made by

Bologna and Lindquist between internal and external fraud was the first which resembled delineation of fraud to 'occupational fraud and abuse' (Bologna & Lindquist, 1995). Fraudulent activities can be distinguished on the basis of the relationship of the perpetrator with the organisation in the field of corporate fraud. If the perpetrator is internal to the victim company, then the fraudulent act will be identified as an internal fraud. External corporate fraud is corporate fraud perpetrated by external stakeholders of the company and vice versa. The focus of this paper is internal corporate fraud or internal fraud and the risks associated with such fraud, although there might be cases where both internal and external stakeholders collude to attempt or carry out fraudulent activities. Another term for internal fraud is occupational fraud. USA-based Association of Certified Fraud Examiners (ACFE) defines occupational fraud as "*those (fraud) in which an employee, manager, officer, or owner of an organization commits fraud to the detriment of that organization*" (ACFE, 2017). It may be highlighted that even owners, shareholders or stockholders of a company are not beyond suspicion for internal fraud risk. Hence fraud committed by shareholders, directors, executives, managers and employees, all are considered part of internal fraud and hence should be provided for, in terms of precautions and systems, accordingly within any comprehensive system of internal controls of the organisation.

It has to be taken into consideration that in organisational settings fraud can also be classified as transaction fraud versus statement fraud. Transaction fraud has been termed as asset-theft fraud and statement fraud has been termed as financial statement balance fraud (Davia, et al., 2000). The company is directly victimised by acts of fraud when transaction fraud takes place and thus internal fraud usually tends to refer to transaction fraud. In organisational context, internal fraud can also be referred to as employee fraud as it is the employees who will be the perpetrator when it comes to internal fraud especially transaction fraud. It is asserted that the perceived opportunity to perpetrate fraud reduces significantly if employees are aware that independent checks are undertaken within an organisation (Buckhoff, 2002). It can therefore be said that the ability to measure risk of internal fraud is likely to have a profound impact upon perpetrators involved in committing such activities. Internal fraud or misappropriation of assets fraud has received little research attention (Coram, et al., 2008). The lack of data examination research on internal fraud within the theoretical domains paves the way for an opportunity to devote attention to it.

The focus of this research is internal fraud, and transactional internal fraud in specific, which has not been investigated in great extent. Lynch and Gomaa (2003) paid attention to the exposure of companies to fraudulent activity undertaken by employees (Lynch & Gomaa, 2003). The researchers commented that unintentional hazards and negative outcomes can be dealt with in the business environment with the use of advanced information technology (IT) in commercial organisations.

### 2.2.4 Types of Fraudulent Activities

Both IAASB and PCAOB, two of the most prominent auditing standards board, offer two categorical distinctions for internal corporate fraud: (i) Misstatements arising from fraudulent financial reporting, and (ii) Misstatements arising from misappropriation of assets (IAASB, 2004)(PCAOB, 2017). Association of Certified Fraud Examiners (ACFE), and independent association based in the US for fraud examiners and related professionals, however, provide a classification of internal corporate fraud into three categories: (i) Financial Statement Fraud, (ii) Asset Misappropriation, and (iii) Corruption. The first two categories exactly match the classification used by IAASB and PCAOB. The third category is, however, unique to ACFE. They defined corruption as, "*A scheme in which an employee misuses his or her influence in a business transaction in a way that violates his or her duty to the employer in order to gain a direct or indirect benefit*" (ACFE, 2017, p. 2). Though the category is unique to ACFE classification, it could be realised after a better glance that 'corruption' as an internal corporate fraud category could be combined with 'misstatements which are arising from misappropriation of assets' or 'misstatements which are arising from fraudulent financial reporting' depending on a case by case basis. ACFE further delves into the categorisation system and has provided classification of specific natures of fraud. The total classification, as prepared by ACFE, is presented below in the format of a tree diagram in Figure 2.2:

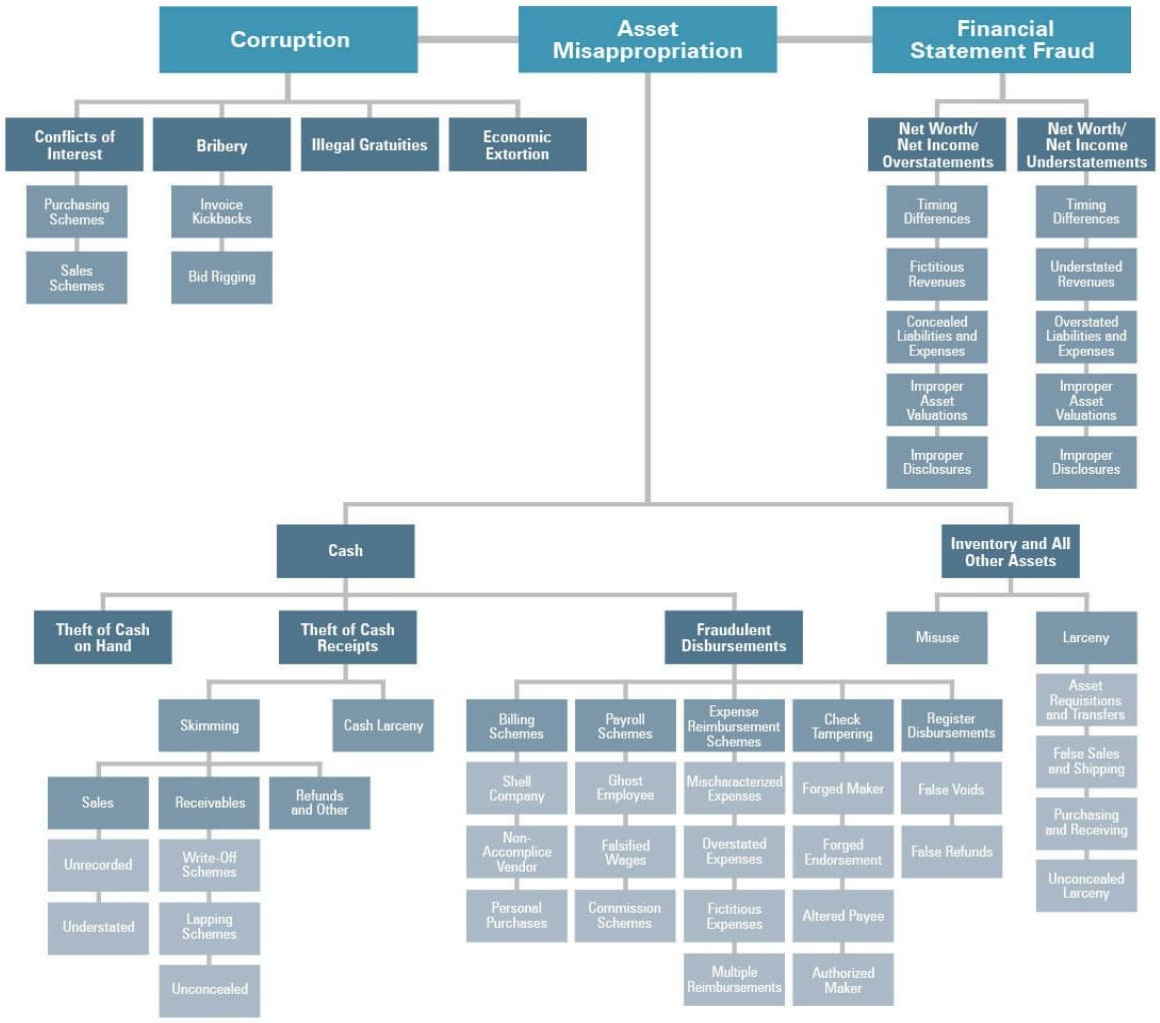


Figure 2.2: The Fraud Tree (ACFE, 2017)

It is commented that the procurement process presents a common risk of fraud across all organisations (Deloitte, 2014). Procurement function involves a series of activities which are aimed at acquiring goods and services. This business function involves interaction with external stakeholders such suppliers and contractors and exchange of value and thus is susceptible to both asset misappropriation and corruption (Rahmawati, et al., 2016). Moreover, individuals involved in the procurement process have the opportunity to deal with disbursements, inventory, and external agents and thus exposing them to a range of fraudulent activities. A number of studies have selected procurement process for conducting studies on internal fraud such as Aalst & Medeiros (2005) and Rahmawati, et al. (2016). Having reviewed the existing literature, it can be stated that procurement process is suitable for developing and testing a method for measuring internal fraud risk.

### 2.2.5 Role of Internal Control in Managing Fraud Risk

Committee of Sponsoring Organizations of the Treadway Commission (COSO), a joint initiative between five of the most prestigious accountancy bodies in USA including American Institute of Certified Public Accountants (AICPA), defines Internal Control system as a *process* effected by the board and management to provide reasonable assurance of attainment of objectives such as operations, reporting and compliance. Internal fraud being one of the hindrances to attaining those objectives has been identified by COSO as one of the focal point of Internal Control system for assessing and managing the fraud risk (Rubasundram, 2015). The Committee released *Enterprise Risk Management (ERM) Framework* in 2004, encompassing as well as expanding its *Internal Control-Integrated Framework* originally published in 1992, which offers an integrated framework along with step by step guidelines for managing risks (Weidenmier, 2006). It has been commented that IT has an important role to play in risk management of business organisations as it is fills in the risk management process as a tool for implementing the components of the COSO framework (Ramamoorti & Weidenmier, 2004). The COSO framework has been graphically represented in Figure 2.3.

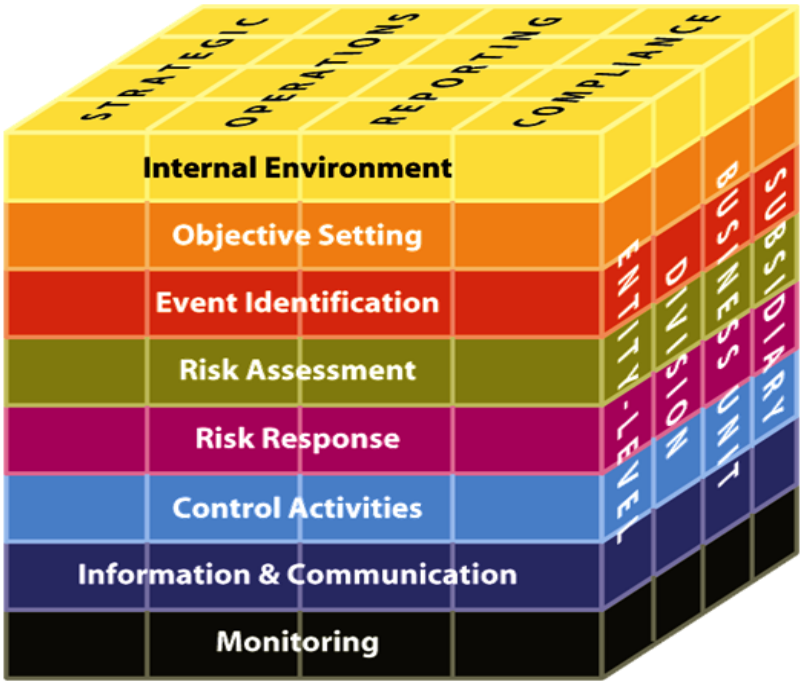


Figure 2.3: COSO Framework (McNally, 2013)

The eight-stage framework is comprised of internal environment, objective setting, event identification, risk assessment, risk response, control activities, information &

communication, and monitoring. The fourth stage of the framework, risk assessment, is of significant as it is of great importance to understand the impact of IT on risk assessment (Weidenmier, 2006). COSO has developed frameworks for assessing the viability of internal control systems, for example assessing the adequacy of internal control system in deterring and preventing fraudulent behaviours. Internal controls are emergent from intelligently designed business processes and effective internal control system reduces the opportunity for fraud thus reducing fraud risk (Mohd-Sanusi, et al., 2015, p. 4). A system of checks and balances in the business process adequately designed to deter and prevent internal fraud can provide to be an effective system for managing fraud risk and the ability to assess risks accurately is a crucial factor for any such system. The objective of this research is to develop a method for measuring internal fraud risk and as such it can be stated that such a method is relevant for the risk assessment stage of COSO framework.

## 2.3 Information Systems in Managing Fraud Risk

Tackling fraud has traditionally been the function of internal auditors and it is now widely agreed that the success of audit activity is dependent on the effective use of information technology tools (Moorthy, et al., 2011). Fraud is a complex phenomenon and as such it is important consider the nature, extent, and contextual aspects related to fraud within business settings. The aim of this research is to utilise features of information systems for addressing the phenomenon of fraud within organisations. It is therefore important to understand what role IS in general is playing in tackling the phenomenon of fraud. In this section a discussion has been included on fraud risk, fraud risks involved in business processes, how fraud risk can be measured, and how IT is currently being applied within business organisations to tackle the phenomenon of fraud. Then existing literature on the role of ERP systems in dealing with fraud risk has been reviewed. Finally, the role of process mining has been analysed.

### 2.3.1 Defining Fraud Risk

Fraud and fraud risk are different from one another as the former one is actuality whereas the latter is possibility; while the former is disruptive, the latter can be managed and governed (Power, 2013, p. 525). Corporate fraud which is of interest to auditors do not require legal determination, but rather intentionality and material misstatement of the financial statement suffices (PCAOB, 2017). The intentionality factor distinguishes fraud from error, though the financial implications of both maybe equally damaging. However, the procedures of detection may be completely different. As mentioned earlier, material misstatement can arise in two ways: misstatements arising from fraudulent financial reporting and misstatements arising from misappropriation of assets. Both such misstatements are regarded as internal fraud as the fraudulent activities are undertaken by individuals who are internal to the organisation.

Also mentioned earlier, there are the factors that increase the susceptibility of an organisation to experiencing internal or occupational fraud. The factors are the three legs of the fraud triangle (Figure 2.1), namely, opportunity, incentive and attitude. Fraud risk is defined as the susceptibility of an organisation to a fraudulent act being committed depriving it of some value. For the purpose of this study, internal fraud risk is focused on in

this paper, which, therefore, may be narrowly defined as fraud risk arising from the susceptibility to internal corporate fraud or occupational fraud carried on by the internal stakeholders of an organisation. Hence, if any of the three factors, jointly or severally, move towards a state of non-conformity, it could be argued that the internal fraud risk of that organisation has increased.

### 2.3.2 Fraud Risk in Business Process

Business processes are the lifelines of modern businesses and internal controls are the mechanism to ensure that adherence to business processes is maintained within an organisation. Executives and managers nowadays emphasize the importance internal control procedure more than ever before due to unearthing of accounting scandals such as Enron, Tyco and WorldCom (Norman, et al., 2010, p. 550). Some academicians go a step further by defining the role of corporate governance and corporate management, in light of fraudulent behaviour, as systems in place to govern and manage fraud risks rather than control specific frauds individually, as that is a legal issue by itself. In Ericson & Doyle's (2003, p. 358) words:

> "*In governance beyond the law… problematic conduct is posed not as illegal behaviour defined by the moral codes of law but rather as a risk defined by the moral utilitarian criteria of the particular institutions involved. The governing mechanisms are not legal controls over unwanted conduct, but rather a network of surveillance systems that form an assemblage to provide knowledge that is useful in addressing moral risks*."

Hence framing internal control systems as a network of surveillance system within the broader business process system provides us with a perspective for the role of internal control system as an apparatus to directly keep the internal fraud risk in check and indirectly be a measure of the internal fraud risk present in an organisation.

### 2.3.3 Fraud Risk Measurement Methods

Both internal and external auditors have responsibilities, as defined by financial reporting and auditing standard-setting bodies, to assess fraud risk (Norman, et al., 2010). Fraud risk assessment has been defined as the "*systematic process for identifying and evaluating events or conditions (e.g. likelihood of fraud risks and opportunities) that could affect the*

*achievement of an organization's objectives, positively or negatively*" (Mohd-Sanusi, et al., 2015, p. 3) and has been termed as a critical part of the audit procedures. Fraud risk can be analysed at the entity-level as well the process level. Entity-level analysis means analysing each individual node in a system of business process, be it authorising personnel, originator of a process request or people involved in handling and delivery. Process-level analysis focuses at individual process paths, and may contain multiple process paths for achieving the same objective with some paths more frequent than others. Though process level analysis is more impersonal and focuses on identifying risky processes, thus indirectly providing solutions for improving business process architecture, process level business risk assessment has generally been termed as the more challenging one of the two levels of analysing internal fraud (Kochetova-Kozloski, et al., 2013). However, with the advent of process mining techniques and tools and the ubiquitous availability of data in modern ERP-system enabled organisations, the attitude towards process-level analysis is sure to change.

Traditional fraud risk assessment by internal auditors involves estimating process deviation in an organisation by using a range of tools such as benchmarking, systems analysis, ratio analysis, mathematical modelling, and exception reporting (Doody, 2008). Use of such statistical methods for detecting and measuring fraudulent activities is referred to as frequentist methods (Sinharay, 2018). None of these tools enables an auditor to quantify the number of processes that have not followed an ideal or stipulated path or sequence. Assessment of deviation from the business process model is often subjective and dependent on the judgement of the internal auditors, and hence is not quantitatively rigorous and may fall victim of individual biasness. A control flow analysis quantitatively examining less frequent flows, with a quantitative cut-off of deviance applied to all business process equally, has been suggested by researchers in this field to a be scientific alternative to traditional internal audit methods (Jans, et al., 2011). An improved process deviation measurement system combined with sampling of fraudulent cases among a sampled group of business process, thus provides the basis for fraud risk measurement for the internal and external auditors. A number of researchers have looked into introducing Evidential Reasoning approach in frameworks for assessing fraud risk (Gao, et al., 2011). It appears that evidence obtained through process mining can potentially be applied in evidential

reasoning using appropriate theory and model. This has been discussed in greater details in section 2.7.

### 2.3.4 Role of Process Deviation in Measuring Internal Fraud Risk

It has been showed empirically that real process executions deviate from the stipulated or process models (Rozinat & Aalst, 2008) (Rozinat & Jong, 2010). Process deviations are prevalent and in many circumstances such deviations are regarded as necessary as they provide process flexibility. Although process deviations are expected, it is commented that on many occasions process deviations are indication of errors or fraud (Depaire, et al., 2012). One of the key aspects of internal control system is to monitor process deviations. The importance of monitoring process deviation as part of ensuring internal control system has been highlighted in regulatory legislative provisions such as Sarbanes-Oxley Act (2002) and Basel II: Revised international capital framework (2004). A process execution that does not conform to the normative process model is denoted as deviation. Deviations can be classified into anomalies and exception where exceptions are acceptable as they are necessary for allowing flexibility and anomalies are undesirable as they indicate errors and fraud. Fraud is the result of process deviation deliberately caused by human agents (Depaire, et al., 2012). It can therefore be stated that process deviations which are not regarded as exceptions by business or system experts are indicative of fraudulent activities.

### 2.3.5 Application of Information Technology in Business Organisations

A great number of research have focused on how IT is being applied within business and organisational contexts. These research vary not only in terms of the type of technology that has been scrutinised but also in terms of business sector. It is important to consider that IS researches can be linked despite being conducted on a completely different filed or industry as it is possible to draw analogies and find new ways for utilising an existing technology. It is argued that fraud research should consider diverse theoretical and empirical approaches as fraudulent activities can take place in numerous ways (Anand, et al., 2015). Application of IT in dealing with fraudulent activities has been considered in telecom sector as well as banking sector and a number of such research have been analysed in this section.

Fawcett and Provost employed sets of data mining methods to detect cellular phone fraud (Fawcett & Provost, 1997). They designed a rule-learning programme that could reveal signs of fraudulent activities by analysing a large database of transactions made by cellular carriers' clients. The programme makes a selection from the generated fraud rules and applies it in the form of monitors. The profiles in these monitors study behaviour of users and discover abnormal activities. The data from the monitors, combined with tags of profile's prior regular activities, are used as records for a Linear Threshold Unit (LTU). This unit attempts to integrate signs of abnormal activity and other data to trigger warning notices with high confidence rates. This technique is a great example of a supervised hybrid-based system which combines learning techniques with a purpose of increasing effectiveness. In another study Fawcett and Provost introduced Activity Monitoring which is an isolated problem set in data mining that has a distinctive structure (Fawcett & Provost, 1999). The authors showed how this framework could be used along with and in combination with other systems to detect cell phone fraud.

Derrig & Ostaszewski (1995) employed data mining method to perform a descriptive analysis. They focused on fuzzy techniques of pattern recognition in risk and claim classification. Stolfo et al. (2000) conducted a remarkable research on identifying fraud. The main objective they had was to develop a model for fraud and intrusion detection. They offered a system, referred to as MADAM ID, short for Mining Audit Data for Automated Models for Intrusion Detection. Similarly, they analysed the findings of the JAM (Java Agents for Meta-Learning) project. It is an integrated meta-learning system used to detect frauds by combining the joint knowledge obtained by individual agents. In application to fraud detection, the system combines data on banks and credit card fraud. These researchers have applied IT in detecting fraud and thus paved the way for IT to play key role in fraud detection and measurement. Modern organisations have embraced IS in all aspects of their activities and as such it is of great importance to utilise IS in detecting, measuring, and preventing fraudulent activities within organisations.

### 2.3.6 Role of ERP Systems in Assessing Fraud Risk

Enterprise Resource Planning, or ERP Systems, is the data hub for an organisation. Given the increasingly data-centric approach to making the business processes effective and efficient in attaining business objectives, the role of ERP systems has proven to of utmost

importance. ERP systems usually record the data such as instances or *cases* processed in the system, the activities or *events* executed for each instance, the timestamp for each event and the resource *personnel* such as an originator, authorisation provider or handler for each event(Jans, et al., 2011, p. 13352). It can thus be observed that implementation of ERP system allows business organisations to opt for automation. On the other hand, ERP systems have been claimed to have exposed organisations to new risks from change management, system security, and privacy & confidentiality perspectives (Addison, 2001). However, it can be argued that business organisations can benefit from embracing ERP systems if there are effective methods for utilising its full potential. ERP system can be an important tool in assessing fraud risk as it allows fast access to relevant data in real-time which can be transformed into information that are useful for enhancing management control systems (Suhaimi, et al., 2016). Process mining, which has been possible due to implementation of ERP systems, has already paved the way for process analysis. However, there has not been any study that focused on developing a method for measuring internal fraud risk within business organisations with ERP system.

### 2.3.7 Role of Process Mining

Process mining is comparatively a new research domain. Process mining focuses on extracting information regarding processes by examining event logs. It has been seen that time of activities performed in practice, performers of such activities and the context of the activities are typical information which is recorded in the event logs (Van Dongen, et al., 2009). Process mining techniques mainly have three functions: discovering process models; checking the conformance of process models; and improving process models by using data regarding process executions(Aalst, 2011). Process discovery algorithms can construct process models by explicitly using the case context that accurately describe the process as it takes place in real life. It has been commented that process mining bridges the gap between data mining and business process management discipline(Eck, et al., 2015). Process mining has already been used for exposure of fraud in healthcare effectively (Yang & Hwang, 2006). It is grounded on medical pathways that discover and analyse patterns. Another method used in several papers is the fuzzy expert system. It can therefore be said that process mining can be utilised in measuring fraud risk in organisations in a variety of ways and it can open new possibilities in ensuring internal control systems by ensuring effective monitoring.

The focus of this research is on how process mining can be utilised for measuring internal fraud risk of business organisations with ERP system in place.

## 2.4 Comprehending Business Process

Various aspects related to business process or process perspective of business operations have been considered in this section. The aim of this research is to develop a method for assessing internal fraud risk using process mining and as such it important to comprehend how business processes lead to achievement of organisational objectives and the vulnerabilities of such processes. First of all, business process has been considered from a definitional perspective. Then the general procurement process within business organisations have been assessed as the focus of this research is specifically on procurement process. Business process modelling, which allows business processes to be understood, has been considered carefully. Finally, existing literature on representation of business process models have been considered with specific attention to BPMN which has been relied for conducting this research.

### 2.4.1 Definitions of Business Process

It is important to understand what a business process is before such processes can be analysed for extracting valuable information. A business process is a sequence of activities which are logically linked where each such activity is comprised of a set of input and value-added tasks resulting in a set of outputs with a view to fulfilling organisational and customer requirements (Hindle, 1997). A process involves activities undertaken by human agents or machines and mostly is concerned about collaborative activities involving multiple parties (Ould, 1995). A business is usually comprised of a number of different processes. Within an organisation there can be several departments each of which is comprised of its own set of processes. A business process is a set of interconnected activities aimed at delivering out for users by utilising materials, equipment, information and people (Rolstadas, 1995). This has been shown in Figure 2.4. Procurement process, manufacturing process, quality control process are examples of a business processes.

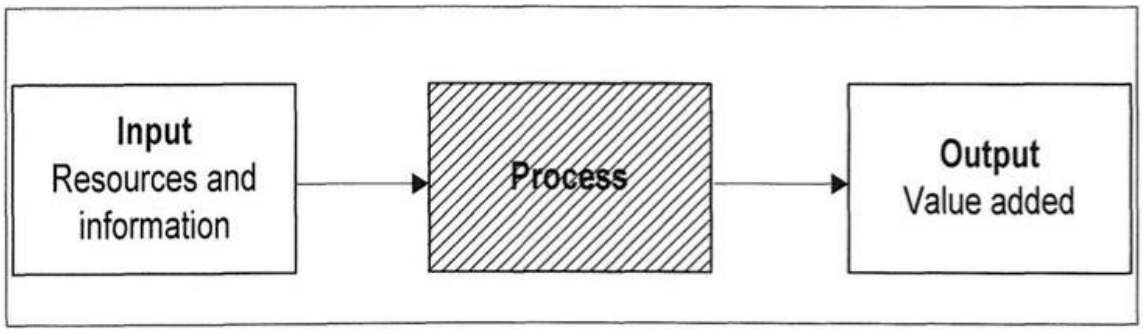


Figure 2.4: Business process flow chart

A business process has been commented to be a set of activities where there will be single or multiple inputs which will deliver an output that is of value to the customer or user (Hammer & Champy, 1993). It is therefore said that a business process involves structured and semi-structured modifications of inputs into outputs with the aim of satisfying the customer or user need. Business process is a relationship between inputs and outputs where a chain of activities turns inputs into value added outputs. Clearly defined and structured business processes can be measured by employing dimensions such as time, cost, customer satisfaction, functionality etc. A process has been commented to be an interconnected sequence of work activities performed across time and place with a definite starting and ending along with clearly identifiable inputs and outputs (Davenport, 2013). A process has also been defined from stakeholder need perspective where it is stated that an important aspect of a process is to cater to the needs or requirements of intended stakeholders (Lunn, et al., 2003). The effectiveness of a process can be measured based on this definition by taking stakeholder or customer satisfaction with the process outputs into consideration.

Business processes may also be represented as interactions taking place between a set of roles, including activities, actions, and decision points, where the set of roles can be people, machines, departments, and companies. Ould has commented that "*a process is a coherent set of actions carried out by a collaborating set of roles to achieve a goal*"(Ould, 2005). It is commented that those who are owners of business processes, responsible for designing business processes and performing business processes should be defined and identifiable in order to ensure that requirements of customers or users are fulfilled (Davenport, 2013). It is opined that perception of business processes to be the transformation of inputs into output is way too simplistic as business processes can be viewed from a range of perspectives

based upon the information required (Curtis, et al., 1992). Business processes are mainly viewed from functional, behavioural, organisational, and informational perspectives. These perspectives can be summarised in the following manner (Giaglis, 2001, p. 212):

*"(1) The functional perspective represents what process elements (activities) are being performed;*

*(2) The behavioural perspective represents when activities are performed as well as aspects of how they are performed through feedback loops, iteration, decision-making conditions, entry and exit criteria, and so on;*

*(3) The organisational perspective represents where and by whom activities are performed, the physical communication mechanisms used to transfer entities, and the physical media and locations used to store entities; and*

*(4) The informational perspective represents the informational entities produced or manipulated by a process and their relationships*".

Melao and Pidd analysed business process from four different perspectives which can be summarised in the following manner (Melao & Pidd, 2000):

(1) Business processes as deterministic machines where a business process is perceived as a fixed sequence of activities performed by human machines with a view to accomplishing specific objectives that converts inputs into outputs;

2) Business process as complex dynamic systems where a business process is perceived as an assembly of interchangeable components with focus on the complex, dynamic and interactive features of such a process;

3) Business process as interacting feedback loops where a business process is perceived as a closed loop with focus on the information feedback structure of business process; and

4) Business process as social constructs where a business process is perceived as creating of people with different values, expectations and agendas as opposed to perception of business process as a dynamic organism pursuing clear objectives.

It can be commented that business processes have become complex in nature and hence it is not easy to comprehend the architecture of business processes in modern organisations. Information technology plays a key role in ensuring business process from both operational and developmental perspectives. Information technology can be utilised for effectiveness and efficiency of business process only if the processes are comprehended rigorously. It is therefore of significance importance to employ methods and techniques for comprehending or developing a blueprint of any business process. Modern businesses are comprised of many processes of which procurement is highly susceptible to fraudulent activates (Deloitte, 2014). Such susceptibility to fraudulent activities make procurement function suitable for conducting fraud investigation. Various aspects related to procurement process have been discussed in the next section.

### 2.4.2 Procurement as a Business Process

Procurement process is one of the significant business processes for most business entities both in the manufacturing and services industry due to the role it plays in fulfilling the strategic objectives of an organisation. Kramer has found empirical evidence which indicates that the procurement process is susceptible to major fraud schemes (Kramer, 2003). Procurement has been defined as, "*the business management function that ensures identification, sourcing, access and management of the external resources that an organisation needs or may need to fulfil its strategic objectives*" (CIPS, 2013). The procurement process involves purchasing raw materials, goods and essential support services which involves interaction between internal management and external bodies with regard to financial terms and conditions.

KPMG's forensic department has reported that fraudsters are second mostly likely to target procurement function of businesses and in the United Kingdom the likelihood of procurement fraud is comparatively higher (Venter, 2007, p. 79). Since the procurement is more likely to be subject to fraudulent activities, it has been chosen for the purpose of developing this fraud risk measuring method. Supply change management, of which the procurement process is an element, has to match specific type of suppliers in order to address varying needs of the buyers and thus the entire process is very dynamic in nature as it is often tailored for serving the purpose of business entities (Wagner, et al., 2013). The human agents involved in procurement activities have to interact with a wide range of

stakeholders, both internal and external, and as such procurement function often requires a great deal of process flexibility paving the way for both legitimate and illegitimate process deviation. It is important to follow a method for understanding any business process within an organisation. It has been discussed how business processes can be modelled methodically in the next section.

### 2.4.3 Definitions of Business Process Modelling

It is of immense importance to comprehend any business process in a systematic manner. An external agent can grasp the processes of a business organisations through effective representation. Business Process Modelling (BPM) is defined as the activity of representing processes which a business is comprised of with a view to understanding, analysing and improving the business process (Ramadan, et al., 2011). The concept of modelling is significant here and Pidd defines a model as "*an external and explicit representation of part of reality as seen by the people who wish to use that model to understand, to change, to manage and to control that part of reality*"(Pidd, 2009). BPM has also been defined as the process of developing a model based upon present situation or a model based upon a proposed situation which ensures functional activities of the whole or part of an enterprise (Tam, et al., 2001). A process model is a representation of an existing or a proposed process where the representation involves all the important elements of the process and can be enacted by human or mechanical agents (Curtis, et al., 1992).

It appears from the body of literature discussed above that business process can be defined and examined from a range of perspectives although the fundamental attributes of a business process are agreed. It can be stated that a business process is a series of activities, mostly structured, which are carried out by human or machines or by a combination of both for turning inputs into desired outputs with the aim of attaining predetermined objectives or purposes. It is important to comprehend various aspects associated with business process in order to analyse a single or a range of business processes for the purpose of improving its effectiveness or efficiency or drawing any analogy. Business process modelling allows an individual to comprehend a business process. It is for business process modelling an individual can grasp how business processes work towards achieving business goals without being a business expert. Business process modelling is thus essential in integrating technology into business processes.

### 2.4.4 Significance of Business Process Modelling

Process modelling allows developing a process-oriented view which is of great significance as organisations are all about inter-related processes involving people and machines. This can allow both internal and external parties to gain understanding of the business processes and pave way for analysis and improvement. Business processing modelling has become increasingly popular as it allows enterprises to gain competitive advantage based upon knowledge of the business processes. Business process modelling can be utilised to make an existing process more efficient, to evaluate process and to develop business process software. In other words, BPM is relevant to process development, process improvement, process management, and process execution (Curtis, et al., 1992).

Today business process can be complex and thus BPM is of significant importance to all the parties related to business processes. Hommes and Reijswoud commented that "*a business modelling technique should provide means to describe the dynamic aspects of the functioning of an organisation as well as the static characteristics of the information space on which the dynamic aspects build*" (Hommes & Reijswoud, 2000). Business process modelling has also been stated to be an inexpensive way for representing business processes and as such BPM can be relied upon for constant improvement of business process in an affordable way by organisations of all size. (Biazzo, 2002). It has been commented that BPM can illustrate the relationship between different organisational concepts and allow parties to comprehend the activities and transformation of resources into output by human and mechanical agents (Caetano, et al., 2005).

Process modelling is significant for multiple reasons. The most important significance is that it allows users to analyse and improve business process. It has been opined that process modelling facilitates to describe a process, analyse a process and enact a process (Warboys, et al., 1999). Modelling has been argued to be at the core of organisational design and information systems development (Giaglis, 2001). It has also been commented that business process modelling can facilitate decision making in business settings by filtering out irrelevant information and thus allowing the users to focus on issues important to the business process. Digitalisation of business processes is another aspect where process modelling can play a significant role by facilitating software development. Tam et al has stated that BPM can play a crucial role in business process restructuring by identifying

critical processes, forming a tool for re-engineering the business process, supporting software package implementation and paving way for software development (Tam, et al., 2001). It can thus be seen that BPM can be relied upon for developing business process-specific software and for ensuring continuous software development as well (Phalp, 1998).

Process modelling can serve a number of purposes. Process modelling can satisfy the need of having a shared understanding of the functions of a business and how the objectives of a business are being attained as well as satisfying the requirement for aligning traditional and computer-based system, managing workflow system, developing new forms of process technology (Ould, 2005). It can therefore be seen that BPM has become a technique which is heavily relied upon by personnel responsible for business process improvement, and information technology analysts. Aguilar-Saven stated that, "*Conceptual modelling of business processes is deployed on a large scale to facilitate the development of software that supports the business processes and to permit the analysis and re-engineering or improvement of them*" (Aguilar-Saven, 2004, p. 129). BPM can also be utilised for explaining and evaluating existing business processes if responsibilities of agents are represented in the model. BPM can allow users and those involved in process design and improvement to contribute in improving business process and turn business process development a continuous cycle. Besides improving the functionality of business process, BPM can add a non-functional perspective as well if additional elements, such as role of agents, are embedded in it and this can result in development of quality of products or services. There are numerous ways for presenting business process models which have been discussed in greater detail in the following section.

### 2.4.5 Representation of Business Process Models

In plain words, model is a simplified representation of a natural object or an artefact and modelling is the process of creating models. It is of significant importance to take into consideration that business process is closely related to enterprises as processes define the way for achieving goals of the enterprise (Aguilar-Saven, 2004, p. 133). Modelling can become a complex matter when it comes to enterprise architecture as enterprise can be a complex system. Enterprise architecture models can be categorised into several classes. Process models, information models and technical models are few examples (Vernadat, 1996). In a study by Kettinger and colleagues represented an important overview of

methods, techniques, and tools which are relied upon in Business Process Re-engineering (BPR) and a list of business process modelling techniques and tools was published as well (Kettinger, et al., 1997). A number of business processes modelling techniques have been developed over the past decades and therefore for the purpose of this research existing literature with respect to most frequently used process modelling techniques such as Flow chart technique, data flow diagrams, role activity diagrams, role interaction diagrams, Gantt chart, Integrated Definition for Function Modelling (IDEF), Coloured Petri-Net (CPN), object oriented methods and workflow technique are considered to be the main techniques (Aguilar-Saven, 2004). These techniques for representing business process models have been considered carefully in this section.

A flowchart is basically a graphical representation of the logical sequence of a programme, business process or organisation where the entire structure is presented in a formalized manner (Lakin et al., 1996). In a Flowchart, various symbols are relied upon such as operations, data, flow direction and equipment for representing definition, analysis and solution to a problem. In the Flowchart modelling processes are represented by flowcharts and it only allows flows of actions to be represented sequentially but does not allow the activities to be broken down. This modelling method has been in use for a long time and is claimed to be the first process notation. The standard provides the designer of the chart with notation although it is for the designer to decide how to lay the building blocks. The advantages of Flowchart method is that it is easy to recognise and it allows the processes to be described in a simple way. The Flowchart is also easy to use and does not take significantly long to be developed. However, there are few downsides associated with this method. Firstly, the boundary of the process is not well defined as it's too flexible and thus flow charts can be very long. It is also difficult to distinguish between a main and subordinate activity in a Flowchart which can make it difficult to comprehend Flowchart. It does not have sub-layers and is hard to navigate. Flowcharts can be useful in identifying bottlenecks in a process and it works as a visual aid. However, Flowchart is not ideal for describing and analysing responsibilities of performers as the method offer the opportunity to exhibit organisational functions or activities in detail.

Data Flow Diagrams (DFD) is a modelling technique where flow of data or information is represented in diagrams (Kettinger, et al., 1997). DFD allows showing how processes are

inter-linked through data stores with the users and the world outside. This method shows how data is organised from its raw state. DFDs are said to be the cornerstone of the structured analysis which Yourdon developed during early sixties. A process can be specified at a logical level by analysts with the help of DFD. In other words, DFDs shows a process will be doing rather than showing how it will be done. DFDs are mostly used in discussions between analysts and users as it is easy to develop and allows amendments. Unlike Flowchart, DFDs allow can be broken down to exhibit sub-processes in greater detail. DFDs are relied upon in functional models where it is important to specify operational constraints and functional dependencies. Flow of information and data are shown in the diagrams and it can be seen how information is stored within the processes and relationship between activities and organisational function.

Role Activity Diagrams (RADs) are role-based techniques where processes are graphically represented from individual-role perspective highlighting the responsibilities of the role-players and how they interact with each other (Holt, et al., 1988). Roles can be stated to be abstract notations of a set of desired behaviour in the organisational setting including software systems, customers and suppliers. RAD provides a different perspective to the users as it can be useful in facilitating communication. RADs are easy to comprehend and present a detailed view of the process and permitted activities in parallel. The interaction between process and degrees of empowerment of the role players can be highlighted using RADs. RADs are, in fact, object state transition diagrams used in object-oriented models. One of the limitations of RADS is that it is difficult to make an overview as process is presented as a sequence of the activities in RADs where a decomposition of processes may not be possible. It also excludes business objects such as machines and products.

Coloured Petri Nets or CPN is a graphical oriented language which allows designing, specification, simulation and verification of systems. CPN is suitable for systems consisting of numerous processes which communicate and synchronize (Jensen, et al., 2007). CPN is an extended version of Petri nets where colours are used to differentiate symbols. A CPN model consists of a set of modules where each of these modules contains a network of places, transitions and arcs. The interaction between processes are easy to comprehend as graphical representation is relied upon in CPN for explain complex models. CP-nets have a formal representation with a well-defined syntax and semantics which is the foundation for

defining different behavioural properties and analysing methods. CPN model allows its behaviour to be analysed by means of simulation or by means of more formal analysis methods. During the 1960s and 1970s Petri nets were recognised as an adequate language for describing and analysing synchronisations, communication and sharing of resources. Later on, it was revealed that Petri nets had serious drawbacks. Firstly, the concept of data flow was absent and consequently all sorts of data manipulation had to be exhibited in the net structure. Secondly, it was not possible to incorporate hierarchical structures which hindered incorporation of separate sub-models within the model. CP-nets have overcome these shortcomings as they incorporate both data structuring and hierarchical decomposition without compromising the qualities of the original Petri nets.

Workflow is another modelling technique where flow of tasks between computer applications or human agents of an organisation is represented. Workflow is more than just a process modelling technique. It can be classed as a method as it allows to analyse and to improve a process besides creating the model of the process. A system that defines, creates, and manages the execution of workflow is called a work management system. A work flow management system relies upon software where a computer representation of the work logic drives the order of execution (Hollingsworth, 1997). Workflow models are used in the workflow development process for capturing relevant information regarding the processes. Workflow development process is comprised of four stages which are information gathering; business process modelling; workflow modelling; and implementation, verification and execution. There are some advantages associated with use of workflow. Workflow can assist in improving processes, can be used in combination with other systems and allows making changes easily. However, there some disadvantages associated with it as it can lead to loss of human contact, loss of motivation and development of a sense of being controlled.

Object oriented method is another process modelling technique. Its origin is rooted in the development of discrete event simulation language, Simula, by Dahl Nygaard in 1967. Object oriented method is relied upon for describing where a system deals with a number of different types of objects and prospective actions depend on the nature of the object that is being manipulated. Object oriented methods can be defined as a method which models and programmes a process where objects are transformed by activities. The objects referred to

in this method may represent real world applications (Rumbaugh, 1991). The advantages of utilising object-oriented method have been highlighted by many researchers (Bruce, et al., 1998). Coad and Yourdon (1991) have identified seven key benefits and motivating factors associated with object oriented method which is as follows:

(1) tackles challenging problem domains;

(2) Improves interaction between analyst and problem domain expert;

(3) Increases internal consistency across analysis, design and programming;

(4) Represents commonality between classes and objects explicitly;

(5) Builds specifications resilient to change;

(6) Reuses results, and

(7) Offers consistent representation for analysis, design and programming.

Object oriented method is one of the main methods which is relied upon for process modelling. It is especially suitable for enactable models. Effectiveness of the process to identify and refine objects is the greatest advantage that objects oriented method offers. There several techniques which have been developed from object oriented method such as Booch's Technique (Booch, et al., 1999), Coad and Yourdon's Technique (Coad & Yourdon, 1991), Rumbaugh's Technique (Rumbaugh, 1991) and Shlaer-Mellor's Technique (Shaler & Mellor, 1990). The key differences among these techniques are related to their notations.

Business Process Model and Notation (BPMN) is a standard for modelling business process which is used by Object Management Group (OMG) (Ramadan, et al., 2011). BPMN was developed with a view to serving all types of business users and application purposes (Mendling & Weidlich, 2012). BPMN offers a graphical notation for specifying business processes, a notation capable of representing complex semantics yet intuitive to business users, which can be used within a Business Process Diagram (BPD) which can be useful for both business and technical users (Object Management Group, 2011). BPMN is a combination of different types of modelling techniques and allows end-to-end business

processes to be created easily. In this way, BPMN bridges the gap between business process design and business process implementation.

The aim of this research is to develop a model for measuring internal fraud risk within the ERP system of an organisation. This involves a wide range of stakeholders as measuring fraud risk involves understanding business process, ERP systems, as well as aspects related to internal fraud. It is therefore important to embrace an integral approach in modelling business process which allows diverse range of stakeholders, such as managers, analysts, business experts, and information system designers, to participate. Having considered a range of business process modelling tools, it appears that BPMN is the most appropriate technique for the purpose of this research as it uses a language that can be understood by both business and system experts (Weske, 2007). BPMN has been discussed in greater details due to its functionalities and suitability for the purpose of this research.

### 2.4.6 Business Process Modelling Notation (BPMN)

Business process is a set of connected procedures which help realising the business goal (Chinosi & Trombetta, 2012). Business process model and notation (BPMN) is a modelling technique which is aimed at visualising business processes. BPMN is similar to Unified Modelling Language (UML) activity diagram and was adopted as a standard by Object Management Group in 2006. The latest version of BPMN is BPMN 2.0. BPMN consists of diagrams which visualise business process. These diagrams are standardized and are mainly comprised of the following sets of graphical elements:

- Flow objects.
- Connecting objects.
- Swim lanes.
- Artefacts.

Flow Objects are the main describing elements within BPMN and a Flow Object consists of three elements: Event, Activity and Gateway. Event denotes to something that happens which is different from an activity which denotes to something that is done. Activity describes a specific kind work that must be undertaken. Gateway determines convergence or divergence of paths based upon the conditions. Connection Objects are used to connect flow objects. Connection Objects are of three types: Sequence Flow which shows order of

activities; Message Flow which tells what messages flow across the boundaries of the organisation; and Association which is used to associate an Artefact to a Flow Object. Swim Lanes are a mechanism for organising and categorising activities visually and are based on cross functional flowcharting. Swim Lanes are of two types: Pool which separates the participants from each other and Lanes which separates the activities of one pool from others.

Artefacts are extension to elementary BPMN objects as they allow developers to adjoin new information into the diagram. Artefacts have been classified into three pre-defined groups: Data Objects, Group, and Annotation. Data Objects show required or produced data with respect to an activity. Group is used to highlight different activities without affecting the flow in the diagram. Annotations are used for providing the reader with comprehendible impression. The full set of BPMN objects and their descriptions have been elaborately discussed in BPMN specification (Object Management Group, 2010). BPMN is implemented in several software tools, most popular are BizAgi, Intalio, ITP process modeler, Oracle BPMN Studio, SparxSystem EA, Visual Architect BP-VA, ARIS Express(Chinosi & Trombetta, 2012).

## 2.5 Process Mining

The key objective of this research is to develop a method for measuring internal fraud risk within the ERP system of any business organisation by utilising information extracted process mining. In this section, a detailed discussion has been included on process mining. A detailed discussion on what process mining is has been included at the beginning followed by an analysis of the role process mining has been playing in measuring fraud risk. A detailed discussion has been included on how process mining can be utilised in diagnosing the deviations within a system leading to a process diagnostic. The subsequent sections focus on various aspects related to process mining application tool and different types of process mining algorithm.

### 2.5.1 Comprehending Process Mining

Process mining or business process mining has derived from the concept of data mining. Data mining basically refers to identification of patterns by processing a set of data with a view to extracting specific knowledge (Witten & Frank, 2005). Extraction of knowledge by analysing and processing a vast amount of data has been extended to the analysis of processes. Data mining techniques which have been developed to analyse data have been adapted to analyse event logs containing process execution data with a view to identifying patterns and extracting specific knowledge. Process mining techniques use execution logs of business processes and this has been possible due to automation of business processes and availability of storage devices capable of recording events. Alast et al stated that, "*Business process mining, or process mining for short, aims at the automatic construction of models explaining the behaviour observed in the event log*" (Aalst, et al., 2007). Execution log of business processes are usually hosted within business process management systems although these can be obtained from other process related systems installed within any organisation (Aalst, et al., 2003).

Agarwal, Gunopulos and Leymann were early pioneers of process mining (Agrawal, et al., 1998). They took an algorithmic approach towards process mining which allowed the construction of process flow-graphs based on the execution logs of a workflow application. Cook and Wolf have also contributed significantly in developing the academic discipline of process mining (Cook & Wolf, 1998). Any transactional information system is capable of

producing event logs for the purpose of business process mining (Aalst, et al., 2003). Van der Aalst and colleagues have identified two types of workflow meta models where each has its own language and graphical representation: one is graph oriented model and the other is block oriented model (Agrawal, et al., 1998). Omnipresence of event logs is observed in information systems like ERP, WFM, CRM, and many B2B systems. These event logs can be transformed into audit trails, history, or transaction logs. Organisations have been storing such logs of events, but the information was not relied upon for analysing processes. It is now possible to store event logs digitally and process them in various ways in this age of information technology. Thus, process mining has made it possible to analyse event logs and enrich knowledge bank with specific objectives. Aalst and colleagues have summarised this by stating that, "*The basic idea of process mining is to diagnose processes by mining event logs for knowledge*" (Aalst & Medeiros, 2005). The workflow has been graphically represented in Figure 2.5 below:

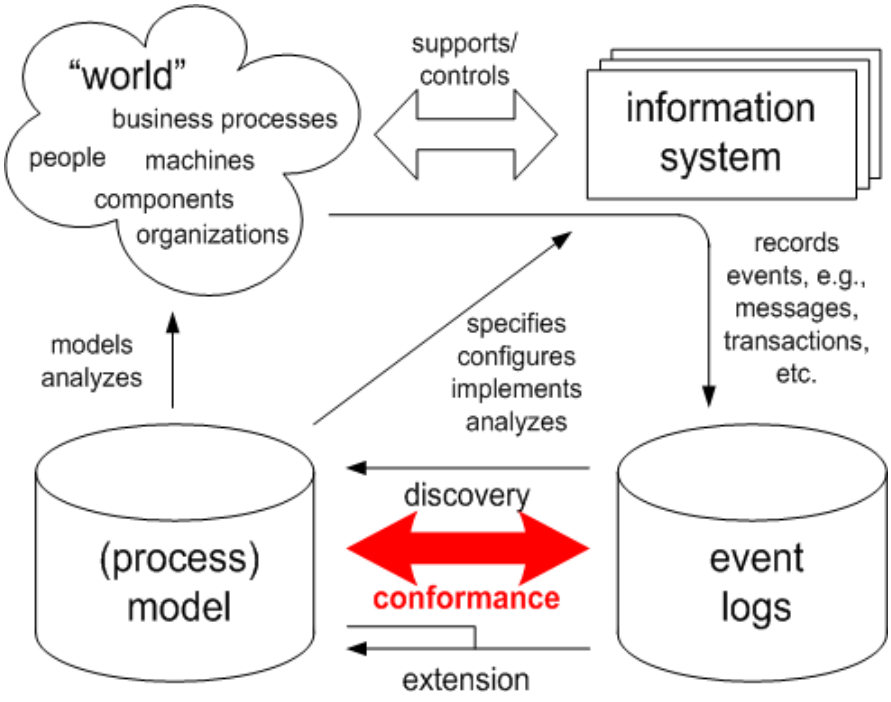


Figure 2.5: Process mining workflow

It is assumed that events with specific characteristics can be recorded for the purpose of process mining where an event refers to an activity, can be related to an originator, refers to a process instance, and can be timestamped. It is possible to apply process mining if available data with respect to any process fulfils the stated assumptions. The following table

is an example of event log where there are a number of events where available data satisfies the criteria. This type of event log, presented in Table 2.1, has been relied upon by Aalst and colleagues with resp ect to studies on process mining (Aalst & Medeiros, 2005).

| Case id | Activity id | Originator | Timestamp |
|---|---|---|---|
| case 1 | activity A | John | 9-3-2004:15.01 |
| case 2 | activity A | John | 9-3-2004:15.12 |
| case 3 | activity A | Sue | 9-3-2004:16.03 |
| case 3 | activity B | Carol | 9-3-2004:16.07 |
| case 1 | activity B | Mike | 9-3-2004:18.25 |
| case 1 | activity C | John | 10-3-2004:9.23 |
| case 2 | activity C | Mike | 10-3-2004:10.34 |
| case 4 | activity A | Sue | 10-3-2004:10.35 |
| case 2 | activity B | John | 10-3-2004:12.34 |
| case 2 | activity D | Pete | 10-3-2004:12.50 |
| case 5 | activity A | Sue | 10-3-2004:13.05 |
| case 4 | activity C | Carol | 11-3-2004:10.12 |
| case 1 | activity D | Pete | 11-3-2004:10.14 |
| case 3 | activity C | Sue | 11-3-2004:10.44 |
| case 3 | activity D | Pete | 11-3-2004:11.03 |
| case 4 | activity B | Sue | 14-3-2004:11.18 |
| case 5 | activity E | Clare | 17-3-2004:12.22 |
| case 5 | activity D | Clare | 18-3-2004:14.34 |
| case 4 | activity D | Pete | 19-3-2004:15.56 |
| case 1, 3: | A-B-C-D | | |
| case 2, 4: | A-C-B-D | | |
| case 5: | A- E -D | | |

Table 2.1: An example of an event log, used by van der Aalst et al. (2007)

### 2.5.2 Role of Process Mining in Measuring Fraud Risk

Process mining is comprised of the steps taken to diagnose business processes by mining event logs for extracting useful information (Aalst & Medeiros, 2005). The data in the event logs of ERP systems can be analysed from three distinct perspectives: the process perspective, the organisational perspective, and the case perspective (Jans, et al., 2011). In light of internal fraud, the process perspective answers the 'how' of fraud, that is how was or might have frauds been carried out within the business process framework. The organisational perspective answers the 'who' of fraud, that is which nodes of the business process, through origination, authorisation and handing of business processes, helped or

can help commit fraud. Finally, the case perceptive tackles fraud on a case-by-case basis. For mitigation of internal fraud, the process perceptive has been cited by researchers to be the most useful. The algorithm used in the process mining of event log data for this research follows a process perceptive of process mining. Process mining techniques can be categorised into four different classes based on the main activities performed: process discovery, conformance checking, enhancement, and process analytics (Aalst, 2011). Process discovery involves production of a model which reflect actual behaviours reflected in the log of events without any information of the event. Conformance checking allows actual processes which have taken place to be compared with a given or stipulated model (Taghiabadi, et al., 2016). Process enhancement focuses on improving an existing model whereas process analytics allows better understanding of process models for using that for various purposes. It can be said that then conformance checking activity of process mining is capable of playing a crucial role in measuring fraud risk as it can enable system experts to measure the rate of non-conformance within an ERP system.

### 2.5.3 Process Diagnostic through Process Mining

Information systems of organisations usually record all the events taking place over time which is referred to as event logs. Event logs contain information with respect to events taking place during the day to day operation of enterprises such as what process are taking place, human agents involved in running processes etc. Process mining allows to analyse information contained in these event logs and to process them with a view to extracting specific knowledge which can then be applied for enhancing process performance, supervising conformity to scheduled steps in a process or redesigning business processes for any functional purpose. Process mining is a "*case-by-case*" activity, as opposed to a "*repeatable service*" (Bozkaya, et al., 2009, p. 1). Bozkaya and colleagues presented a methodology, shown in Figure 2.6, based upon process mining with a view to conducting process diagnostic where the methodology incorporated a control flow perspective, a performance perspective, and an organisational perspective (Bozkaya, et al., 2009). This process diagnostics methodology successfully incorporated aspects such as the representation of the process model, performance of the processes, and involvement of various agents of organisation in the process. It is claimed that process diagnostic was

conducted on the basis of event logs by utilising process mining for the very first time in that study.

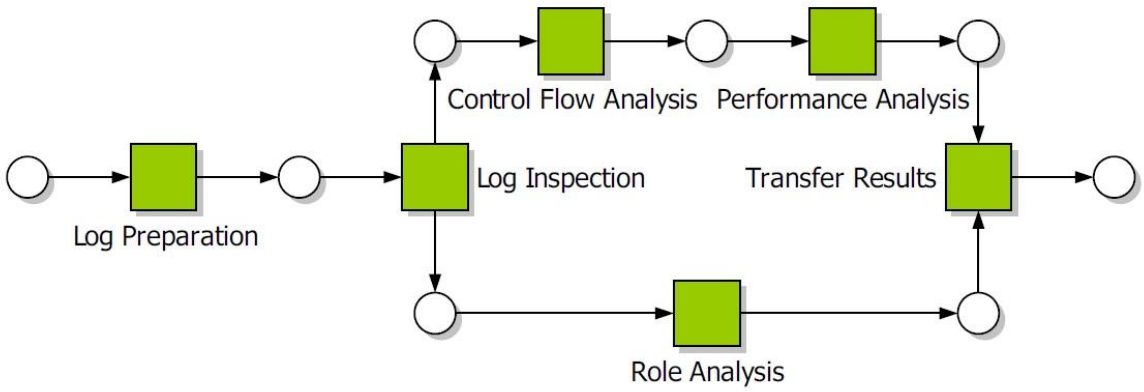


Figure 2.6: Phases of Methodology - Adapted from Bozkaya, Gabriels, Werf (2009)

Various phases of this methodology have been described in detail below:

**Log preparation:** For conducting process mining, the data has to be transformed into a usable format such as XES and MXML. Log preparation is the step which ensures that information stored in an event log is in the desired format.

**Log inspection:** Log inspection focuses upon statistical data about the events. This step gathers data regarding number of events, frequency of such events and some other types of statistical data which are essential for the purpose of process mining (Bozkaya, et al., 2009). Cases which initiated event log and remained continuously running are filtered out at this stage.

**Control flow analysis:** Control flow analysis focuses on identifying the process description of the organisation and performing a conformance check. A process discovery technique is used for identifying process description if an organisation does not have a process description. A number of algorithms are available for discovering process description (Aalst, et al., 2005), (Werf, et al., 2008), (Aalst, et al., September 2004), (Weijters, et al., 2006). Afterwards, a conformance check is done to identify whether or not process description is being conformed.

**Performance analysis:** Process analysis focuses on identifying the bottlenecks prevalent in the process and this is done by undertaking dotted chart analysis where spread of events of an event log over time is considered (Process Mining Group, Endhoven University of Technology , 2015). Throughput times of individual activities and the process time are calculated which can produce valuable information regarding infrequent behaviour (Hornix, 2007); (Bozkaya, et al., 2009). This assists to identify the unusual events and paves way for in-depth analysis of such events.

**Role analysis:** Role analysis about identifying the agent who is responsible for performing any process. Role analysis matrix can assist in identifying specialist and generalist hierarchy of the organisation (Song & Aalst, 2007). The role analysis can be of great importance for comprehending the nature of functions individuals perform with the organisation. Specialists are those who execute only a handful of limited activities, and generalists are those who execute multiple and varied activities within a single event. Third, this allows for social network analysis, to check for handover of work and subcontracting. Three matrices specifically mentioned as useful are the betweenness centrality, the degree of incoming edges, and the degree of outgoing edges.

**Transferring the results:** This is the step which facilitates the findings of the analysis of the event logs to the users so that information system of the organisation can be fully comprehended. Process diagnostic itself does not suggest anything and this step allows such diagnostic to serve a purpose. The findings of process diagnostic are assessed and a knowledge base is formed.

### 2.5.4 Process Mining Application Tool

There are several process mining tools available for users. ProM, Nitro, XESame, BPMOne, Future Reflect and ARIS Process Performance Manager are some of the renowned process mining applications. It has been showed in a study, results of which have been showed in Figure 2.7, that Prom is the most popular process mining tools and it is popular for both research and practice (Claes & Poels, 2013). ProM offers a framework which is in line with a range of mining perspectives with respect to business processes. It paves way for different mining perspectives by way of 'plug-in' feature. Plug-in is a functionality that can be added to or removed from a framework without affecting the functionality of the entire

framework. In other words, ProM allows a range of software compatible with different perspectives of mining to be used in its framework.

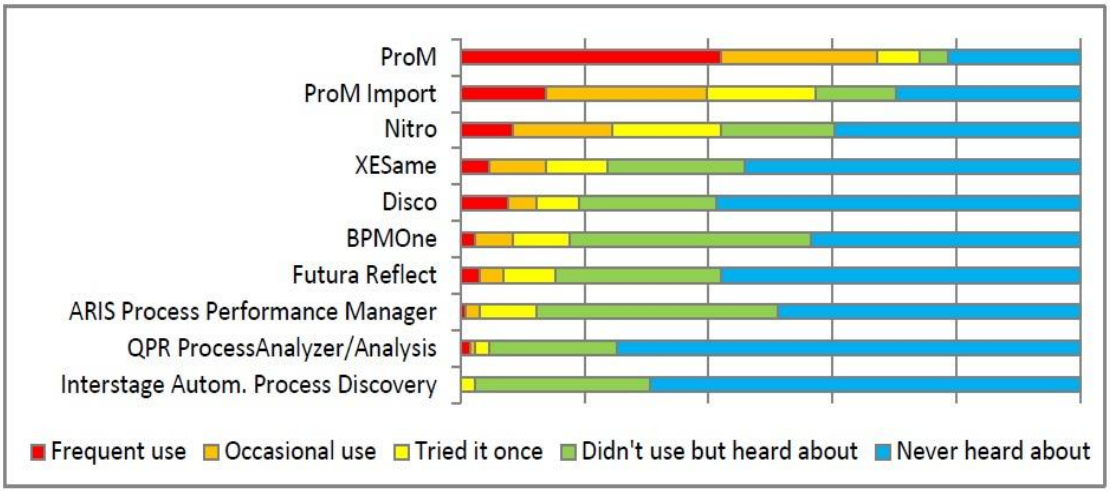


Figure 2.7: Usage and awareness of process mining software

ProM framework has several core components including Input/output component, Visualisation, and Analysis (Van Dongen, et al., 2005). Input/output component handles the input and output of the framework files. Process logs stored in XML format are feed into the ProM framework as input. Format of the output is flexible. A visualisation plug-in is offered by the framework which handles drawing of shapes and graphical elements. Analysis component is comprised of plug-ins which offers different sorts of analysis such as Petri net analysis, log replay analysis. One of the key features of ProM is that it supports a range of modelling language. The plug-ins supported by ProM framework has mostly evolved from independent mining tools. It also supplies interface description so that new plug-ins can be developed. It can therefore be said that the ProM framework offers a flexible and function platform for process mining.

### 2.5.5 Process Mining Algorithm

Traditional process mining approaches have limitations in dealing with unstructured processes. Hence process mining techniques must be capable of offering a high-level view on the process while filtering undesired details in order for being suitable in less-structured environments. It is of crucial importance to select an appropriate algorithm. There are three recommended miners for using in ProM software which are heuristic miner, fuzzy miner, and multi-phase miner. The purpose of fuzzy miner is to explore processes from event logs

interactively. Fuzzy miner was developed with a view to structuring topology in a proper and simplified manner considering the challenges of process mining (Gunther & Van der Aalst, 2007). It is opined that fuzzy miner is suitable for mining less-structured processes which exhibit a large amount of unstructured behaviour (Process Mining Group, 2015). The methods used should deliver a high-level outlook on the process, which is separated from unnecessary information (Gunther & Van der Aalst, 2007). Heuristic or multi-phase miners are only suitable when the log data is not complex or unstructured. It can therefore be stated that fuzzy miner appears to be the most suitable miner for dealing with the type of subject matter of this research.

## 2.6 Evidential Reasoning and Bayesian Theorem

This section includes discussions on evidential reasoning and Bayesian Theorem. One of the novelties of this research is that it incorporates evidential reasoning in measuring internal fraud risk. First of all, a detailed discussion on probability theories has been included. Then the key attributes of evidential reasoning with statistical probabilities have been analysed. Subsequently, a detailed discussion on Bayesian Statistics and its role in risk assessment has been included. The role of Bayesian Theorem in measuring internal fraud risk and how this can be utilised for the purpose this research have been evaluated in great detail.

### 2.6.1 Overview of Probability Theories

Probability can be interpreted along various paradigms. Broad categories of interpretation of probability can be articulated as frequentist probability, Bayesian probability and propensity probability. Frequentists probability is defined as relative frequency of occurrence of a particular type of event given multiple and large number of repetitions of an event generating process. Propensity interpretation of probability is comparatively a more ill-defined paradigm. It follows a deductive reasoning approach combined with a basis on relative frequency. It argues that probabilities are inherent within a process or artefact and hence is the reason behind long run achievement of relative frequency due to forces such as *law of large number* at work.

Bayesian probability is distinct from the other two interpretations in the sense that it approaches probability in an entity-sensitive manner where probability is thought to be the likelihood of an event as being considered by a body of knowledge or system of thought process, be it a person, an organisation or a software system. The current state of knowledge and epistemological experiences with regard to Bayesian probability allow new information to be included. Frank P. Ramsey, one of the key contributors to Bayesian theory, in one of his papers tried to establish Bayesian probabilities as degrees of beliefs and how beliefs on probabilities can follow mathematical rigor in its effort to maintain logical consistency (Ramsey, 1931). In contrast, estimates of frequentist probability changes with repetitions and propensity probability really do not change unless something inherent to the object of interest changes. While Bayesian probability is subjective to the entity,

frequentists and propensity probabilities are independent of the entity and hence are objective in nature.

Among these three paradigms or perspectives of looking at probability, for evidential reasoning, Bayesian theorem is most well suited due to its adaptability and flexibly with flow of information and because the basic premise built around degrees of belief. Evidential reasoning is important for developing a risk assessment framework, which is discussed in the following section.

### 2.6.2 Evidential Reasoning

The term Evidential Reasoning (ER) was coined by SRI International which referred to the body of techniques designed for arriving at reasoning from available evidential information (Lowrance, et al., 1986). Evidential reasoning refers to the notion of reasoning with evidence and this approach has been used for developing models for audit risk, fraud risk, and information security risk (Srivastava, 2010). ER paves the way for utilising any new information that is relevant to phenomenon to be incorporated so that a more probable assessment can be made. This is crucial in assessment of risk as risk is measured using probability theories. Gao et al. (2011) relied upon evidential reasoning for developing a frameowrk connecting risk assessment, audit planning, and evaluation of audit results by integrating fraud scheemes and incorporating prior fraud frequemncy information. Loebbecke et al. (1989) developed a fraud risk analysis model under bayesian framework using evidential reasoning approach. It is important to derive at a fraud risk formula for ustilising evidential reaosning approach for asssessment of risk (Srivastava, et al., 2009).

### 2.6.3 Bayesian Statistics and Risk Assessment

It has been commented that Bayesian networks is an emerging tool which is being relied upon for a range of risk management applications (Cowell, et al., 2007). Bayesian probability is based on the theorem, put forward by Bayes, which allows posterior probability to be calculated. The key aspect of Bayesian process of statistical estimation is that it continuously revises and refines the subjective beliefs about the state of a phenomenon as more data become available (Alexander, 2000). This flexibility in terms of data availability and its timing is why the theorem has been widely used in many real-world operational, financial and business analysis of risks. Bayesian statistics is being used to assess risks in business cases such as operational risk assessment (Barua, et al., 2016) and supply chain risk assessment

(Qazi, et al., 2017), to diverse cases such as industrial and production engineering risk assessment (Kwag, et al., 2018) to portfolio management applications (Kolm & Ritter, 2017). Such diverse uses, especially in the risk management field, not only validates the robustness of the framework but also the potential suitability of the framework in assessing internal fraud risk, the case for which is developed in the following section.

### 2.6.4 Bayesian Theorem in Measuring Internal Fraud Risk

Bayesian methods have been widely relied upon in measuring operational risks (Alexander, 2000). Bayesian framework has also been used in fraud risk measurement. Bayesian formula has been utilised in conducting financial statement audits for measuring fraud risk by accounting professionals and researchers (Srivastava, et al., 2009). Propagation of probabilities in a network of variables through local computation, known as belief networks, are now being applied in information filtering and pattern recognition. Bayesian Belief Networks, besides Decision Trees and Neural Networks, have been relied upon for managing fraud detection using data mining techniques (Kirkos, et al., 2007). Demster-Shafer theory of belief function has also been applied in conjunction with fraud triangle theory to assess internal fraud risks of businesses, modelled in a way to be used by external auditors (Gao, et al., 2011). Dempster-Shafer theory is a generalised version of probability theory which allows evidence to be associated with multiple possible events as opposed to only one possible event (Yager & Liu, 2008). Dempster-Shafer model collapses to traditional probabilistic formulation where the evidence is sufficient to permit assignment of probabilities to single events and application of traditional probabilistic formulation to subjective or epistemic uncertainty is referred to as Bayesian probability (Sentz & Ferson, 2002).

The method developed in this thesis uses the basic premise of Bayesian theorem and a one-dimensional evidential model, in contrast to the three-dimensional model found in fraud triangle framework (Figure 2.1), which is namely the dimension of opportunity risk arising out of deviant processes. A similar framework connecting Baye's theorem and fraud triangle can be found in the paper by Srivastava, et al. (2009, p. 73), where the unidimensional simple form of Baye's theorem is extended to fit the three-dimensional (in terms of sources of 'evidence') fraud triangle. However, as the model for this paper is solely focused on

process deviation as a form of preliminary indication for fraud, the basic unidimensional Bayesian theorem's functional form serves the purpose of this study.

## 2.7 Summary

This chapter encapsulates key literature that is relevant for conducting the research. The focus of this research is on fraud within organisational settings and as such this chapter contains key aspects that is available in the existing literature related to organisational fraud. A number of fraud theories have been discussed along with description of various types of frauds, especially internal fraud, which take place within organisational setting. This is a research in the field of IS and as such a wide body of literature that focuses on the role of IS in tackling internal fraud has been considered. In subsequent sections, literature relevant to business process and fraud risk measurement methods have been discussed as the aim of the research is to measure internal fraud risk within business processes of organisations. Then a wide body of literature available on process mining has been analysed with a view to dealing with the phenomenon of internal fraud using a IT tool i.e. process mining. Finally, role of probabilities has been considered with specific focus on Bayesian theorem in order to develop a method where process mining can be utilised for measuring internal fraud risk with greater effectiveness and reliability.

# 3.0 Research Methodology

## 3.1 Overview

This Chapter explains the research approach used in investigating how best business modeling and process mining techniques and tools are used in various strategies and goals to measure the internal fraud risk of an ERP system. Section 3.2 contains a detailed discusses on various philosophical perspectives in information system research. A range of research paradigms which are relevant for conducting IS research have been highlighted. Then it highlights variety of research approaches that can be employed in information systems. It involves a thorough explanation of the approaches used in creating and testing the internal fraud measurement framework. Section 3.3 focuses on a range of methods which are relied upon for conducting research: Quantitative, Qualitative, and Mixed methods. The chosen method for this research is a mixed method approach and the underlying reasons for embracing that approach have been stated in great details. In Section 3.4, a number of relevant research strategies are considered with detailed discussion: Case Studies, Surveys, and Experiment. A detailed discussion of case study strategy can be found in the Section 3.5. The key choice between single case study and multiple case studies has been made after having considered a range of relevant factors. The underlying reasons for selecting the cases also have been analysed. Then Design Science Research Method (DSRM), which plays a key role in setting the outline of this research as the chosen research paradigm, is discussed and applied in Section 3.6. The artefacts which can be produced as a result of DSR research are described and the artefact which this research aims to produce has been discussed elaborately. Section 3.7 is titled “Research Design” which includes detailed description of the design for conducting this research. It has been showed how appropriate methods were selected based on careful analysis for achieving the aim of this research. In Section 3.8 data collection techniques are discussed in great details. Subsequently, data analysis techniques have been considered in Section 3.9. The final section, which is Section 3.10, is about pilot study where the significance for conducting a pilot study has been discussed besides a detailed evaluation of the pilot study conducted with respect to this research. An outline of the research methodology has been presented

here diagrammatically, in Figure 3.1, which shows how logical analysis of each step discussed in this chapter led to the selection of subsequent methods and techniques.

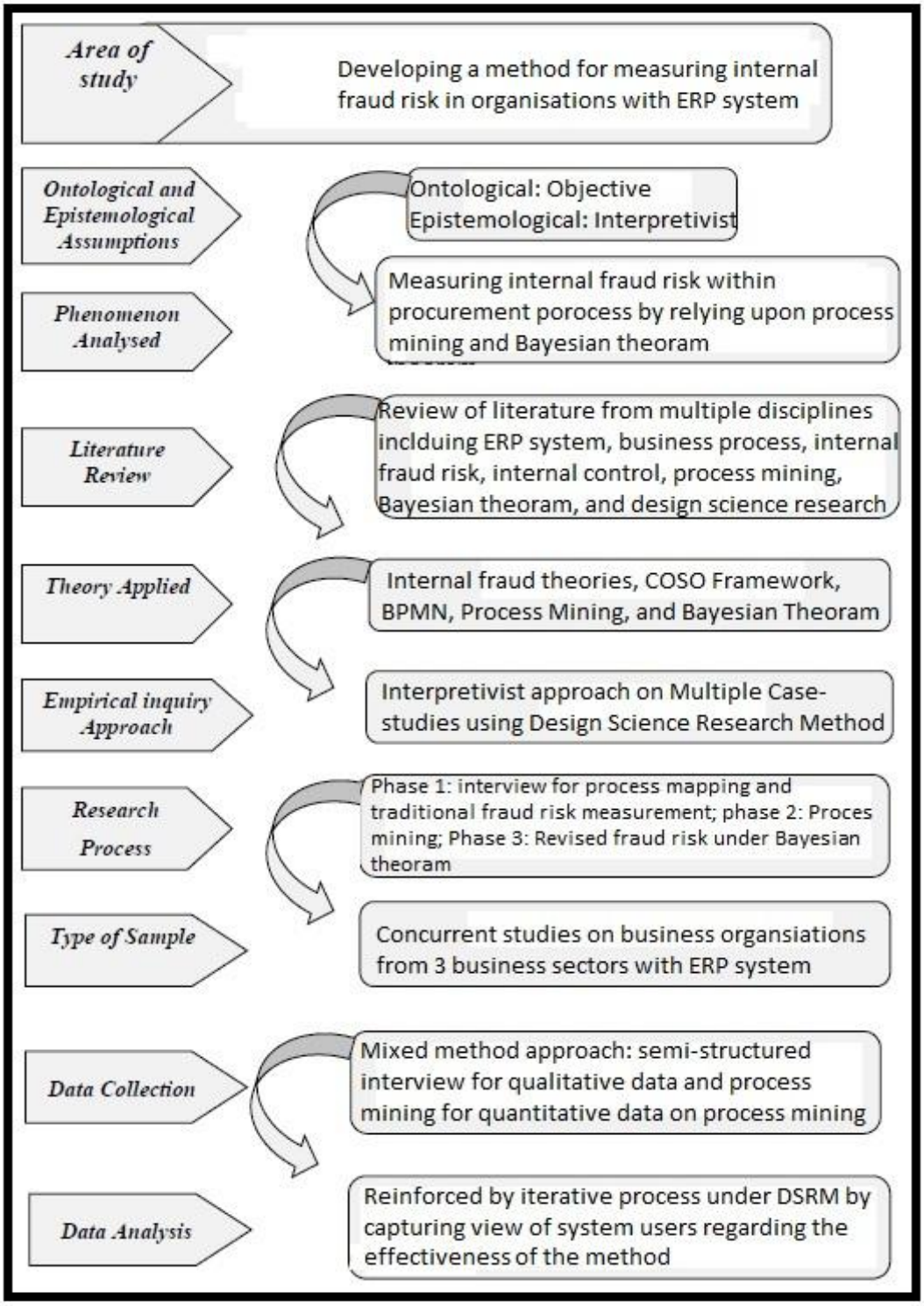


Figure 3.1: Outline of research methodology

## 3.2 Philosophical Perspectives

The philosophical aspects related to conducting empirical research have been considered in this section. It is of great importance to comprehend a range of philosophical issues relevant for conducting research and to have a defined standing with respect to the research paradigm and the research approach which are being embraced for the purpose of conducting this research. The first part defines the ontological, epistemological, and methodological standpoint of the research. Then four most relevant research paradigms have been discussed in detail along with justification for choosing design science research paradigm for conducting this research. Finally, different types of research approaches have been carefully considered with specific attention to research approach which are suitable for conducting IS research.

### 3.2.1 Research Philosophy

One of the most difficult aspects associated with conducting a research is answering the philosophical questions that a researcher is expected to answer. It is argued that research philosophies are incoherently classified into ontology, epistemology, axiology, and doxology and qualitative-quantitative dichotomy debates (Mkansi & Acheampong, 2012). Different studies have used different categorisation and classification of research philosophies and paradigms (Saunders, et al., 2009)(Ritchie & Lewis, 2003). According to Filstead (1979) a paradigm can be defined as "*set of interrelated assumptions about the social world which provides a philosophical and conceptual framework for the organized study of that world*". The paradigm certainly leads the researcher in philosophical assumptions about the research and in the selection of tools, techniques, contributors, and methods used in the study (Joseph G. Ponterotto, 2005). Guba and Lincoln (1994) suggested three questions which are vital is defining research philosophies and research paradigms as they reproduce the underlying beliefs of researchers:

1. Ontology: is the nature of realism that is addressed.

2. Epistemology: is the dualist nature of valid or true knowledge.

3. Methodology: is the best procedure or set of guidelines which helps in producing the desired knowledge and understanding in valid and reliable method.

These three philosophical aspects are discussed in greater detail in the following sections both from theoretical and the researcher's perspectives.

#### *3.2.1.1 Ontology*

The world view of an individual has three main aspects which guide his or her action – ontology, epistemology, and methodology (Denzin & Lincoln, 2011). Ontology refers to the philosophical stand point of a human agent whether or not social and physical worlds can be observed objectively which is free from subjectivity of the human agent. Philosophical ontology, which is referred to as science of what is, is concerned about the classification of entities (Smith & Welty, 2001). It has been commented that computer scientists and philosophers do not have consensus in their communities for creating ontologies which are required although they have necessary formal languages to achieve that (Niles & Pease, 2001). The ontological view of the researcher has implications upon aspects such as what the subject matter is that is being studied. The ontological standpoint that has been embraced for the purpose of this research is that a phenomenon can be understood and dealt with objectively. Such standpoint has implications on the reliability and general applicability of the findings of this research.

#### *3.2.1.2 Epistemology*

The aim of this research is to develop an artefact that involves comprehension of a social phenomenon and the role of machines in dealing with that phenomenon. An interpretive research has been adopted for the purpose of the research as access to reality is assumed to be possible through social constructions such as consciousness and language (Avison & Pries-Heje, 2005). Human perception of a phenomenon and the role of any artefact in dealing with that phenomenon remain the focus of an interpretive study and thus dependant and independent variables do not require being predefined (Kaplan & Maxwell, 2005). The aim of this research is to comprehend the context in which IS is being utilised and the process whereby information systems influences and is influenced by the context and thus the interpretive philosophical standpoint can be argued to be appropriate (Walsham, 1993). It is commented that interpretive researches are suitable for comprehending how information systems and human thoughts interact with a view to improving the role of information systems in dealing with phenomena faced in organisations

(Klein & Myers, 1999). A range of methodologies have been developed for conducting interpretive researches over time which are discussed in the following section.

#### *3.2.1.3 Methodology*

Research methodology includes a report on the actions performed in a research. It typically incorporates such elements as stages, activities, methods and instruments. It is of crucial importance to select an appropriate methodology for conducting a research. Methodologies are broadly classified into two categories in social research: qualitative research methodology and quantitative research methodology. The key distinction is that qualitative research methodology emphasises on comprehending the factors behind any social phenomenon whereas quantitative research methodology focuses on understanding a phenomenon objectively (Chen & Hirschheim, 2004). Qualitative research methodology adopts a subjective approach and aims to discover and understand issues holistically by taking perceptions, attitudes, onions, insights, and processes into consideration (Marshall & Rossman, 1995). Quantitative research methodology adopts an objective approach and aims to extract information by gathering data through experiments and surveys (Klein & Myers, 2001).

IS is an area consisting of multiple disciplines, such as IT, mathematics, engineering, management and many others (Baskerville & Mayers, 2002). Therefore, a single standard methodology cannot fully embrace the scope of information systems research. Instead, one can choose from a wide range of research approaches, models and methodologies. There is no such a single approach is applicable in all cases, but a variety of research paradigms, techniques methods and approaches can be used in different situation. Researches based on several paradigms are gaining increasingly more prominence in information systems (Mingers, 2001). Some researchers struggle to choose the right research approach due to having diversity of research background and variety of approaches. The discipline of information system has to be uniform; otherwise the IS disciplinary will be split (Benbasat & and Weber, 1996), on the other hand Robey (1996) argued that such diversity in IS research is a positive source of strength and inspires creativities.

There is no defining answer whether research paradigms, approaches and methods are completely unique or could be mixed with some other situations. There are lots of options to use various research methods in IS research community. There is still enough room for

combining the methods to enhance the IS research value (Mingers, 2001). In the next section, the research paradigms in Information Systems are explained to guide the selection of which paradigm is suitable to lead the development of an internal fraud risk measurement of an ERP system. The following section also guides the underlying principle for the chosen paradigm.

### 3.2.2 Research Paradigms

According to Robey (1996) research approaches vary in their suitability according to the research questions, the hidden way of marvel under scrutiny, and the fundamental philosophical position of researchers. The main paradigms which are regarded as being fundamentally opposed are those of positivism and interpretivism (Creswell & Plano Clark, 2007). It is important to integrate quantitative and qualitative research strategies in mixed methods research and as such pragmatism, which is commented as an alternative research paradigm, is of great relevance for any research where mixed methods are being relied upon (Miller, 2006). In information system research, traditionally three major paradigms are distinguished, they are positivist, interpretive and critical (Joseph G. Ponterotto, 2005). So, the selection of the right approach is a vital task during the process of research design whether the researcher follows one or more perspectives. To reduce the confusion towards a particular approach, researchers must understand the whole range of research paradigms, techniques and approaches in a significant manner. This sort of understanding helps the researcher to be open to the option of other assumptions which might fit their interests and doubts (Orlikowski & and Baroudi, 1991). It is of great importance to choose the appropriate research paradigms while conducting research in the field of information systems (Walsham, 1995). The paradigms can be summarised as follows:

#### *3.2.2.1 Positivist Paradigm*

Positivist (Positivism) paradigm involves the scientific technique of systematic observation and description of phenomena contextualized within a model or theory, the representation of hypotheses, the execution of controlled experimental study, the use of inferential statistics to test hypotheses, and, finally, the interpretation of the statistical results in light of the original theory (Cacioppo, et al., 2004). Positivism challenges the traditional notion of absolute truth of knowledge (Phillips & Burbules, 2000). According to Joseph (2005) the main objective of positivistic paradigm is an explanation that eventually leads to prediction

and control of occurrences. Positivists mostly conduct quantitative research as they try to learn about the things which warrant for knowledge. It has been observed by a range of scholars, like Marx, Adorno, Babermas, and Freire, that assumptions made by positivists impose structural theories which fail to fit marginalised groups (Neuman, 2014). A positivist approach is appropriate in a IS research if there is evidence of formal propositions and quantifiable measures for associated variables and inferences can be drawn regarding a phenomenon from a representative sample population (Orlikowski & and Baroudi, 1991).

#### *3.2.2.2 Interpretivist Paradigm*

Interpretive (Constructivism) paradigm can be acknowledged as a substitute to the "received view" or positivist paradigm (Joseph G. Ponterotto, 2005). In marked contrast to positivism's simple realism (a single objective external reality), constructivism follows to a relativist position that assumes multiple, apprehend able, and equally valid realisms (Joseph G. Ponterotto, 2005). The dependent or independent variables are not predefined in interpretive research rather the focus remains on the complexity associated with comprehending situations as they arise from a human perspective (Kaplan & Maxwell, 2005). It has been stated that interpretive approach is taken when the aim is to understand why and how individuals interact in a social environment (Orlikowski & and Baroudi, 1991). Walsham (1993) argued that the goal of interpretive research is "*understanding of context of the information system and the process whereby the information system influences and is influenced by the context*" (Walsham, 1993). It has been opined that interpretive research is capable of assisting IS researchers to comprehend human thoughts and actions in organisational contexts which can eventually give insights into information systems phenomena (Klein & Myers, 2001).

The aim of this research is to develop a method which will allow IT to be utilised in a manner that can allow human agents a better understanding of the breaches of internal control system which are taking place within an organisation. This demands a deeper understanding of a range of associated phenomena, such as business processes, internal control system, use of ERP system, and process mining, within an organisational context. It can therefore be argued that the objectives of the research can be achieved by embracing an interpretive paradigm as interpretive studies are capable of offering deeper understanding of such phenomena (Klein & Myers, 2001). The choice of research paradigm can be claimed to be

justified if the nature of the problems associated with measuring risk of fraud. It is hard to define fraud as deviation from stipulated business processes within an organisational context cannot be identified as fraudulent. The research demands reliance upon information technology for dealing with social problems and as such interpretive research paradigm appears to be more suitable as it attempts to link between social processes with information technology.

#### *3.2.2.3 Critical Paradigm*

Critical paradigm emphasises on the practical values of the researcher which are principal to the task, purpose, and methods of research (Joseph G. Ponterotto, 2005). This Type of research predicts that "*Social reality is historically constituted and that is produced and re produced by people*" (Avison & Pries-Heje, 2005, p. 244). Critical paradigm is regarded to be appropriate where the main aim of the researcher is to critically evaluate social context with a view to enhancing the opportunities for human potential. A researcher often embraces a critical paradigm when the objective is to expose the structural contradictions prevalent in social system where underlying philosophical view is that a phenomenon, often a social one, can only be comprehended historically. Critical paradigm would be appropriate for this research had the key objective been to critically evaluate the role of IS or an artefact of IS in organisations. During the recent years a fourth paradigm called design science starts to appear and be recognised in information system research targeting to expand the significance of the IS discipline. The summery of the design science paradigm is discussed in the next section.

#### *3.2.2.4 Pragmatic Paradigm*

#### *3.2.2.5 Summary of IS Research Paradigms*

There are several research paradigms that are embraced by researchers in IS. It is of crucial importance to select an appropriate research paradigm considering the nature of the research problem. Vaishnavi & Kuechler (2004) have contributed greatly by consolidating and accumulating ideas with respect to research paradigms that are prevalent in IS. A summary of the research paradigms within the information system is developed which is presented in Table 3.1 below:

| Basic Beliefs | Research paradigm | | | |
|---|---|---|---|---|
| | **Positivist** | **Interpretive** | **Critical** | **Pragmatic** |
| **Ontology** | **A single reality knowledge; probabilistic** | **Multiple realities; socially constructed** | **Reality is historically constituted** | **Singular and multiple realities that are open to empirical inquiry; existential reality; multiple contextually situated alternative worldview;** |
| **Epistemology** | **Objective; dispassionate; detached observer of truth** | **Subjective i.e. values and knowledge emerge from the researcher participant interaction** | **Reality is shaped by its social context; knowledge is grounded in social and historical practices; facts and values are entwined.** | **Objective; knowing through making; constrained construction within a context;** |
| **Methodology** | **Observation; quantitative; statistical** | **Participation; qualitative; hermeneutical; dialectical** | **Assumptions, beliefs, and values shape and shaped by the investigation.** | **Independence of method and underlying theory; Mixed methods;** |

Table 3.1: Research Paradigms in IS

In order to find the difference amongst the research paradigms in information systems and the type of the research question tackled in this research, the pragmatic research paradigm is considered to be fitted. The aim of the research is to develop a method that can effectively measure internal fraud risk by relying upon process mining and Bayesian theorem. This issue is highly relevant to the ERP systems employed in organisations and ERP consultant companies as their current practices concerning internal fraud or error does not seem to be adequately effective. This research develops a method in the form of ontological framework to change this field into more valuable one. The method followed in this research, along with the approaches and techniques are fully discussed in the following sections.

### 3.2.3 Types of Research Approaches

#### *3.2.3.1 Deductive Research*

Deductive approach refers to the development of a theory by subjecting it to a rigorous test (Saunders, et al., 2009). This type of research approach is prevalent in various branches of natural science where hypothesis, in the form of theorems and laws, have to be proved by way of observation or repetitive experiments. Deductive approach is argued to be a set of techniques which applies, tests, or assesses the validity of a hypothesis (Crowther & Lancaster, 2008). The deductive research approach is embraced when the key objective is to test a hypothesis by confirming its validity (Krishnaswamy, et al., 2009). Deductive research involves several phases including selection of theory related research question, formulation of hypothesis, collection of empirical data, analysis of data, confirmation or rejection of hypothesis, and revision of theory (Figure 3.2).

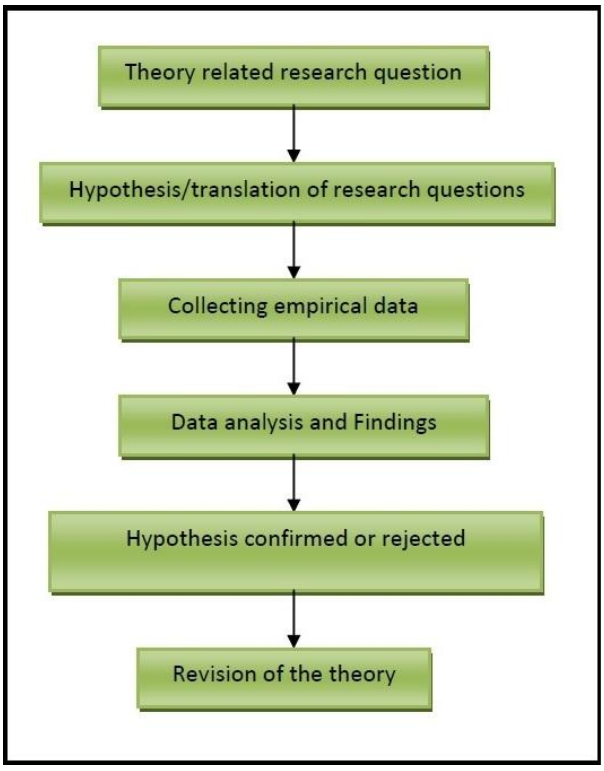


Figure 3.2: Deductive research approach (Bryman & Bell, 2007)

#### *3.2.3.2 Inductive Research*

Inductive approach refers to idea of developing theories based on available data (Crowther & Lancaster, 2008). It is appropriate where theories and methods are developed based on

observed phenomena. Inductive theory is in contrast with deductive method. Inductive research is suitable where the researcher aims to come up with a proposition for explaining why certain phenomenon occurring whereas deductive approach is more suitable where the researcher aims to identify what is happening (Easterby-Smith, et al., 2008). It has been commented that inductive research approach is taken when the objective of the research is to formulate generalised propositions that can be applied in similar problem areas (Dane, 2010). There must be adequate grounded data available for choosing inductive approach in conducting a research (Saunders, et al., 2009). Inductive research involves several steps such as formulation of research question, collection of data, analysis of data, and formulation of theoretical statement (Figure 3.3).

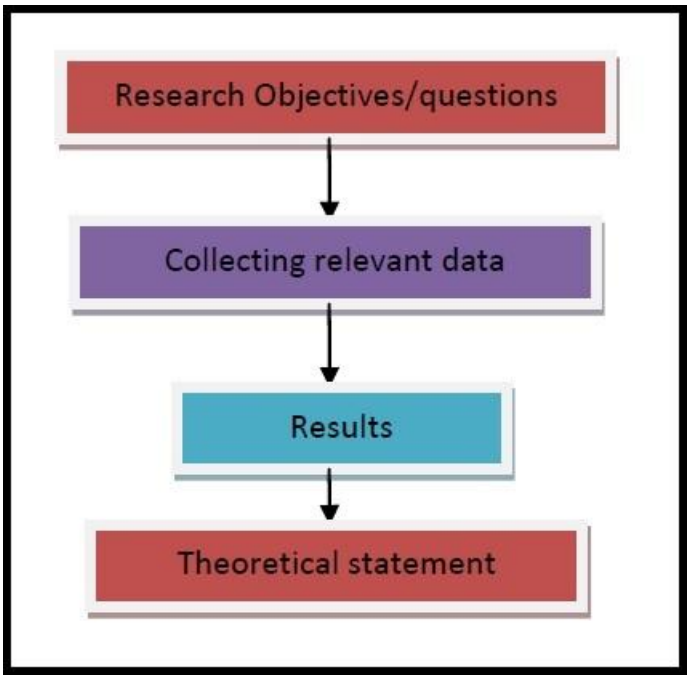


Figure 3.3: Inductive research approach (Bryman & Bell, 2007)

#### *3.2.3.3 Research Approaches in Information Systems*

Information Systems (IS) research has been stated to be a multi-disciplinary social research filed that is related to Information technology (Land, 1992). It should be taken into consideration that IS research not only involves information technology but also touches upon natural sciences, behavioural sciences, and linguistics. It has therefore been commented that it is difficult to identify a single framework that adequately encompasses all the domains of knowledge for the study of Information Systems (Galliers, 1991). Information Systems researches often involve dealing with a phenomenon that is related to

a wide range of philosophical assumptions and is not rooted to a single theoretical perspective. Therefore, it is important to carefully choose relevant research approach from a plethora of research approaches and research strategies.

## 3.3 Types of Research Methods

Much confusion is encountered with the terms 'methodology' and 'methods.' As Mingers (2001) suggests, there are 3 meanings of the term 'methodology'. The first and the broadest definition mean the study of methods. The second definition provides a more specific meaning, which is a description of the methods used in a specific research. The third definition generalises this concept more and includes all the norms and guidelines that can be used in a certain sphere of research. For the purpose of this paper, the second definition is adopted, and the notion of methodology means the ways of conducting the research, which comprises several methods (Mingers, 2001). The purpose of methods is to perform tasks within different processes that compose a methodological framework. Mingers (2001) describes methods as clear series of tasks that if performed effectively produce predictable outcomes. However, this research aims at combining various research methods to increase its significance and relevance. Different types of research methods are discussed in detail in this section.

### 3.3.1 Quantitative Research

Quantitative research has been defined as a "*means for testing objective theories by examining the relationship among variables, which, in turn, can be measured, typically on instruments, so that numbered data can be analyzed using statistical procedures*" (Creswell, et al., 2009). Researchers who embrace quantitative method often have to make assumptions about testing hypotheses deductively. Hence, quantitative research method is often associated with positivist research paradigm. Quantitative method is suitable for researches which aim to do comparison, to determine reliability or validity, or to analyse objectively. This research aims to develop a method that can be applied in organisational context in a reliable manner and as such it is appropriate to rely on quantitative method, at least to some extent, for the purpose of this research.

### 3.3.2 Qualitative Research

It is stated that qualitative research is influenced by the philosophical stand point of the researcher whereas quantitative research attempts to report the reality objectively (Silverman, 2000). The degree of uncertainty associated with the research area, epistemological issues of the researcher, and the nature of the phenomenon that is being

investigated are the three main factors that may lead to a qualitative method is being adopted (Trauth, 2001). Data are gathered primarily by way of interviewing participants in qualitative studies. It has been commented that a qualitative method is appropriate where the research objective requires a social phenomenon to be considered. This research requires the phenomena of internal fraud and business process to be comprehended and as such qualitative method is relevant for this research at least to some extent.

### 3.3.3 Mixed-method Research

Mixed method research refers to the mixing of more than one prominent method and generally it is relied upon to refer to the use of combination of qualitative and quantitative methods. It has been stated that mixed method is the third major contemporary research method. There are numerous definitions of mixed-method research but all the definitions emphasise on the use of more than one approach, more than one way of collecting the data, or more than one way data analysis (Johnson, et al., 2007). One of the comprehensive definitions of mixed-method defines it as a "*research in which the investigator collects and analyses data, integrates the findings, and draws inferences using both qualitative and quantitative approaches and methods in a single study or program of inquiry*" (Teddlie & Tashakkori, 2006). Mixed method is often adopted by researchers when the research question cannot be answered adhering to one paradigm (Leech & Onwuegbuzie, 2009). There has been a sharp rise in mixed-method research.

It has been commented that there are two significant reasons for adopting a mixed method instead of relying upon exclusively on a qualitative or a quantitative method (Kelle, 2006). First argument is that a researcher can enhance the validity of both the methodology and findings of the research by combining more than one method and this is often regarded as a good scientific approach in the research community. The second argument is that a researcher can obtain a deeper understanding of the phenomenon being looked at as mixing methods will allow the findings to be cross validated where the findings under the multiple methods complement each other. Mixed method has been argued to be of even greater significance in Information System as it focuses on concepts with attributes and meanings (Kaplan & Cincinnati, 1988). It has been asserted that mixed method should not be perceived simply as the process of mixing methods as reliance upon mixed-method

involves philosophical assumptions in order for ensuring validity of the methodology and findings (Irani & Love, 2008).

## 3.4 Types of Research Strategies

A detailed discussion of various types of research strategies has been included in this section. Among many other, survey, experiment, and case study, are major strategies for conducting IS research. Each of these strategies have been considered carefully and key attributes of each of these strategies have been presented in a table at the end of the section. Justification for choosing case study as the research strategy for conducting this research has also been included.

### 3.4.1 Surveys

Surveys are employed for obtaining data via questionnaire from a large population for the purpose of research. Surveys are predominantly conducted by distributing questionnaire among sample population and then collecting data from the recorded responses of the participants. Surveys are primarily employed for collecting quantitative data (Klein & Myers, 2001). Rarely, interviews are also employed to collect survey data. It has been commented that conducting survey is the most cost-effective way for obtaining data from a large number of participants who are situated across the globe. However, quantitative data collected by surveying a large sample population is not appropriate for the purpose of this research as this research aims to develop a method that can applied in organisational context.

### 3.4.2 Experiment

Experiments are widely relied upon for conducting empirical studies where quantitative data is gathered for establishing existence of a causal relationship (Klein & Myers, 1999). Experiments are conducted in scientific research as well as in social science research. Experiments are usually conducted for finding out reality about the physical world. Experiments are suitable if the research aims at figuring out physical properties of materials or performance of gadgets. This research aims to address a social issue within commercial settings by using information technology. It can therefore be said that an experimental research may not be appropriate for this research.

### 3.4.3 Case Studies

Case study is one of the widely relied upon methods in information systems research. Yins defined case study as *"an empirical inquiry that investigates a contemporary phenomenon*

*within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident*" (Yin, 2009). Soy described case study, emphasising on the qualitative nature of case studies, as a way for conducting detailed contextual analysis of a limited number of events and their inter-relationships in a qualitative way (Alnaim, 2015). However, case study is regarded as an appropriate research strategy not only for qualitative approaches but also for quantitative or mixed method approaches (Stake, 2005). It has been opined that case study research method is appropriate for empirically enquiring a contemporary phenomenon within real-life context where boundaries between phenomenon and context are blurred and multiple sources of evidence are taken into consideration (Yin, 2009).

Case studies are usually conducted by utilising questionnaires, interviews, or systematic observations which involve intense examination of a small number of entities where neither the independent variables are manipulated nor the confounding variables are controlled (Boudreau, et al., 2001). A summary of all three research approaches have been presented in Table 3.2 below:

| | **Survey** | **Case Study** | **Experiment** |
|---|---|---|---|
| **Scope of study** | Naturally occurring case selected to maximise sample's representativeness | Naturally occurring case where the aim is not to control variables | Cases where aim is to control important variables |
| **Data quantification** | A priority | Not a Priority | A priority |
| **Aim** | Generalisation | Comprehending relationships and processes | Looking at causation |
| **Number of cases** | Large number of cases | Single or small number of cases | Relatively large number of cases |
| **Number of methods** | Single method | Single method | Multiple methods and sources of Data |

Table 3.2: Overview of various research strategies (Thomas, 2011)

This research aspires to develop a method which can enhance the reliability of artefacts of information systems that addresses problems faced by human agents at organisational level based on empirical findings. It can therefore be argued that case study is an appropriate method for conducting the research. A case study can be of different types depending on what nature of the case that is being studied: critical case, unique case, revelatory case, representative case, and longitudinal case (Bryman & Bell, 2007). The proposed research will involve considering representative cases as the objective is to test a method. Case study as a research strategy has been discussed in greater detail in the following section.

## 3.5 Case Studies

This sections included a detailed discussion on two different types of case studies – single case study and multiple case studies. These two types of case studies have been compared from data analysis, resource, and methodological perspectives. The comparisons have been presented in a table along with a justification for choosing multiple case studies strategy. The latter part contains a detailed discussion of criteria for selecting cases. The selected criteria which would be the basis for choosing business organisations for conducting case studies have been critically analysed.

### 3.5.1 Single vs Multiple Case Studies

One of the most important decisions that has to be made with respect to case study methodology is whether to conduct a single case study or a multiple case study. This debate is prevalent among academics and researchers. It has been commented that case study research should not be confined to single case study (Yin, 2009). The external validity, which refers to extensibility of the findings, can be enhanced by conducting a multiple case studies in the field of information systems (Bandara, et al., 2005). Various factors related to the research are considered below in Table 3.3 for both single case study and multiple case studies.

| | **Single Case Study** | **Multiple Case study** |
|---|---|---|
| **Data Analysis** | - Single case designs are vulnerable<br><br>- The results may be viewed with scepticism | - Will be more powerful, substantial and stronger in effect, because of contrasting (comparable) situations<br><br>- Cases represent generalised theoretical propositions and not limited to samples |
| **Flexibility** | - Case study design should be modifiable by new information or discovery during data collection | - Case study design should be modifiable by new information or discovery during data collection |
| | - Extensive resources not required | - Require extensive resources |

| | | |
|---|---|---|
| **Resources** | - Single experiment | - Findings considered more compelling and the overall study is therefore more robust |
| **Replication** | - Replication is not possible | - Each case must be chosen carefully.<br>- Multiple case study design should follow replication, not sampling logic |
| **Methodology** | - Single Case study is not sufficient to answer when, how and why questions | - Multiple case study is sufficient to answer when, how and why questions |
| **Holistic** | - The holistic design is advantageous when no logical subunits can be identified<br>- When the relevant theory underlying the case-study is itself of a holistic nature | - Each individual case may consist of multiple holistic cases or multiple embedded cases<br>- The difference between these two depends upon the type of phenomenon being studied and the research questions<br>- Conducting multiple case studies cannot be taken lightly |
| **Embedded** | - The case study focuses on the submit level and fails to return to the larger amount of analysis | - In embedded design, a study may call for the conduct of a survey at each case study site |

Table 3.3: Comparison between single case study and multiple case studies (Yin, 2009)

The research aims to develop a method that can be practically adopted by organisations and multiple case studies will allow the general applicability of the method across organisations to be tested. Conducting multiple case studies will demand extensive resources but this approach will allow to gain insight into the data that will be collected. This research aspires to develop a method and as such it is important to be able to answer when, how and why questions which would only be possible if multiple case studies are conducted.

### 3.5.2 Criteria for Selecting Cases

The selection of cases is dependent upon the nature of the research topic (Benbasat, et al., 1987). The aim of this research is to develop a method which allows organisations with ERP system in place to measure risk of internal fraud within the system effectively by relying upon process mining. The aim of this research thus requires this real-life problem of internal fraud to be comprehended at organisational level. It has transpired during the review of existing literature that business organisations have several processes, including procurement process, human resource management process, service delivery process, and operational process, which can differ significantly from each other. The degree to which any specific business process is susceptible to internal fraud also varies. The chosen business process for the purpose of conducting tis research is procurement. Therefore, one of the main criteria for selecting cases was the role of procurement within the organisations.

The difficulties associated with obtaining access to data from relevant organisations have been acknowledged and therefore it is emphasised that cases should be selected by having regards to both theoretical and practical aspects (Crompton & Jones, 1988). Research access has shrunk as the value of project work has been realised by academics which led to increase in case study-based research activities and the willingness of corporate managers to devote time for non-productive activities has declined due to harsh economic realities (Buchanan, et al., 1988). Therefore, the ease of access to organisational data has been the most important criterion for selecting cases. All the cases selected for the purpose of this research are based in Bangladesh. There are several reasons for selecting Bangladesh as the domicile for case study organisations. First of all, corruption and poor governance are prevalent in Bangladeshi organisations especially in procurement function (Mahmood, 2010). Secondly, the large business organisations in Bangladesh are implementing ERP system and as such the systems are more likely to be vulnerable to internal fraud paving way for the opportunity for testing the validity and reliability of the proposed model (Alam, 2016). Lastly, the researcher is a native Bengali speaker which is advantageous for data collection purposes.

A number of organisations was identified which are operating in Bangladesh and had an ERP system in place. Bangladesh is a developing country with an emerging economy and as such the number of business organisations with sophisticated supply chain management in place

is limited. Seven identified companies were contacted and requested to take part in this research from both manufacturing and service sectors. There were one ready-made garments (RMG) manufacturing company, one pharmaceutical company, and one commercial airlines company who agreed to take part in the research. There are few differences between manufacturing and service organisations, such as customer specific production, and need for physical production location, which impacts upon the procurement process (Linton, 2015). The three cases selected were suitable for enhancing the credibility of the research as there were organisations from both manufacturing and service sector. The organisations selected for the purpose of this research agreed to take part in the research on the conditions of strict confidentiality and anonymity.

## 3.6 Design Science Research Method (DSRM)

A detailed discussion on Design Science Research Method (DSRM) has been included in this section. DSRM has been chosen as the research method for the purpose of this research and hence it is of great importance to understand various aspects related to this research method. DSRM has been considered from a definitional perspective at the beginning of this section. Then the role and suitability of DSRM in conducting IS research has been analysed in great detail and its key features have been summarised in a table. The artefacts that can result in from a DSRM research have then been discussed carefully. How a new method will be developed as an artefact in this research using DSRM has been highlighted. Finally, each phase involved in conducting DSRM research has been discussed in detail in light of the proposed research.

### 3.6.1 Design Science Research Method

The DSR is based on the ideas of Simons (1996) of a product created by humans, or an artefact. Design process as the creation of items that help people fulfill certain purposes (March & Smith, 1995). DSR aids in creating and assessing artefacts that are used for business purposes. Its main focus lies on creating and assessing IT artefacts that serve specific purposes, and are characterized as innovative and original (Henver, et al., 2004). To "serve specific purposes" means that the created artefacts should have 'usefulness' that facilitates existing practices in solving specific problems or offers new solutions that are more effective (Vaishnavi & Kuechler, 2004). The design science of DSR differs from other approaches by its focus on creating purposeful artefacts. The main distinction of DSR is that it intends to create, capture and communicate the knowledge obtained during the design procedures (Vaishnavi & Kuechler, 2004). DSR can be also described by the iterative restoration of artefacts, basing on the assumption that knowledge is extracted during the iterations (Vaishnavi & Kuechler, 2004). One may compare the DSR to the process of learning, in which comprehension and knowledge is improved with each new iteration. Such process is effective in enhancing the quality of artefacts.

### 3.6.2 Design Science in Information Systems

It has been commented that knowledge and comprehension of design problems and their solutions are acquired in the building and application of an artefact within the information systems (Henver, et al., 2004). Henver et al. (2004) developed seven-point guidelines which

are the design science principles for Information Systems (IS). These guidelines are useful for any research within the realm of information systems where design science methods are embraced. These guidelines are summarised below in Table 3.4:

| Key Guidelines | Description |
|---|---|
| Design as an Artefact | A viable artefact in the form of a construct, a model, a method or an instantiation. |
| Problem Relevance | Develop technology-based solutions to important and relevant business problems. |
| Design Evaluation | The evaluation methods proposed can be broken down into the following groups:<br>a. Observational – via case studies (in business environments) or field studies (monitoring the use of the artefacts in multiple projects).<br>b. Analytical – examining the artefact for static qualities such as complexity, fit of artefact in technical architecture, demonstrated optimal properties of artefact, or its performance (dynamic qualities).<br>c. Experimental – either in a controlled experiment (for example: usability) or in a simulation where one can run the artefact with artificial data.<br>d. Testing – Black Box (test interfaces to artefact) or White Box testing (using metrics such as execution paths in artefacts implementation).<br>e. Descriptive – use of information from knowledge base to build argument for artefact's utility or in the form of scenarios. |
| Research Contributions | a. Design Artefact – the ability to reuse the artefact itself to solve other unsolved problems.<br>b. Foundations – to create new constructs, models, methods etc. to extend or improve existing foundations.<br>c. Methodologies – to produce new ways to evaluate and create new contributions to design science. An example is a framework for predicting and explaining why a particular information system will or will not be accepted in a given organisational setting. |
| Research Rigour | Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artefact. |
| Design as a | The search for an effective artefact requires utilising available means to reach |

| | |
|---|---|
| Search Process | desired ends while satisfying laws in the problem environment |
| Communication of Research | Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences. |

Table 3.4: Design Science Principles for Information Systems (Henver, et al., 2004)

It can be observed from the guidelines that the key objective in a design science method is to develop an artefact, which can be a construct, model, or instantiation, which must lead to a technology-based solution to a problem in organisational or business context. It has also been stated that there must be rigorous design evaluation including observations, experiments, testing, descriptive process and analysis. The research has to have novelty as such the artefact must be innovative or the research must lead to improvement in the efficiency or effectiveness of ab artefact. Design science requires the artefact to be rigorously defined and as such the entire research must be formally represented upholding internal consistency. The process which leads to the development of the artefact must enable others to rely upon a search process for finding a solution to the problem. Finally, design science method requires the research to be presented in a form and manner that is comprehendible by both technology oriented and business management oriented audience.

### 3.6.3 Research Artefacts of Design Science

Design Science Research in Information Systems (DSRIS) has been evolving over the past decades which led to the increasing discussion about the definition of the DSRIS artefact - i.e. what is to be built and also about the methodology of DSRIS – i.e. how it is be built (Kuechler & Vaishnavi, 2008). There is ongoing confusions and misunderstandings with respect to DSR which are subverting the significant impact that design science research paradigm can create in IS researches (Gregor & Henver, 2013). DSRIS has been extended in theory development which has given rise to complexities. The theories which are in use in the field of IS have been classified into five types: (1) theory for analysing, (2) theory for explaining, (3) theory for predicting, (4) theory for explaining and predicting and (5) theory for design and action (Gregor, 2006) (Table 3.5). It has been commented that design science strives to create models, methods, and implementations which can be regarded as innovative and valuable (March & Smith, 1995).

| Theory Type | Distinguishing Attributes |
|---|---|
| I. Analysis | Says what is.<br>The theory does not extend beyond analysis and description. No causal relationships among phenomena are specified and no predictions are made. |
| II. Explanation | Says what is, how, why, when, and where.<br>The theory provides explanations but does not aim to predict with any precision. There are no testable propositions. |
| III. Prediction | Says what is and what will be.<br>The theory provides predictions and has testable propositions but does not have well-developed justificatory causal explanations. |
| IV. Explanation and prediction (EP) | Says what is, how, why, when, where, and what will be.<br>Provides predictions and has both testable propositions and causal explanations. |
| V. Design and action | Says how to do something.<br>The theory gives explicit prescriptions (e.g., methods, techniques, principles of form and function) for constructing an artifact. |

Table 3.5: Types of Theories (Gregor, 2006)

Information System, as a discipline, deals with issues that are associated with human aspects related to information technology in connection in social or organisational contexts. It is understood that DSR is mainly involved in constructing a range of socio-technical artefacts which can contribute in areas such as decision support systems, modelling tools, formulating governance strategies, and IS change interventions. There are no set rules for evaluating what constitutes as an artefact in Design Science Research (DSR). It has been argued that only information technology artefacts can be accepted in DSR-based IS researches (Orlikowski & Iacono, 2001). It has to be carefully considered whether or not pure organisational or social artefacts can be regarded as suitable for Information Systems Design Science Research (Winter, 2008). Design science artefacts have been categorised (March & Smith, 1995) and broadcasted (Henver, et al., 2004) as *constructs*: vocabulary and symbols demonstrating a specific domain as they define problems and state solutions; *models*: demonstrating realism with suitable levels of concept showing plans expressing connections between the established design constructs in the domain under investigation; *methods*: the procedure of algorithms or guidelines used to achieve an individual task; and *instantiations*: which are applied systems or their model developed as proof-of concepts (Table 3.6).

| No. | Design Artefact | Brief Description |
|---|---|---|
| 1 | Constructs | The conceptual vocabulary and symbols describing a problem within a domain |
| 2 | Models | A set of propositions or statements expressing relationships between the underlying design constructs; they represent situations as problem and solution statements. |
| 3 | Methods | A set of steps used to perform a task – how-to knowledge; method can be tied to particular models; they may not be explicitly articulated but represent tasks and results. |
| 4 | Instantiations | The operationalization of constructs, models and methods; it is the realization of the artefact in its environment to ensure its feasibility; e.g. (prototypes or the implemented artefacts). |

Table 3.6: Design Science Research Artefacts (Henver, et al., 2004)

This objective of this research is to develop a method that will allow organisations, who have embraced ERP systems, to utilise the process mining tool for measuring fraud risk more effectively and efficiently. The research is aimed at developing a method by relying upon information technology and thus it satisfies the criteria for being regarded as an IS research. The Design Science Research (DSR) paradigm is appropriate for conducting the research as it aspires to develop an artefact that has socio-technical aspects associated with it.

### 3.6.4 Phases of DSR

The pattern of constructing design artefacts in IS design-science research is very vast. Build and evaluate is the main general process of IS design science (March & Smith, 1995). Design Science research activities begins with problem identification than that is turn into technology invention or design, after that it need to be evaluated to ensure it is fulfilling the intended purpose (Venable, 2006). Similarly, design artefacts demonstrate feasibility argued by Henver et al (2004), they are assessed against criteria of importance to a community of intended users to ensure utility, quality, and efficacy.

DSR processes rely on a logical methodology model. Kuechler and Vaishnavi (2008) provides an additional insights concerning to DSR processes. Kuechler and Vaishnavi (2008) also linked these processes to knowledge flows and logical formalisms. Vaishnavi and Kuechler (2004) divided DSR processes into 5 stages as showed in Figure 3.4. This section provides descriptions and explanations of all the phases and their outcomes.

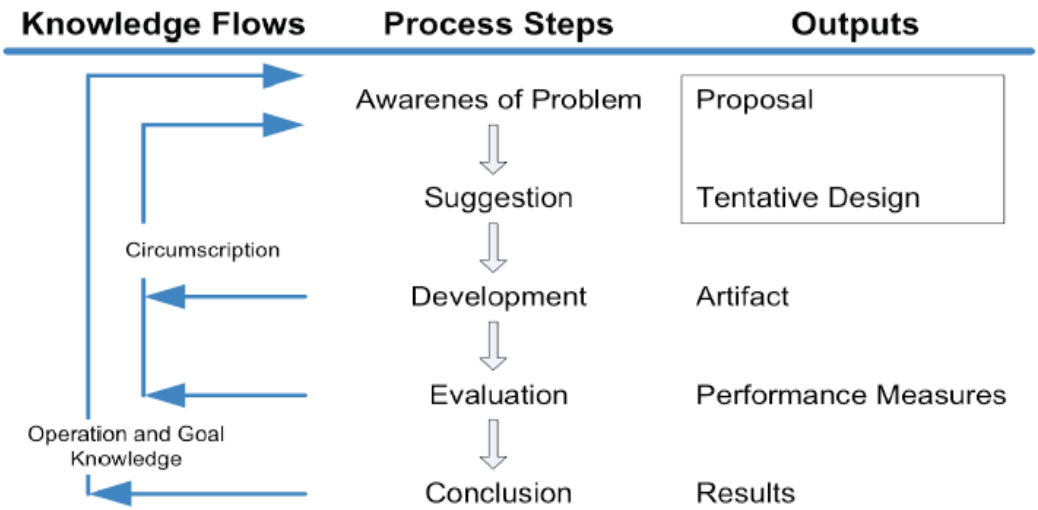


Figure 3.4: Design Process Stages (Vaishnavi & Kuechler, 2004)

### *3.6.4.1 Problem Awareness Phase*

As argued earlier, a 'problem' is the first constraint of any design Science research. This stage employs various sources, such as the new advancements in the field or theoretical frameworks. The major objective of this stage is to clearly articulate research problems and properly identify the research scope. The desired outcome of this stage is a definition of a suggestion for a new study. Awareness of Problem is clearly defined as the first activity in the design science research and also aforementioned in two the three methodologies (Peffers, et al., 2007). Moreover, 'Problem' is the pre-requisition of design science research process which is implicitly stated by March and Smith (1995). Consequently, describing a significant problem is considered as a vital activity in design science research and is included in a design research methodology used in this thesis. The goal of DSR is to gain knowledge in order to resolve a vital and related problem, which should be described in this phase. It is vital to remember that problems are perceived and each researcher may have a diverse view on a related class of problems. Therefore, a resolution to a problem from an observation of the perceiver of the problem would be a desired one as opposed to the ultimate best solution (Walls, et al., 1992). This phase is the output of the formal or informal proposal for a new research effort (Vaishnavi & Kuechler, 2004).

#### *3.6.4.2 Suggestion*

At this point, potential solutions to the specified problems are explored and evaluated. The first steps in this phase involve analysis and design, which allow obtaining insights of the problem domain. Moreover, an important task in this stage is to produce design or a depiction of proposed techniques. The methodologies of Vaishnavi & Kuechler (2007) recommend 'suggestion' and 'define the objectives for a solution' as their second activity correspondingly. Aims of the two activities are considered to be similar as it is to explain what is going to be done as the outcome of the research. Theorising is the central activity in design science research and closely related to the problem identification and the solution suggested for a particular problem (Walls, et al., 1992). Therefore, suggestion and theorising are considered to be vital parts of the DSR which is included in the design research framework in this research. In this phase, various types of solutions are suggested to fulfil the research problem. Throughout this phase researchers design the goals of a solution from the problem definition and knowledge of what is possible and viable (Peffers, et al., 2007). The result of this phase is a tentative design, and it is underlying utility theory, as a set of ideas believed to provide suitable solutions to the problem elaborate in the previous phase.

#### *3.6.4.3 Development*

This phase involves developing the DSR artefacts basing on the proposed results of the previous phase. The artefacts are the desired outcome of this stage and the central product of the entire DSR procedure. According to the classification of March and Smith (1995), artefacts are divided in into the following groups: methods, models, constructs, and instantiations (the explanations are given in above Table 3.2). According to Venable (2006) 'development' and 'evaluation' are the most important activities. Hevner et al. (2004) also mentioned that these two activities are the vital activities in design science research in some other publication. Hence these two activities are considered as essential parts of the design science research and are encompassed in the design research methodology adopted in this thesis. The artefact, which is the resolution to the specified problem and its defined goal, is built in the 'development' phase. The result of this phase is an artefact or a set of artefacts (Vaishnavi & Kuechler, 2004). The methods for constructing the artefact differ depending on the sort of the artefact to be developed. The execution of the artefact itself does not need

to include novelty beyond the state-of-practice for the given artefact. The novelty is primary in the design not the building of the artefacts (Vaishnavi & Kuechler, 2004).

#### *3.6.4.4 Evaluation*

After development stage, the artefacts are analysed to ascertain whether or not they comply with the specifications give in the suggestion phase. As illustrated above 'evaluation', is the most-accepted activity in Design science research, that is why it is included in the research method in this thesis. Additionally, 'demonstration' is an activity which only appears in design science research methodology (Peffers, et al., 2007) and targets at representing the use of the designed artefact to resolve one or more cases of the defined problem. In this thesis 'demonstration' is considered to be a secondary part of the 'evaluation' phase or one way of doing so. The DSR process is repeated from the phase one. Subsequently, this would require acquiring new knowledge during the previous stages. Such cycle has to be performed as many times as needed to meet the specifications. The output of this stage is performance assessment, which seeks to enhance efficiency and credibility. Evaluation is the vital phase to represent the utility, relevance and efficacy of design artefacts, as mentioned by several authors (March & Smith, 1995; Henver, et al., 2004; Walls, et al., 1992). The design artefacts require to be assessed depending to a set of defined criteria, therefore building these criteria is a part of the evaluation in design research. According to Peffers et al (2007), this phase observes and measures the result of the artefacts contribution, to a solution of the problem.

#### *3.6.4.5 Conclusion*

The final phase of the DSR cycle involves communicating the outcomes of the entire process to the wider audience. The final results of research and knowledge received during this process can be used by other researchers as recommendations on using the artefacts in related contexts. Despite the slight dissimilarities in the present approaches that are recommended for DSR in information systems, there is a visible contract that design processes form a loop which is usually iterated a number of times before the final artefact are produced (Markus, et al., 2002). Though, in the perspective of information system DSR, the current design tactics requires further methodical breakdown which is appropriate for different types of artefacts. Thus, these types of artefacts can be produced by following Design science research differs in term of purpose, functionality, and nature.

## 3.7 Research Design

This section contains a detailed discussion on the design of this research. Firstly, all the methods which will be applied for conducting research have been discussed and analysed. This research involves a number of methods for collection of data and testing the validity and reliability of the proposed method. Each of the methods that has been relied upon has been discussed in great detail. Then a detailed discussion on the application of DSRM has been included. Application of various phases of DSRM has been discussed and depicted in a diagram. Finally, each step that has been taken in conducting case studies has been explained. The tasks and deliverables in relation to each step for conducting case studies have been presented clearly.

### 3.7.1 Applied Methods

The aim of this research is to develop a new method for measuring internal fraud risk within business organisations with ERP systems. It appears that conducting a multiple case study will allow the reliability and general applicability of the method to be tested. The appropriate research paradigm will be pragmatic paradigm and the appropriate method will be DSRM. Design Science is considered in the field of information research when the main goal is to change a present situation related to an organisation or a social structure through the development of novel artefacts (Henver, et al., 2004). It is argued that design science attempts to create new artefacts for serving human purposes whereas natural science aspires to understand reality (March & Smith, 1995). Hevner et al. (2004) stated that design science is responsible for creating artefacts that offer solutions to specific complications faced by human agents out in the commercial world. According to Purao (2002) design science research explains the significance of iterations in generating the artefacts and presumes that realism and knowledge arise throughout the iteration effort.

The proposed method, which will have to be developed as a design artefact, demands two types of data to be acquired. The first set of data is required for mapping the business process of case company. This is qualitative in nature and this will enable the researcher to comprehend the business process which is essential for conducting process mining. The second set of data is required for quantifying the number of process that deviate from stipulated process path. This is quantitative in nature and this will enable the researcher to

calculate the revised fraud risk measure using the Bayesian theorem. It can therefore be stated that a mixed method approach for collecting data is appropriate.

DSRM requires the results obtained through the proposed method to be compared with results obtained through previous methods in order to complete the evaluation phase. The proposed method aims to measure internal fraud risk and thus the data available regarding internal fraud risk measured historically using other methods has to be obtained. Information regarding historically measured internal fraud risk can be extracted besides obtaining data regarding business process. The research has to be designed that will allow all required data to be gathered in the most efficient way. The key step for conducting this research is to calculate the number of deviated process that take place within a given time by using process mining. This research will therefore rely on interviews for collecting data regarding business process in case company and also regarding historically measured internal fraud risk. The next step will involve conducting process mining on the event logs of the case company for quantifying deviated processes. This information will then be applied in Bayesian theorem which will have been adapted for measuring internal fraud risk.

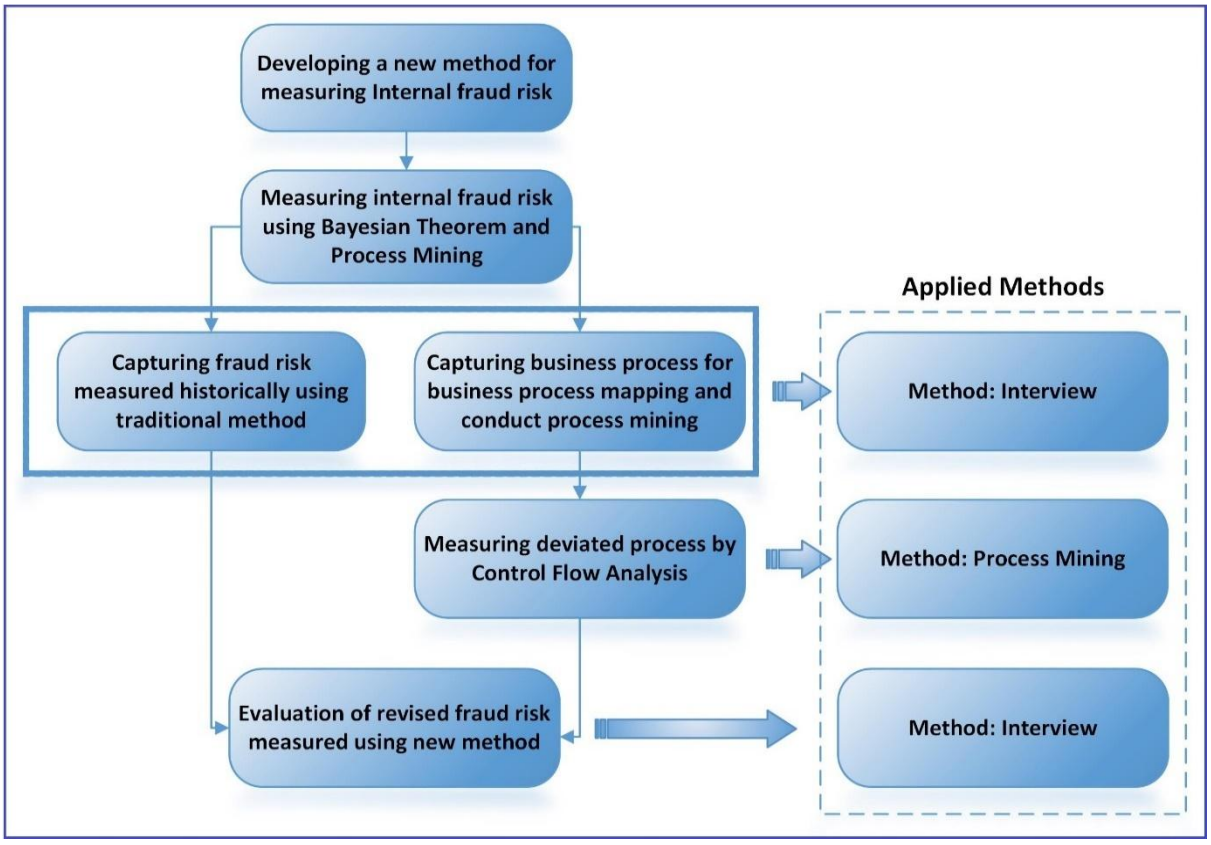

Figure 3.5: Chosen methods for conducting research

The key methods which will be relied upon are interview and process mining as has been showed in Figure 3.5. Interview will allow data to be collected for mapping the business process which is essential for conducting process mining and also for obtaining data regarding fraud risk measured over the past years. Process mining will allow deviated processes to be quantified which is required for arriving at a revised fraud risk rate as this research aims to develop a method for measuring internal fraud risk using Bayesian theorem. The chosen methods will be coherently applied in all the chosen cases. The detailed application of these methods are discussed in greater details in later sections.

### 3.7.2 Application of DSRM

This research has been designed in light of Design Science Research Method (DSRM). The main aim of the research is to develop a method, as an DSRM artefact, that will allow the risk of internal fraud taking place in an organisation with ERP system to be measured effectively with the use of information technology. The research will have five stages: awareness of problem; suggestion; development; evaluation; and conclusion (Figure 3.6). In the first stage of the research will have to focus on understanding the problem that is being dealt. The review of existing literature has revealed internal auditors heavily rely on traditional method for measuring internal fraud risk within organisations. Process mining has been relied upon in identifying fraudulent activities in ERP systems but no comprehensive method has been developed. This led to the proposal being put forward for developing a new method using enhanced probability theory and information technology.

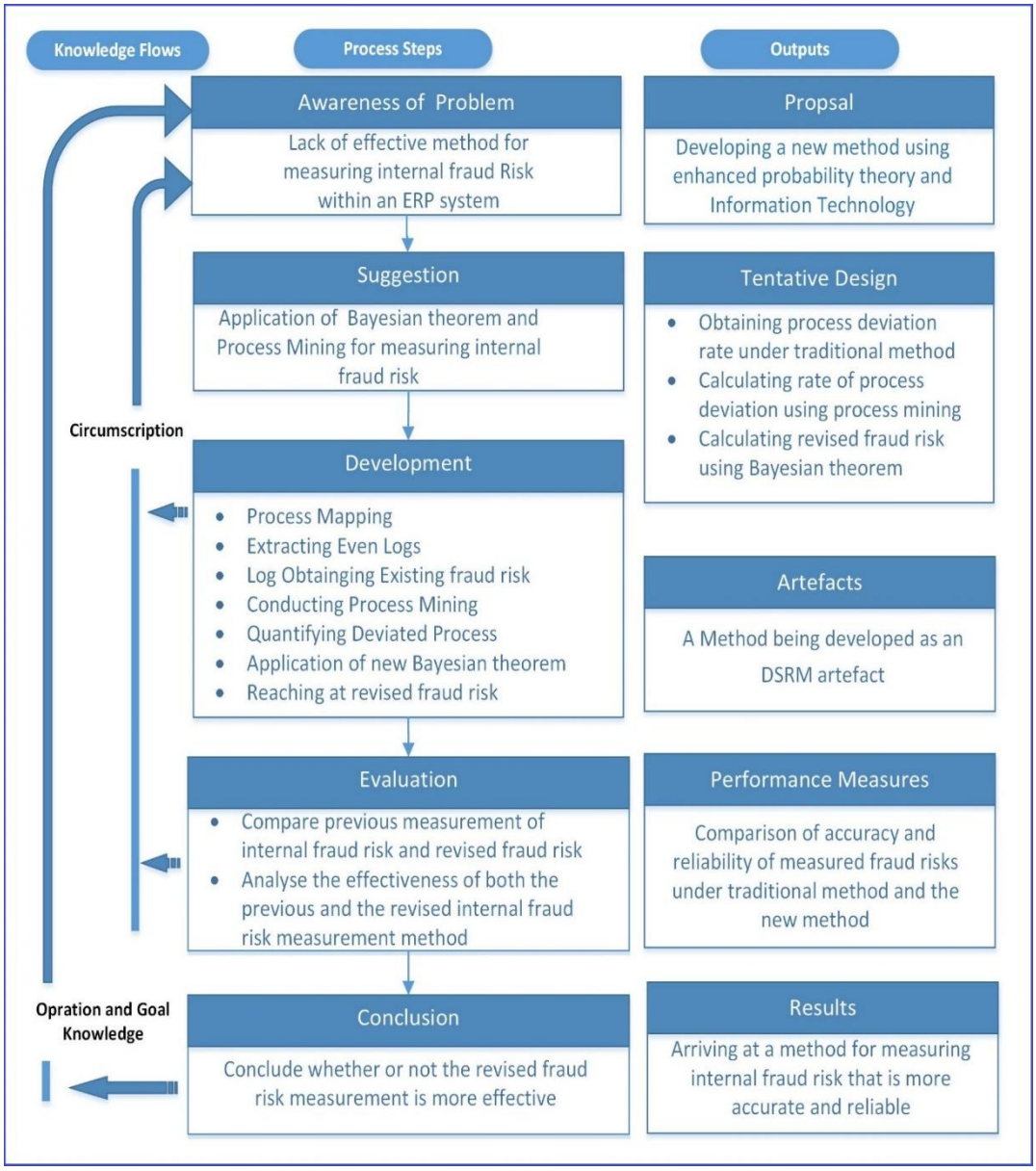


Figure 3.6: Application of Design Process Stages (Vaishnavi & Kuechler, 2004)

The second stage is to suggest a possible solution to the problem. It has been suggested that a method be developed where Bayesian theorem and process mining are applied for measuring internal fraud risk more effectively. A design which will allow internal fraud risk to be measured using Bayesian theorem by relying upon process deviation rate calculated by conducting process mining. The third stage of the design process is to develop an artefact. The research aims to develop a new method, a set of steps to perform the task of measuring internal fraud risk, which can be regarded as a DSR artefact. The set of steps involve business process mapping; extracting event logs from ERP system; obtaining information regarding fraud risk under traditional method; conducting process mining on

chosen set of event logs; quantifying rate of process deviation derived at by using process mining; applying gathered information as inputs in Bayesian theorem adapted for measuring internal fraud risk; and arriving at a revised fraud risk. The artefact can be mathematically expressed in an equation. The next process step is evaluation. This step involves comparison of previous measurement of internal fraud risk with revised measurement of internal fraud risk. It also involves analysis of both results for determining the effectiveness of each method. This step results in measurement of performance which is conducted by evaluating the accuracy and reliability of internal fraud risk measured under the two different methods. The final step is conclusion which involves concluding whether or not the developed method is better than existing methods based on the results.

### 3.7.3 Conducting Case Studies

One of the most challenging methodological steps is to conduct case studies. Each organisation has its own rules of engagement with researchers. The case studies are to be conducted separately adhering to the rules of each of the organisations. The key personnel who are crucial for the purpose of the research have to be identified with respect to each individual case. The aim of the research is to develop a new method for measuring internal fraud risk more effectively by utilising process mining within the ERP system of an organisation. For the research, it is of immense importance to identify the human agents who are aware of and responsible for ensuring internal control system for specific business process. The chosen process is procurement. So, the first task is to extract information about the internal control system and the business process from the human agents i.e. the internal auditors and ERP system administrators. The next important stage is to obtain data regarding fraud risk within the process as measured by the existing system in place. Then the business process of each organisation has been mapped so that the data available within the ERP system can be utilised for conducting process mining. The next step is to obtain data from the ERP system for conducting process mining using relevant software in consultation with the system experts. The collected data then has to be analysed in conformance with theoretical framework i.e. the Bayesian theorem. The calculated fraud risk measured in accordance with the proposed method would then be presented to the internal auditors for capturing their views with regard to the effectiveness of the method

developed for the purpose of this research. The steps followed for conducting case studies are represented in below in Figure 3.7:

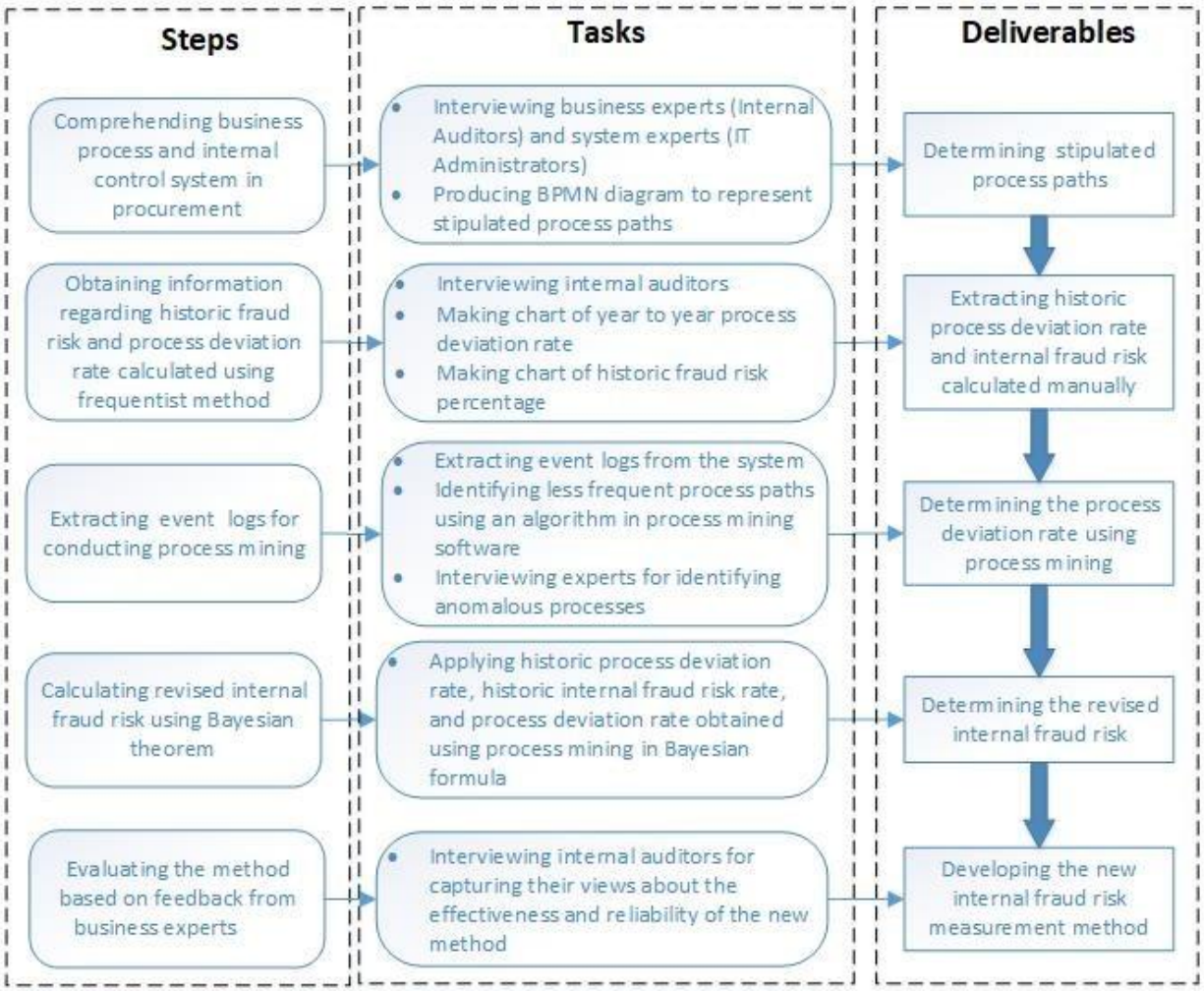


Figure 3.7: Steps for conducting case studies

## 3.8 Data Collection Techniques

Data collection techniques which have been relied upon for conducting this research has been discussed in this section. Data has been collected in two ways for this research - through interviews and through process mining. In the first part, methods for conducting interviews have been analysed. Then detailed discussion on semi-structured interview, which is the chosen interview method for collecting data, has been included. This has been followed by a detailed analysis of the design of the interview questionnaire that has been employed. The second part includes detailed discussion on data collection through process mining. Each step involved in conducting process mining, such as planning, extraction, data processing, mining & analysis, evaluation, and process improvement, has been discussed in light of this research.

### 3.8.1 Data Collection through Interviews

#### *3.8.1.1 Interview Methods*

Interviews are in-depth conversations between two or more people in a formal way with a specific topic in mind. Usually an interviewer has a topic about which he or she is interested to know from the interviewee or interviewees. One-on-one face-to-face interviews between two persons is a popular format in social and business studies. Group interviews are also common. Interviews are generally classified as structured or unstructured (Sekaran, 2003). A structured interview follows a tight question answer session, where the questions are set beforehand and the sequence, wording, and time allocated for each of the answers are maintained strictly. The strict adherence to the question set adds a flavour of its own, and the interviewees often become aware of the formal nature of the interview. On the other hand, an unstructured interview follows a more open format, where the questions are not usually set beforehand and are developed as the interview progresses. The nature of the interview gives more space to the interviewees, providing hidden insights to the topic at hand, but it also runs the risk of the conversations being drifted away.

Robson (2002) has classified interviews in a third and middle category called semi-structured interviews. In a semi-structured interview, the questions are set beforehand like a structured interview, but the interviewer has more freedom in terms rearranging the sequence of the questions, changing the wordings of the questions and pacing the allocated

time to each answer upon his or her discretion. This is an Information Systems research and the nature of the research questions requires in-depth understanding of issues which are closed related to human behaviour and social interaction within organisational contexts. The interpretivist nature of the research demand selection of open-ended unstructured interviews to be conducted whereas the aim to conduct multiple case-studies require the interviews to be structured for ensuring validity. It is therefore important to choose an interview method that draws a reasonable balance between the two contrasting needs. The chosen interview method for the purpose of this research is thus semi-structured interview.

#### *3.8.1.2 Semi-Structured Interview*

The semi-structured interview format was selected for part of this research. The research design required interviews to be conducted in three phases with respect to each of the case company (Figure 3.8). The first phase of the interview is aimed at understanding the internal control system and extract information with respect to the procurement process of the organisation. The interviewees were selected based on their knowledge about the internal control system and business process ideally working in internal audit team. Data collected during this interview phase were used in understanding business process, internal controls, and creating BPMN diagram. The second phase of the interview is aimed at obtaining technical information for conducting process mining in order to quantify process deviation. The interviewees were selected based on their knowledge about the ERP system ideally working IT or Business Systems Management team. Data collected during this phase ensured that process mining was conducted in a reliable manner with respect to each of the case companies. The third and final phase of the interview is aimed at understanding the view of internal auditors about the new method that has been developed in this research which is a formal evaluation of the effectiveness of the proposed method. The interviewees for this phase were selected from the participants who took part in the first phase. Data collected during this phase on interview provided the researcher with insight into the effectiveness and reliability of the newly developed method.

The first phase of semi-structured interviews was carried out within the office premises of the three case study companies, and the interviewees were all internal audit team members of the respective companies. The second and final phases of the interviews with respect to all three case companies were conducted via Skype. The reason for conducting the second

and final phases of interviews remotely is logistical as it would have become quite onerous for the researcher to travel between two geographically remote countries. Although the first phase of interviews took place face-to-face, it was logistically inconvenient for the researcher to travel to Bangladesh for collecting data for phase 2 and phase 3 interviews. Skype was selected as the mode for conducting the interviews remotely as it was perceived to be safe and secure by all the interview participants.

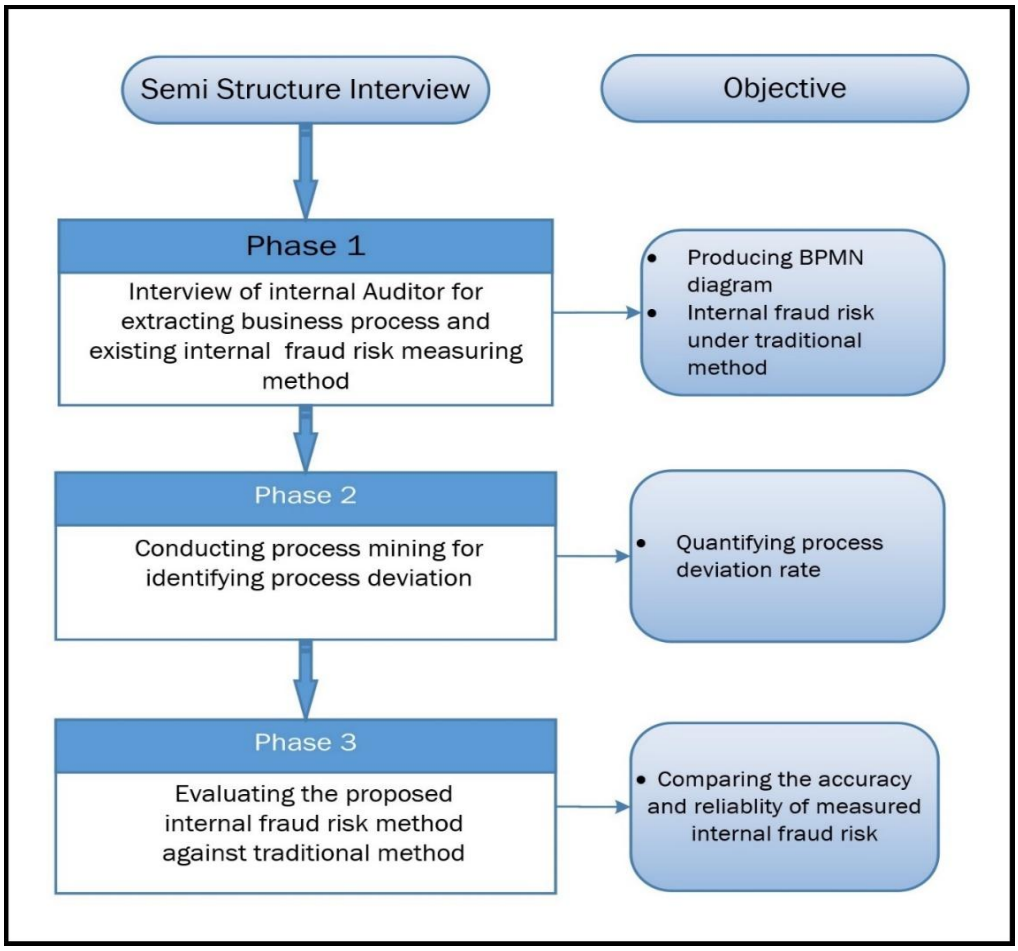


Figure 3.8: Phases of interview and their objectives

The interviewees, both from IT and Audit departments, had professional competencies in their respective fields and as such the semi-structured format allowed for a more open ended and insightful conversations between the interviewees and the interviewer. Partially exploratory and qualitative researches do call for a semi-structured format (Dikko, 2016, p. 523). One of the reasons for selecting semi-structured format was the level of expertise on internal audit and fraud risks possessed by the interviewees and the level of expertise in information systems possessed by the interviewer and a requirement for fusing these two

areas of concern. The semi-structure format provided the flexibility, and yet provided a solid question-answer session to accompany the quantitatively intensive process mining part of the research.

#### *3.8.1.3 Designing Interview Questionnaire*

The questionnaire for the semi-structured interview was formally written down and put on paper for the interviewer guide himself through. However, the sequence, wording and pacing of the questions were free to be changed in each case. The interview was designed to take place in three phases: first phase conducted before running the process mining, second phase to be conducted concurrently with process mining, and the final phase to be conducted after running and showing the process mining results to the members of the internal audit teams of the cases study companies. It was designed so to assess the reaction of the internal auditors to new analytical procedures for gathering audit evidenced and reactions to any change in the measures of risk found out during conducting the process mining. The questions for each phase of interview was designed keeping the objectives in mind. The questions in the first phase are designed to extract information for producing a business process map using BPMN and to obtain relevant statistics related to existing method employed in measuring fraud risk. The questions involved in the second phase are technical in nature as those were aimed at conducting process mining on the logs of events. The third phase was focused on capturing the evaluations of the system experts and thus questions were reflective in nature.

### 3.8.2 Data Collection through Process Mining

One of the most important data has to be obtained through process mining for this research. The main aim for conducting process mining is to check the rate of conformance in existing event logs of the selected case companies. Process mining has to be conducted with respect to each case and a specific method will be followed. The methodology developed by Aalst (2015) which is know as PM2, will be followed for conducting process mining in this research. PM2 has six stages: planning; extraction; data processing; mining and analysis; evaluation; and process improvement and support. Planning and extraction involve defining initial research question and extracting event data (Kromhout, et al., 2016). Then following stages of data processing, mining, and evaluation are regarded as analysis iterations which focus on answering a research question by applying processing mining and evaluating

discovered process models (Eck, et al., 2015). The process mining methodology has been represented below, in Figure 3.9, with elaborate discussion on each stage:

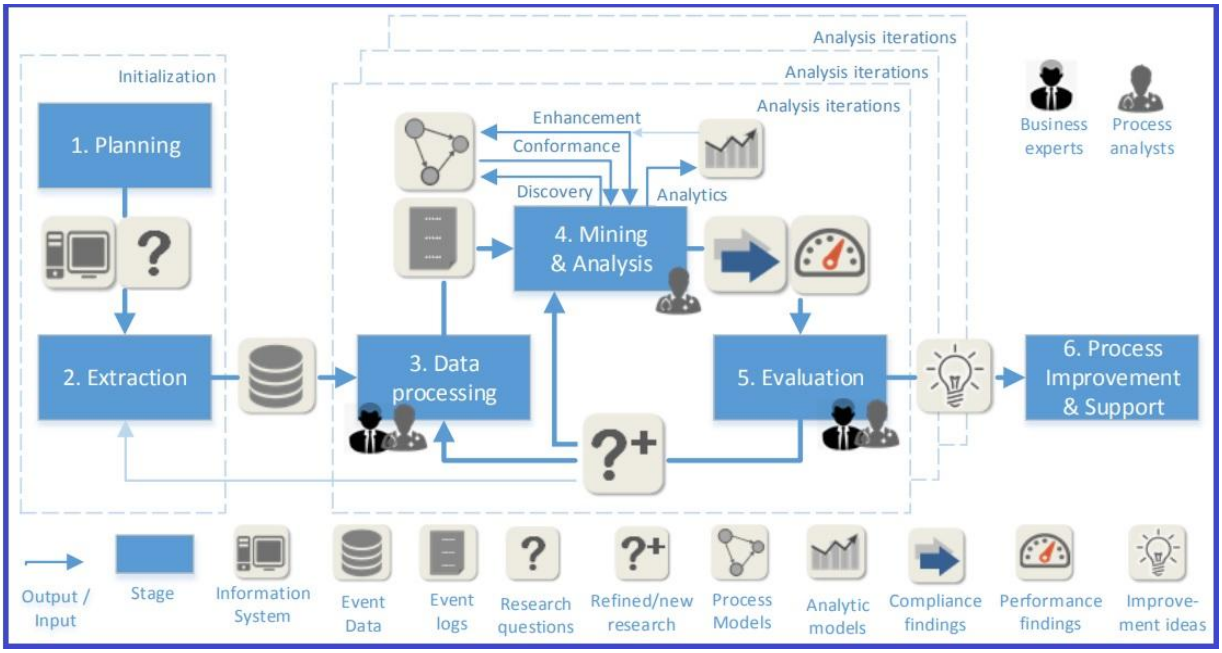


Figure 3.9: Process mining methodology (Aalst, 2015)

### *3.8.2.1 Planning*

Planning is the first stage for conducting process mining which is preparatory in nature. The main objective is to determine the research question. Planning involves three activities: identifying research questions, selecting a business process, and identify human agents who are essential for conducting process mining (Eck, et al., 2015). The aim of the research is to develop a method for measuring internal fraud risk within organisations with ERP systems where process mining will have to be conducted for quantifying deviated processes. It can be said that the aim of conducting process mining is to check conformance. The business process that has been selected for this research is procurement. Three types of role players will have to be involved for conducting process mining with respect to each case company: business experts, system experts, and process analysts (Suriadi, et al., 2013). The key human agents who are essential for conducting this research are the members of internal audit and ERP system teams as they have requisite knowledge about adopted process model and the ERP system. It has to be ensured that a unique identifier is carefully selected and is capable of linking related events (Bose, et al., 2013).

#### *3.8.2.2 Extraction*

Extraction stage is aimed at extracting event data and, optionally, process models. The process model will be extracted by process mapping based on interview data so the main activity that will be performed in this research is extraction of event data. Determination of scope, extraction of event data, and transferring of process knowledge are the three key activities which are performed in this stage (Eck, et al., 2015). Determining the scope involves fixing the granularity, period, data attributes, and data orientation. It appears that Purchas Order (PO) can be regarded as a starting point as the selected business process is procurement. The timeframe will have to be selected after having consulted the business and system experts of each case company. Then the selected process related data will be extracted. Tacit knowledge regarding the business process and data attributes will be required to be exchanged between business experts and process analysts. This can be done during the phase 2 of the interview that will take place between internal audit team and the researcher. The extracted data then will have to be processed.

#### *3.8.2.3 Data Processing*

The processing stage is not essential as the retrieved data can, on many occasions, be directly used for process mining (Taghiabadi, et al., 2016). Creating views, aggregating events, enriching logs, and filtering logs are the main four activities involved in data processing stage (Eck, et al., 2015). Data filtering can be done by applying process models a filer. The key activity that will be performed for the purpose of this research at data processing stage is filtering logs. Filtering is widely used data processing step which can be classified into three main techniques: slice and dice; variance-based; and compliance-based. Slice and dice is used for removing events based on attributes and this technique is also known as attribute filtering. Variance-based filtering is used for partitioning event log for discovering process models (Rebuge & Ferreira, 2012). Compliance-based filtering used for removing events that are not compliant with given process models. Compliance-based filtering will be run for this research with respect to each case.

#### *3.8.2.4 Mining and Analysis*

Mining and analysis stage involves application of process mining techniques on the selected event logs for gaining insight into process performance and compliance (Eck, et al., 2015). The key activities performed during stage are conformance checking; process discovery; enhancement; and process analytics. The main input at this stage for this research is event

log and the main objective is to check conformance of event logs with the stipulated process model. Conformance checking techniques are performed with the aim of detecting inconsistencies between a process model and its corresponding execution log (Rozinat & Aalst, 2008). The software that has been chosen for this research is ProM, which has been the de-facto standard for conducting process mining over the past decade, and allows process discovery, conformance checking, and history-based prediction to be performed (Aalst, 2012) A Performance Sequence Analysis plugin will be used to observe the patters in event logs. Most infrequent patterns will be identified at this stage with respect to each case company. Required algorithms, such as Fuzzy Mining algorithm, and filters, such as LTL Checker, will also be relied upon for lowering the level of noise present in the event logs (Gunther & Van der Aalst, 2007). Conformance checking conducted as this stage has been represented below in Figure 3.10:

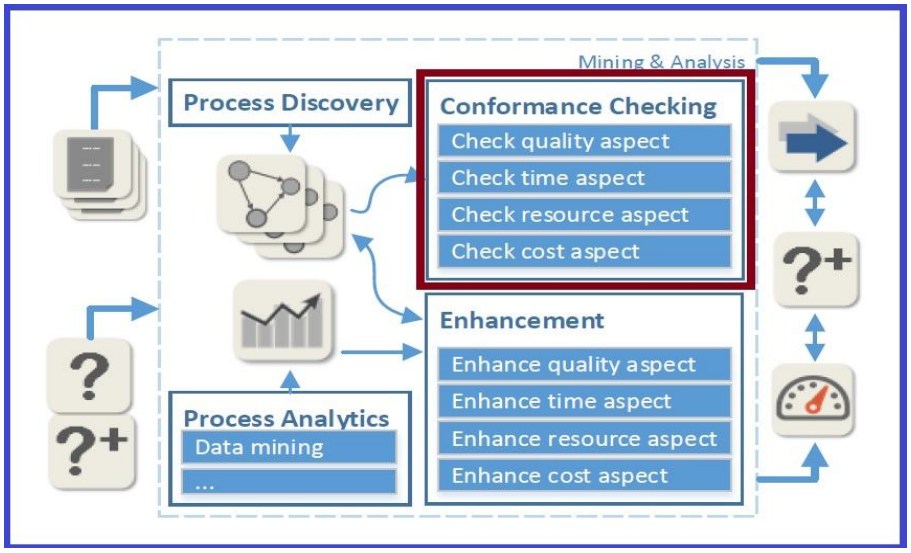


Figure 3.10: Mining and Analysis stage for conformance checking (Eck, et al., 2015)

### *3.8.2.5 Evaluation*

The evaluation stage of process mining allows the results of process mining to be applied for address the issue raised as the research question. The input for this stage is the compliance, or performance findings derived from the mining and analysis stage. Two main activities associated with this stage is to diagnose and verify & validate (Eck, et al., 2015). The diagnosis for this research is to distinguish unusual process paths so that those can be examined by business experts. Verify and validate activity is about assessing the correctness of the findings. Verification involves comparing the findings with the original data and

validation involves comparing the findings with the claims of process stakeholders. Diagnosis and verification & validation are conducted at the Phase 2 of the interview process in this research with respect to each of the selected companies.

#### *3.8.2.6 Process Improvement*

The main objective of this stage is to utilise the information gained through process mining for improving organisational performance. Process improvement can be considered as a separate task or project. The aim of this research is to develop a method for measuring internal fraud risk using process mining and thus it is up to the management of the case companies to adopt and implement the findings of the research. The findings of this research can be subject of further research. It can therefore be said that the process improvement stage will not be directly applicable while conducting process mining on the case companies.

## 3.9 Data Analysis Techniques

Techniques which have been relied upon for analysing data collected through interviews and process mining have been discussed in this section. Analysis of interview data has been conducted in three ways. Firstly, interview data have been utilised for the purpose of business process mapping. Then the internal control system of each case study organisation was extracted by analysing the interview data. Finally, information in relation to fraud risk measured historically was also obtained through interviews. The latter part of this section includes discussion on the way data obtained by conducting process mining has been discussed in detail. Discussion has been included on how process deviation rate has been quantified and also on how Bayesian theorem has been applied for incorporating evidential reasoning.

### 3.9.1 Analysis of Interview Data

#### *3.9.1.1 Business Process Mapping*

Business process mapping is the set of activities related to systematically laying down the rules of business processes. The term 'mapping' relates to the fact that contemporarily business processes are often diagrammatically represented, often following standard notations such as Business Process Model and Notation (BPMN) developed by the US-based non-profit organisation Object Management Group. Business process mapping has become a key part of standardising business processes in modern organisations. This has also become an integral part of implementing Information Systems such as Enterprise Resource Planning architectures. Implementation of all modern ERP systems require business process mapping, including those by SAP and Oracle and which were found installed in the three organisations of the case studies for this research.

Since the business processes were already extensively mapped at the case study organisations, mapping as part of this research mainly involved extracting the business process maps into the system utilised for process mining, which is the Prom 6. Prom 6 can process mine files in the eXtensible Event Stream or XES event log format. This format is an upgrade to the MXML format that were used in the earlier versions of Prom. This new format is an effort by IEEE Task Force on Process Mining (Verbeek, et al., 2010). Prom 6 has a module named XESame, which enables the extraction of event logs from various ERP

systems into XES format. This extraction of the event logs into a format readable by Prom 6 essentially completes the step of business process mapping and enables Prom 6 to go about further with the process mining.

#### *3.9.1.2 Extracting Internal Control System*

Internal control is the framework employed in an organisation from a governance, management and operational perspective to ensure the achievement of organisational goals. The framework typically includes procedures of control for achieving reliability in financial reporting, efficiency and effective of operations and compliance with law and regulations. In the process of achieving these goals, internal control reduces the operational risks of an organisation, thereby increasing the value of the organisation for its stakeholders.

Usually the business processes themselves embody the internal control procedures, and implementing and monitoring of internal control procedures usually lie with the internal audit team or experts. Record-keeping is an essential part of internal control, and the three organisations of the case studies have strong record keeping procedures given they all have ERP systems implemented and have produced strong policies regarding its use. Modern ERP system often prove to be the backbone of internal control system, especially if the organisations strictly follow a business process mind-set and have almost all business processes mapped and integrated into the ERP systems.

In the case studies, all the three companies have had multiple years of full ERP integration, together with strict policies regarding its use. Two of the companies use SAP ERP, while the third uses ERP system by Oracle. Both these ERP systems are highly trusted at a global level. However, in many cases the management has yet to understand the full potential of its use. For example, none of the three companies had used any kind of data or process mining application before the conduct of this research. Also, many of the internal auditors were not up to date in terms of ERP related technologies in general and concepts such as data and process mining to be specific. However, the record keeping standards implemented at these companies had ensured the possibility of retrospective analysis. All the three companies mainly relied on authorisation as well as cross-validation and record keeping for effecting internal control. Together with a modern ERP system implemented and excusive internal audit team and resource personnel employed, the companies on a superficial level at least looked to be adequately prepared for operational risks.

Modern enterprises are immensely complex entities in terms of process flows. Often a practical workable solution around a business problem cannot be found within the existing approved or designed business processes. Often the designs of any implemented process may not be optimal or conducive to reducing operational risks. Oftentimes, the internal control steps deemed necessary may be out of step with existing business process. These situations create what is known as a business process gap between information system process flow and internal control flow (Huang, et al., 2009, p. 436). Such business process gaps may weaken the results of extracting internal control system from implemented business process mapping only. In case of the three case study companies, such business process gaps were low or non-existence as assured by the internal audit teams and specialists of the respective companies.

#### *3.9.1.3 Fraud Risk Measured Historically*

The aim of this research is to develop a method for measuring internal fraud risk using Bayesian theorem and process mining. The research is based on DSRM where the developed method is an artefact. It is therefore important to be able to evaluate the findings of the result. It is therefore of great importance to learn about the existing methods which are being relied upon by the business experts in the case companies. Historically measured fraud risks will be analysed statistically. The process deviation rates of the past years can be analysed by finding out the correlation between the rates. The fraud risk to process deviation rate can also give indications about the consistency of the results. This can then be compared with the process deviation rate obtained by process mining and the revised fraud risk measured under the proposed method.

### 3.9.2 Analysis of Process Mining Results

#### *3.9.2.1 Quantifying Process Deviations*

Process deviation, in its simplest terms, could be understood as any deviation from a defined process or path. In reality, however, practitioners will have to define tolerable degrees of deviation and standards of measures based on assurance level requirements and application domain knowledge. When defining, measuring and quantifying business process deviation, an introduction to standard practices in Quality Management Systems (QMS) used in operations management would provide invaluable insights. However, measures of process deviations appropriate for this research is based on internal audit standards,

analysis of which will shortly follow after a brief overview on process deviations as defined in QMS.

One of the many procedures for product and service quality management is the Six Sigma framework. Six Sigma framework allows managers to think of product quality and deviations from standard quality due to business process errors from a statistical perspective. For example, the aim of Six Sigma QMS is to, at least in essence, reduce the number of 'consumer-perceptible defects' to 3.4 defects per million units of production (García-Alcaraz, et al., 2014, p. 94). Here, the standard of tolerable degrees of deviations, in terms of product quality, is set by an outside stakeholder, the customer, which is to say that if a product is defective or not is initially perceived by the consumers.

In QMS, the customer effectively sets the minimum quality in terms of product. In internal audit, however, it is the auditing standards, internal auditors, the audit committee of the board and the company policies which dictate the assurance requirements. The assurance from internal auditors is based on the internal audit evidences gather during the period of audit. Complying to International Standards on Auditing, which is in turn adopted by Institute of Chartered Accountants of Bangladesh, internal auditors are required to "obtain sufficient appropriate audit evidence to be able to draw reasonable conclusions on which to base the audit opinion" and apply 'test of control' procedures or 'substantive procedure' in collecting such evidences (Institute of Chartered Accountants in England and Wales, 2009, pp. 70, 71). Substantive procedures can include tests of detail and analytical procedures. One of the theme of this research is to provide information system-based analytical procedures that can prove to be complementary to the traditional sampling-based analytical procedures typically employed by Bangladeshi companies and their internal auditors.

In the three case studies conducted during this research, all the three companies employed sampling of procurement cases and applying the standard of 'sufficient appropriate audit evidence' for identifying process deviations. Hence, the tolerable degree of deviation set by auditors mostly remained subjective rather than objectively quantitative. After identifying deviant cases, it was a simple case of finding out the rate of deviance by dividing number of deviant cases by the number of sampled cases. Here it must be mentioned that even though the process deviances actually occurred at the event-level, that is, individual events in a case

deviated from the prescribed or allowed business process paths, the rates were calculated on a case-basis. This is mainly because upon finding a deviation in an event, a total case was being put to 'test of detail' by the audit teams starting from case initiation through procurement request.

In case of the process mining conducted using Prom 6, the ERP logs were analysed in terms of their frequency of paths and frequency distributions were formed internally by the software. Prom 6 allows a 'cut-off' of frequency to be selected, that is it dissects the frequency distribution into acceptable and unacceptable categories in terms of the frequency cut-off set, so as to allow easy passage of frequently travelled business process paths, while putting less frequent paths under scrutiny. Hence, the tolerable degrees of deviation are set by the analyser of the process mining test through tweaking the cut-off. In the three case studies, all three cut-offs were set at 0.80 at the discretion of the researcher.

One of the crucial factors in quantifying process deviations is the setting of tolerable degrees of deviation. It was seen that in a QMS, the customer effectively sets this factor, whereas in traditional internal audit analytical procedures the internal auditors mostly subjectively set this factor. In process mining analytical procedure for internal audit, the internal auditor can quantitatively set this factor through selecting the 'cut-off' factor.

#### *3.9.2.2 Application of Bayesian Theorem*

The Bayes' rule is a formula for updating existing Bayesian subjective probabilities upon arrival of new evidence. The following equation shows the functional form of Bayes' theorem:

$$P(A \mid B) = \frac{P(B \mid A)\, P(A)}{P(B)}$$

The formula shows that the new probability of an event conditional on the new evidence is a function of the conditional probability of that event, the past probability of that event and past probability of the evidence itself. Based on standard notation of probability, the formula shows conditional probabilities by placing a vertical line between the variable of interest in the left and the condition it is exposed to on the right of the vertical line.

The Bayes' Theorem is based on probabilities, that is, the inputs and outputs of the function are probabilities: unitless measure that signifies frequency, propensity or subjective likelihood based on the context and interpretation of probability. Since the framework of the research is based on subjective assessment of fraud risk, as considered by the internal control and internal audit team of a company, the Bayesian interpretation for all the probabilities is assumed. Until now the rate of process deviation, as found by either traditional sampling utilised by the internal audit team or the rate found upon utilising process mining within the Enterprise Resource Planning software system, were considered to be simple rate. However, these rates could intuitively also be interpreted as probabilities of process deviations, or more precisely the point estimation of sample statistic of probability for process deviations. The fraud risk measure, too, are measures of probability of fraudulent events within the whole population of events generated by the ERP system within a year. Using this line of thought, it could be argued that using the existing probability for fraudulent events and existing probability for process deviation, and incorporating the updated probability for process deviation found through process mining, a new and updated probability of fraud could be found using the Bayes' formula. In that case, the assignment of roles for the three probabilities within the Bayes' rule is as follows: P (B|A) is the new and updated probability of process deviation as found from process mining; P (A) is the probability of fraud as was believed to be before the new evidence arrived; and finally, P (B) is the probability of process deviation, again as was believed to be before the arrival of the new evidence. The adapted form of the Bayesian formula that will be used in this research is:

**Revised Fraud Risk = (Rate of Process Deviation $_{\text{Process Mining}}$ x Fraud Risk $_{\text{Traditional Internal Audit}}$) / Rate of Process Deviation $_{\text{Traditional Internal Audit}}$**

Here, Revised Fraud Risk is the updated risk of fraud upon incorporating process mining results into traditional fraud risk measure. Rate of Process Deviation is the equivalent to P (B|A) factor of the generalised Bayesian formula, which is conditional on the term of current Fraud Risk, or P (A) within general Bayesian framework, as available from traditional internal audit. Here the conditionality of process deviation on fraud risk assumes perfect correlation between process deviation and fraud risk in general. Finally, the Rate of Process Deviation, as measured through traditional internal audit approaches, also enters the equation as P

(B). In fact, this is the rate that is being updated with a revised rate through this Bayesian framework.

## 3.10 Pilot Study

This section includes a discussion on the importance of conducting pilot studies. The main objectives for conducting a pilot study for the purpose of this research have also been stated. Then the ways for assessing the validity and reliability of the research have been analysed. The steps which have been taken for ensuring the validity and reliability of this research have been analysed. In the latter part, various aspects related to the pilot studies conducted for this research have been evaluated.

### 3.10.1 Importance of Pilot Study

Pilot study has been defined as a "*small study for helping to design a further confirmatory study*" (Lancaster, et al., 2004). It is of great importance to conduct pilot studies prior to embarking on conducting the full-scale research. It helps the researcher to assess the difficulties which he or she may face while conducting the research and as such the researcher can evaluate risk and complexities associated with the research strategy. It also assists the researcher to identify any flaws that may exist in the research design. It has even been commented that a pilot study may require more resources to be allocated than the actual data collection phase of the research as the reliability of the research depends on the pilot study (Yin, 2009). A pilot study offers the researcher with the opportunity to be more effective during the actual data collection phase as the research design and research artefacts can be tested on a smaller scale. Pilot studies have two main functions: feasibility studies prior to conducting the main research and pre-testing a research instrument (Teijlingen & Hundley, 2001).

The main objective for conducting a pilot study for this research was to test the feasibility of methods employed for collecting qualitative and quantitative data. The qualitative data was collective through interview of participants. The quantitative data was collected by way of process mining. The key objective was to evaluate the ability of the methods for obtaining the data required. The pilot study also aimed to check whether the collected data could be analysed using the proposed research design for arriving at meaningful analogies. The aim of this research is to develop a method for measuring internal fraud risk effectively by relying upon process mining. The pilot study was therefore important as this could reveal

whether or not data collection methods were capable of generating data required for testing the effectiveness of the method as well as any flaws in the research design.

### 3.10.2 Assessing Validity and Reliability

Validity and reliability are two very important measures of the quality of an experiment and its results. The terms validity and reliability is used in the field of psychometrics, whereas in statistics the same could be meant with the terms accuracy and precision respectively, even though in psychometrics there is a growing opposition towards interchangeably using these terms (Streiner & Norman, 2006). However, for the purpose of this study in information systems, the terms would be used interchangeably.

Validity is the quality of a test or its results in measuring what it says is measuring. That is a result that is close to the true value is a valid one. Stating differently, a test which is free from bias or systematic error is a valid one, even though it may have unsystematic or random error to it. There are two types of validity we are interested in for this research, namely construct validity and content validity. Construct validity ensure that the test designed from the theory measures what the theories try to predict, whereas content validity attempts to ensure inclusion of all critical items of a theory in a test (Boudreau, et al., 2001, p. 5). Pilot and pre-test studies are one way to handle construct validity. For this research, a pilot study was carried out to ensure construct validity and feasibility of the research. The pilot study provided the required assurance and hence the full-fledged study was taken upon. For content validity, literature review and expert opinions are key. The semi-structured interview of the internal auditors of the case study companies provide such expert review, whereas the literature review of the study complements it. Upon reviewing the literature, one issue that came up challenging content validity was the concept of business process gap between information system process flow and internal control flow (Huang, et al., 2009, p. 436). However, upon assurance from the internal auditors, such concerns has been dismissed.

Apart from validity, pilot tests also provide preliminary assurance for reliability together with opportunities for designing the research better (Dikko, 2016, p. 522). Reliability is defined as the consistency of a measure or test and its results. That is values close to average values are reliable, it does not have to valid to be reliable. Reliable measure has low unsystematic or random error. There are mainly four kinds of reliability, namely, test-retest

reliability, inter-rater reliability, inter-method reliability and internal consistency. During the process mining studies, multiple stances of process mining were run and were found to be reliable. Hence, research could be argued to be test-retest reliable. However, inter-rater and inter-method reliability check remained outside the scope of this paper as only Prom 6 software and process mining framework were used for risk of fraud assessment. Finally, the use of pilot study remained internally consistent with the full-fledged case studies.

### 3.10.3 Evaluation of Pilot Study

It is commented that one of the key functions of a pilot study is assist the researcher in pre-testing the research instrument in terms of ease of understanding the questions by respondents and the duration of an interview (Bell, 1991). The pilot study involved conducting semi-structured interview of participants. Two participants agreed to volunteer who are currently working as accountants or auditors in Bangladesh and were not from companies selected for conducting case studies. The participants were interviewed separately. The semi-structured interviews were conducted in accordance with the interview questionnaire that was prepared for this research. The interview was conducted only with respect to collecting data for mapping the business process and internal control system. The actual data collection phase involves to interviews but it was not feasible to conduct pilot study regarding the follow up interview as the quantitative data collection instrument, i.e. process mining, was conducted under simulation environment.

Several issues surfaced while conducting the pilot interviews. Some questions were difficult to understand due to terminological issues and as such some of the questions were reformulated. Some questions were also identified as repetitive by the participants in the pilot study. The total duration of the interview also raised a concern as they went over the set time limit of 1 hour and thus some of the questions were rearranged. The pilot study interviews were conducted in English although the actual interviews were conducted in native language of the participants. This posed a challenge as the interview questionnaires were translated in Bengali and the recorded responses were then translated into English (Hines, 1993). However, the challenge was tackled as the interviews were semi-structured and also due to the researcher being a speaker of the native language of the participants.

The pilot study was conducted with respect to the quantitative instrument of the research which is process mining. It was not possible to conduct process mining with respect to a real

log of events due to not having access to any organisational data other than the actual participants. The process mining was conducted in simulation environment. The approach that had been embraced for conducting simulation was 'process-interaction'. A discrete event simulation package had been used for generating events with stipulated processes along with variations. This allowed conformance checking to be performed using process mining. The pilot study provided some insight regarding the choice of process mining software, selection of algorithm, and selection and preparation of logs. The pilot study had limitations as it was conducted on simulated data but it assisted the researcher to gain hands-on experience in conducting process mining. The simulation data was related to procurement process which created similar process paths as could be expected during actual phase of data collection.

## 3.11 Summary

The research approach that has been adopted for this research has been set out in this chapter. The methods which have been followed for attain the aim of this research have been discussed along with justifications for choosing those methods. This research can be replicated by following the road map that has been laid out in this chapter. The chapters begin with evaluation of philosophical perspectives that researchers take into consideration. Then a range of research methods relevant for conducting research in the field of IS has been considered and the justification for selecting mixed method approach have been stated. Then, a number of research strategies has been discussed and the reasons for selecting case study approach have been explained. In the subsequent section, detailed discussion took place with respect to case study research strategy. This research has been conducted following the DSRM and as such various aspects associated with DSRM have been discussed in great details. The design of the research has been clearly set out along with diagrammatic representation in the Research Design section where the artefact developed in this research, which is the method for measuring internal fraud risk, has been laid out. Then the chapter focused on the data collection techniques and data analysis techniques which have been relied upon for developing a new internal fraud risk measurement method suing process mining and Bayesian theorem. Finally, detailed discussion of the pilot study conducted prior to the actual research has been stated.

# 4.0 Case Study Findings

## 4.1 Overview

This chapter includes detail findings with respect to each of the three case studies which have been conducted for this research. Section 4.2 focuses on the findings of Case Study 1 conducted on Company A. Then Section 4.3 and Section 4.4 respectively focus on Case Study 2 and Case Study 3. Each part starts with an overview of the organisation on which the case study has been conducted. The next part includes description of the procurement process of the case company which has been mapped using Business Process Modelling Notation (BPMN) based on qualitative data obtained through semi-structured interview of the internal auditors of respective organisations. Then the fraud risk of the relevant case company, based on historic frequency, has been stated with detailed discussion. Historic frequency had been calculated manually by quantifying the number of process deviation identified by way of random process compliance inspection done by auditors in each of those case companies. Figures were obtained for multiple years with a view to depicting the range of fraud risk. Then, in the next section, detailed discussion about the data obtained through process mining with respect to the number of deviated processes in the relevant case company has been included. Number of deviated processes has been identified with the help of process mining software. Then detailed description has been given of how a revised measurement of fraud risk was arrived at by employing Bayesian theorem. A simplified Bayesian formula has been relied upon which considered Rate of Process Deviation based on historic frequency, Fraud Risk based on historic frequency, and Rate of Process Deviation based on process mining. This offered a refined measure of fraud risk for each case company. Findings with respect to each of the case company has been discussed under separate headings.

## 4.2 Findings of Case Study 1

### 4.2.1 Overview of Company A

A clothing manufacture is selected as the first case study as one of the objectives of the research was to evaluate the general applicability of the method across manufacturing, logistics, and service industry. Garment manufacturing is a vital manufacturing sector in the selected country, Bangladesh, for the purpose of the research (Islam & Liang, 2010). Bangladesh started exporting RMG at a yearly value of US$32 million in 1983-84 but experienced a non-stop huge growth which resulted in an almost US$18,000 million of export value of RMG in 2011-12 (Asgari & Hoque, 2013). The export value of RMG out of whole exports was nearly 76% in 2008 and 79% in 2012 (Asgari & Hoque, 2013). Because of this, companies operating within this area must then be able to apply business plans that would help bear the growth of the clothing sector. This means that by altering some of the current business processes of the apparel companies, such as their procurement process, continuous progress and development in the industry may be observed (Islam & Liang, 2010).

A garment manufacturing company has been selected for the purpose of the research. The selected company, which is referred to as 'Company A' hereafter is using SAP as an integrated ERP system to execute their business process. Activities of Company A can be divided into two categories: one is primary activities and another is support activities. The primary activities are logistics, internal operations, marketing and sales, and service. Logistics (incoming) activities are comprised of functions such as receiving input and resources and storing them until they are being utilised for the value creating process. Internal Operations activities are hose which focus on the conversion of inputs to goods to be sold. Logistics (outgoing) activities are concerned about the path from production to delivery customer including warehousing and distributing. Marketing and sales activities aim at creating demand for the manufactured or delivered good or service. Service activities signify the customer support and service later delivery of goods or services, with claims handling.

These primary activities have impact upon the operational and financial performance of the company. The primary activities are reinforced by support activities, also contributing to a higher margin when performed efficiently. The key focus is on the procurement process

which is a primary activity at Company A. The material source selection information and details of material procured is updated in this process. These activities focus on purchasing raw material, supplies, equipment, spare materials etc. At company A, all business processes are integrated in a significant degree of IT. A significant amount of revenue is spent by the procurement department. The department is responsible for around USD 20.4 millions of materials every year. The nature of the functions performed by the procurement department demands some internal control to be put in place. The initial interview of the domain expert of Company A has revealed the prescribed process paths and the internal control mechanisms which are in place.

### 4.2.2 Procurement Process

The first phase of interview with Company A took place where the key objective was to be able to generate procurement process map. Members of the internal audit team, composed of 4 members - Senior Internal Audit Officer, two Junior Internal Audit Officers, and a Trainee Officer, were interviewed. The Trainee Officer was present during the interview but did not actively take part in it. The interview took place at the head office premises of Company A. It took place before data were extracted from the ERP System and analysed. The semi-structured interview had been designed to gain in-depth understanding of the business process and internal control (Appendix – E: Session - 1). The data gathered during the semi-structured interview was then analysed to generate BPMN diagram.

The Company A has got a procurement department along with a team which is responsible for monitoring the procurement activities with due care to any potential fraud or malpractice. A purchase is triggered by an internal request. The request will be directed to the Subject Expert of the desired object. This Subject Expert fills out a Purchase Request Form that is handed over to one of Procurement Officers. There are about 20 Subject Experts and 3 Procurement Officers within Company A who are scattered over a four business lines. The business lines are divided into four categories: raw materials; machineries; human resource related procurement; and IT related procurement. The designated Subject Expert then takes necessary action for obtaining quotations for selected item from a number of enlisted suppliers by sending over an Expression of Interest for Purchasing (EIP). The Subject Expert is responsible for assessing that the price and

description of items are satisfactory and selects on of the suppliers. A Purchase Order is then created which is the first formal process instance formally logged into the SAP.

The Purchase Order has to be approved by either the procurement manager, if the amount is not exceeding USD 100,000. Approval of the CEO will be required if the order amount exceeds USD 100,000. The approval is obtained in the form of electronic approval which is described as signature. Then the PO is marked as 'released' by the Subject Expert once the PO is formally sent out to the intended supplier. The PO is then sent out to the supplier. The supplier takes necessary actions for delivering the items. The goods are then received at the warehouse and the procurement department receives a description of the items along with an invoice from the supplier. The designated Subject Expert examines the items and recommends a Procurement Officer to mark the goods as received electronically in SAP. The invoice is then forwarded to the accounts department who then marks the invoice as received on SAP and takes necessary actions for releasing payment.

The responsible members of staff from the accounts department them marks the payment as completed in SAP once the payment is made. It can be observed that from the creation of PO to the making of Payment there are several internal control mechanisms in place. First of all, a signature is required prior to sending out a PO. So same person should not both 'Sign' and 'Release' a PO according to the stipulated process path. Similarly, the goods cannot be marked as received by the Subject Expert who has been dealing with suppliers. Goods Received function should be performed by a person, ideally the Procurement Officer, other than who was responsible for creating the PO. Similarly, the person marking goods as received should be different from someone who makes the payment. The entire procurement process of Company A has been represented in Diagram 4.1 which has been generated using BPMN.

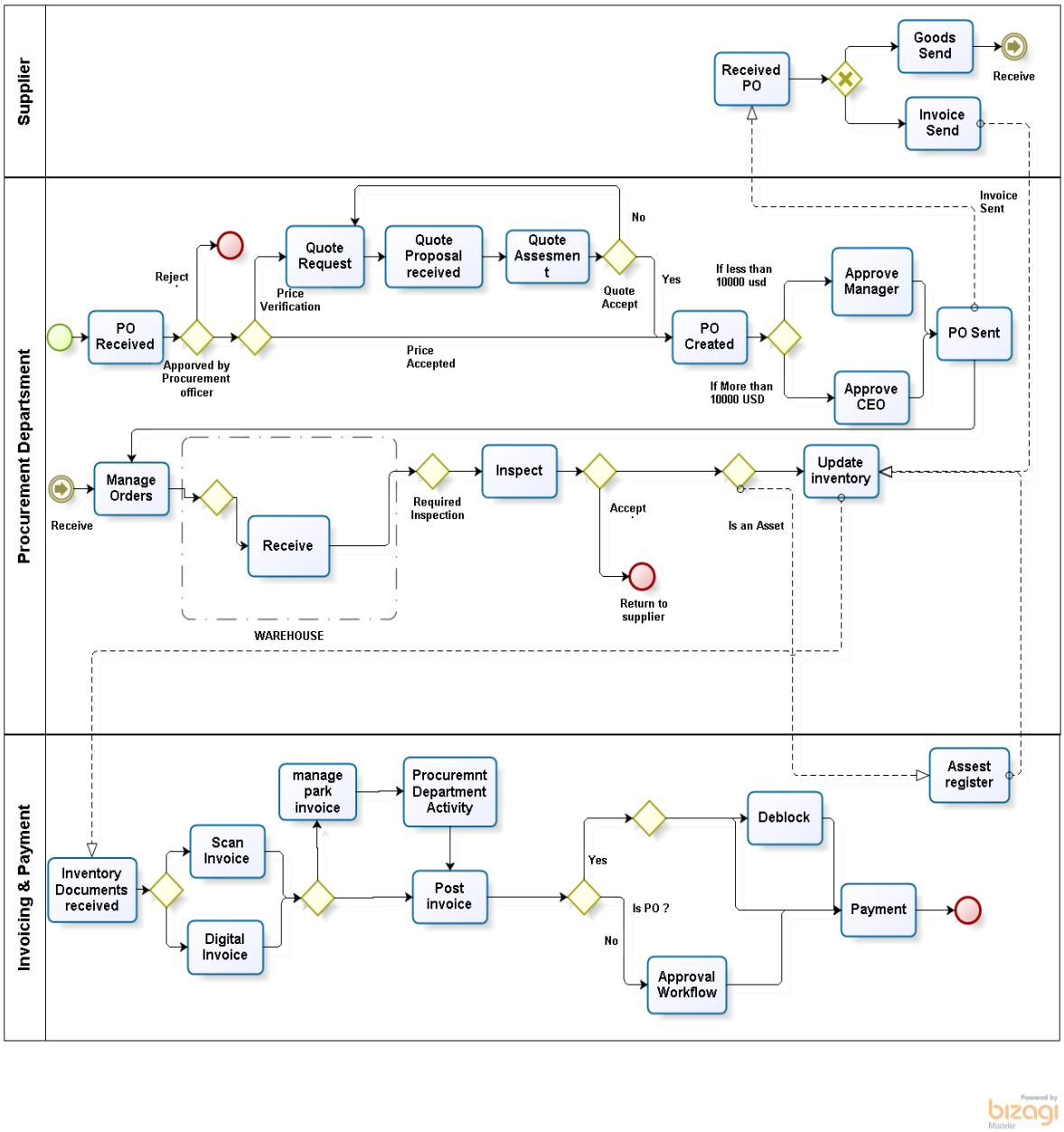


Diagram 4.1: Procurement process of Case-A represented on a BPMN Diagram

### 4.2.3 Fraud Risk based on historic Frequency

Auditors may identify a range of fraud risk factors such as industry/ competitive position, quality of the internal control system, financial condition, and pressure to meet financial targets (Mock & Turner, 2005). The key responsibilities of an auditor are to review the ongoing economic activities of an entity and to evaluate the level of conformity of the accounting entries (Petrascu & Tieanu, 2014). The internal auditor of Company A identified a number of fraud risk factors which primarily focused on the issues related to internal control system. It has been stated that the key focus for detecting fraudulent activities with respect

to procurement activities at Company A is on assessing two types of internal control: the authorisation control and the control of the transactions carry out. The person authorising a transaction is at the centre of authorisation control where any document must be authorised by an appropriate person (Daniella & Attila, 2013). Internal auditors primarily relied upon identifying transactions related to procurement activity which are of high amount from the logs of the ERP system with a view to scrutinise whether or not the transaction in question had been duly authorised by concerned member of staff. Internal auditors use a red flag system to high light if any sign of nonconformity is present and carries out an investigation. This may involve going through documentations or even interviewing associated personnel. The control of the transactions carried out involves inspecting random procurement related transactions from the log with a view to inspecting transactions for any sign of nonconformity.

The number of deviations identified based on such internal control system has been analysed with a view to obtaining a reasonable value that can be relied upon in the Bayesian theorem. It has transpired that a total of 157 procurement related cases had been shortlisted in 2015 for the purpose of exercising internal control. The total number of cases logged in the SAP system of Company A stood at 15,256. The 157 procurement cases were originated by 68 employees and among the 157 cases there were 1196 events that the log of the SAP system registered. Each of these 1,196 events were scrutinized of anomalies and deviations. This is one of the key determinants of fraud risks, though a word of caution must be stated that the severity or frequency of process deviation is by no means a direct representation of fraud risk. Rather process deviation combined with fraudulent intent and activity is the true measure of fraud risk. The criteria for short listing cases for conformance checking were internally developed methods which focused on processes with high historical frequency of actual occurrence of fraud that were discovered in past years and also departments with higher incidence of fraudulent activities historically were of particular focus. The methods were not fool-proof and could have been sources of biases into the system of internal control due to somewhat ad hoc sampling and influence of prejudices among the internal audit members into the sampling processes. The thought-process of the internal audit team that fraud is often rampant within pockets of authenticators and originators of procurement cases is not wrong, but rather is true as evident in the wider

economy. However, the sampling process seems to be weak and victim of its own argument by missing out these 'pockets' due to inadequate sampling.

Among the 157 cases, 16 cases had deviated processes from the prescribed business process under normal conditions. This is a realisation of about 10.5% deviation among the sampled events. Historical rates of process deviation as revealed by the internal audit team, based on similar surveys, were 13.7%, 11.6%, 9.7% and 8.8%% for the years 2011, 2012, 2013 and 2014 respectively (Table 4.1). A slight downward trend together with random shocks can be seen within the time-series data, however, analysis of that remains outside the scope of this research. The internal audit team, for 2015, further inspected closely the 16 cases for signs of any fraudulent activity, attempt or intent through various stipulated audit procedures and have discovered 1 case with successful fraudulent transaction and 1 case of unsuccessful attempt of fraudulent transaction. Apart from these 2 cases there have been 2 cases of reports of fraudulent activities from honest whistleblowing employees against their superintendents, neither of which fell within the 157 cases for survey shortlisted by the internal audit team in 2015. The cases of whistleblowing are out of the sample used by the internal audit team and hence are not eligible for computation of any sample statistic. Also, the whistleblowing cases could be considered as outlier for the purpose of this study as the last case of whistleblowing before these two was back in 2009.

| Year | Sample Size | Process Deviations | Process Deviation Rate | Frauds | Fraud Risk | Fraud-to-Deviation Ratio | Correlation |
|---|---|---|---|---|---|---|---|
| 2011 | N/A | N/A | 13.7% | N/A | 1.3% | 9.5% | |
| 2012 | N/A | N/A | 11.6% | N/A | 1.2% | 10.3% | |
| 2013 | N/A | N/A | 9.7% | N/A | 0.8% | 8.2% | 0.67 |
| 2014 | N/A | N/A | 8.8% | N/A | 1.0% | 11.4% | |
| 2015 | 157 | 16 | 10.2% | 2 | 1.3% | 12.5% | |

Table 4.1: Fraud risk measurement statistics obtained manually

2 incidents of fraudulent activity or attempt among a sample size of 157 cases equals to about 1.3% rate of fraudulent events. This is a direct measure of fraud risk and is the focus of this research. Given that this rate of fraud is found out through traditional internal control procedures applied at Company A, it is the prime focus of this research and one of the key desired outcome of this research is to update this measure of fraud risk in light of the evidence gathered through process mining to better reflect fraud risk within the

country, and in process find out the imbalances and inadequacies that may have been present in the conventional measure of fraud risk. Fraud risk, measured this way, was 1.3%, 1.2%, 0.8% and 1.0% respectively for the years 2011, 2012, 2013 and 2014. Fraud risk, like its counterpart Process Deviation rate, shows slight downward trend with random shocks. The correlation between these two rates is visible, at about 0.67, which is the Pearson product-moment correlation coefficient of the Process Deviation Rate and Fraud Risk rate of each of the five years of data available. However, due to only five data points, the correlation is not very reliable statistically. However, based on expert opinion of the internal audit team at Company A, the correlation is most likely to be actually high in reality, and is the basis for designing fraud risk assessment techniques within internal control procedures of the company around the more 'risky' deviations in events and processes from the ideal business process design. That is to say, process deviations are the most likely candidates to look for fraudulent activities according to the internal control team. This is also one of the key premise of this research, as will be further discussed in Section 4.1.5 when updating the fraud risk of Company A for the year 2015 upon evidence of updated Process Deviation Rate assessed from the Process Mining procedures employed in the framework for this research.

It must be noted that the fraud risk rate of 1.3% is based on per case basis, rather than a per event basis, and both the incidents of fraud in 2015, excluding the two cases of whistleblowing, were from different procurement cases. Where not specifically mentioned, fraud risk will be stated on a case-basis for the latter part of this study. As has been notified by the internal audit team, there have been cases of multiple event fraud conducted by multiple employees within the same case in the past.

### 4.2.4 Results Obtained Through Process Mining

All the processes instances which have taken place during 2015 have been taken into consideration for the purpose of conducting process mining. The time stamp was selected 'Create PO' in 2015. The cleaning of logs was conducted by using 'Pay' which means that all activities after the last 'Pay' had been performed were cut-off. The total number of cases recorded in 2015 is 15,256 which are comprised of 123,212 events. The selected events have been classed into seven types and a total of 147 originators were involved. The case with minimum number of events was comprised of 3 events whereas 266 events took place with respect to the case with highest number of events. The average number of events is 8

for the selected cases. The process mining has been conducted using ProM 6 software. Performance Sequence Analysis plugin has been relied upon for observing patterns of the selected event logs. A total of 123 patterns have merged which are unique with respect to aspects such as process path, time, and originators. 5 patterns are responsible for about 85 % of the data set. It can be commented that the noise level is quite high as there are 123 patterns presented in the system whereas most transactions should have followed stipulated process paths conforming to the path described by internal auditor during the preliminary interview. A Fuzzy Miner algorithm has been selected for the purpose of this research for tackling the problem of noise as it is capable of dealing with situation where high amount of anomalies are present (Gunther & Van der Aalst, 2007).

A Fuzzy Miner algorithm is run with the default settings of 0.20 for the selected cases in ProM software. This reveals the most frequent path that has been followed by the cases. The most frequent path has been depicted in Figure 4.1 which is Create PO-Signed-Release PO-Goods Received-Invoice Received-Pay. There are some cases which have digressed can be observed but such digressions are allowed to take place as in realty process steps may not happen sequentially for practical reasons. The patterns which have been discussed above appear to be similar to those process paths which have been stipulated by domain experts of Company A. Now the main focus has to be turned to most infrequent patterns in light of the existing fraud risk literature where it is agreed that most usual process paths are unlikely to be linked to fraudulent activities. The infrequent data sets can be comprised of large number of cases although 5 patterns are responsible for 85% of the data set which will be excluded while dealing with infrequent patterns. Now the operation of Fuzzy Miner algorithm in default status reveals the most frequent paths based on frequency based significance and correlation.

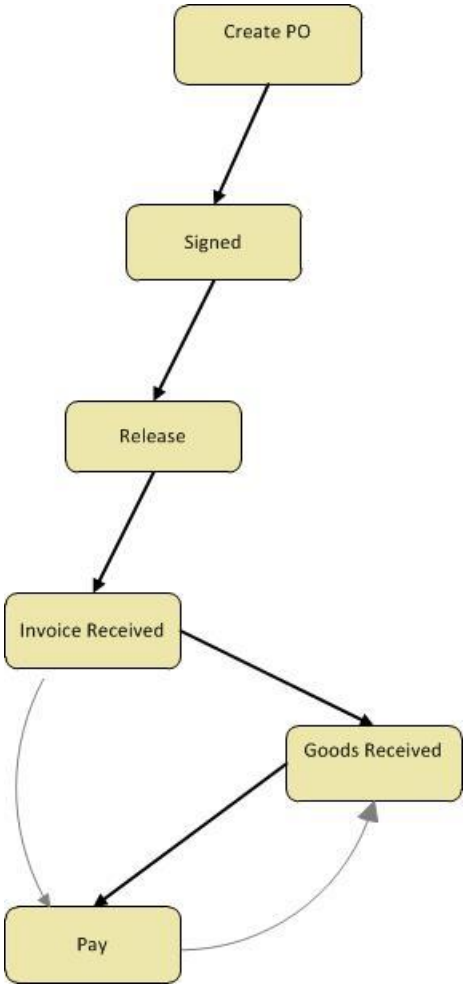


Figure 4.1: Fuzzy mining default settings screen shot for Company A

Now lowering the threshold should allow observing more flows which are infrequent. This can be done by adjusting the 'Cut-off' edge. The 'Cut-off' edge filter value of 0.80 has revealed four extra flows (Figure 4.2). The four extra flows are: Create PO-Release; Release PO-Pay; Release PO-Invoice Received; and Create PO-Goods Received. It is of immense significance to analyse why these infrequent patterns might have emerged. It appears that in a Create PO-Release PO flow a signature was not obtained from an authorised person i.e. Procurement manager or CEO. This flags up a potential deviation of stipulated process path. The Release PO-Pay flow is also a potential deviation as payment should not be made without having received an invoice. The Release PO-Invoice Received flow may happen when payment is required prior to shipment of the goods by a supplier. The Create PO-Goods Received flow gives rise to suspicion as it flouts the requirement for obtaining signature from an authorised person. The infrequent flows do not imply that those are

related to fraudulent activities but they demand scrutiny as they may be susceptible to fraudulent activities.

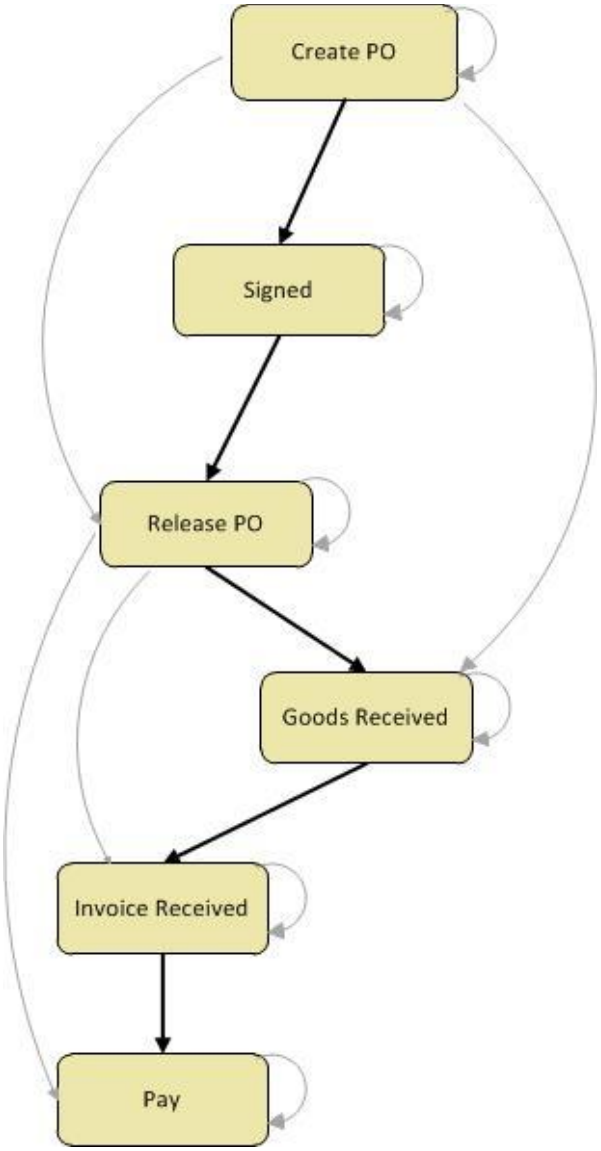


Figure 4.2: Fuzzy mining screen shot of ‘cut-off .80’ for Company A

Now it is important to segregate the cases which have followed the unusual process path. The final interview with the internal auditor revealed that a procurement process completed without obtaining the signature of an authorised person is inexplicable and should not have occurred. This means that the flows Create PO-Release PO and Create Po-Goods Received are not compliant with approved process sequence. All other infrequent or unusual flows, such as Release PO-Pay and Release PO-Invoice Received, were regarded as necessary for practical reasons.

It has surfaced that Company A has flows such as Create PO-Release PO and Create Po-Goods Received which could only happen if the value of the item being procured is a minimum stipulated amount and the supplier is enlisted with Company A. That means a signature is not required only when PO document has a maximum value of 'X' and is being sent to a supplier who is enlisted (Supplier – '1.0'). These properties were checked using LTL Checker in the process mining software. The LTL checker is a feature of ProM software and these properties were inserted by using few simple steps. The results produced by the LTL Checker revealed that a total of 897 cases were registered which did not follow all the conditions. 18 originators were associated with the 897 cases. It can therefore be said that a total of 897 cases out of 15,256 procurement related cases registered in the SAP system of Company A deviated from the designed process paths (Table 4.2). There can be other cases which might have deviated from stipulated process paths but these are some processes which have been filtered out by conducting process mining. Now these deviations may involve fraudulent activities which can be evaluated by taking necessary actions for conducting fraud investigation.

| Year | Sample Size | Process Deviations | Process Deviation Rate |
|---|---|---|---|
| 2011 | N/A | N/A | *13.7%* |
| 2012 | N/A | N/A | *11.6%* |
| 2013 | N/A | N/A | *9.7%* |
| 2014 | N/A | N/A | *8.8%* |
| 2015 | 157 | 16 | *10.2%* |
| PM | 15,256 | 897 | *5.9%* |

Table 4.2: Comparative process deviation statistics

Process mining procedures employed in this research provides an updated and improved statistic for Process Deviation rate. The intuition is that Process Mining provides a more comprehensive statistic for Process Deviation rate compared to the sampling procedures stipulated by the framework used conventionally by the internal audit team of Company A. Since the process mining procedure do not directly measure fraud risk, a Bayesian Framework for updating fraud risk is more appropriate. If the process mining tools were able to directly detect fraudulent activities and attempts, measure of fraud risk found through using conventional internal audit procedures could have been directly replaced by that found during process mining. However, being an indirect measurement technique of

likelihood of fraud risk, the process mining tool only provides updated information regarding fraud risk, and hence demands a Bayesian framework for updating such risk.

### 4.2.5 Outcome of Case Study

The fraud risk as found by the internal audit team using conventional sampling methods was 1.3% for the year 2015. The process deviation rate, using the same method, was found to be 10.2%. The process mining procedures, with its theoretically more comprehensive and rule-based unbiased sampling method, however, has found the process deviation rate for 2015 to be 5.9%, rate that is lower than what was believed to be true earlier. Since the process mining procedures do not directly measure fraud risk the evidence of a lower than expected process deviation rate should be reflected within an updated figure for fraud risk. Here, the Bayesian theorem is used to update the probabilities for fraud risk. Hence the new fraud risk is found as:

Revised Fraud Risk = (Rate of Process Deviation $_{\text{Process Mining}}$ x Fraud Risk $_{\text{Conventional Internal Audit}}$) / Rate of Process Deviation $_{\text{Conventional Internal Audit}}$

Therefore, Revised Fraud Risk = (5.9% x 1.3%) / 10.2% = 0.75%

It can be seen that the revised fraud risk, at 0.75%, is lower than the earlier estimate of fraud risk at 1.1%. This is due to the fact that Rate of Process Deviation, as found using process mining, is evidenced to be lower than that found using conventional internal audit procedures. One crucial assumption implicitly made when utilising the Bayesian framework in this case is that Rate of Process Deviation and Fraud Risks are perfectly correlated. Though this may not be the case always, expert opinion from the internal audit team of Company A as well as other companies suggests a strong correlation between these two variables of interest.

## 4.3 Findings of Case Study 2

### 4.3.1 Overview of Company B

A pharmaceutical company has been selected for conducting the second case study with a view to evaluating the applicability of Bayesian theorem using process mining techniques for measuring fraud risk within procurement department. Pharmaceutical industry is one of the most significant manufacturing industries in Bangladesh which has been marked with robust growth over the past few years (Shawon, 2011). The reason for selecting a pharmaceutical company for the purpose of this research is that pharmaceutical companies have to procure materials ensuring rigorous quality control and high level of regulatory compliance. The procurement process is thus often a complex one which demands use of IT systems.

The selected company has been referred to as 'Company B' hereafter is one of the largest pharmaceutical companies in Bangladesh and has recently emerged as a high performance global player. Company B has adopted ERP system in 2008 and it currently has a fully integrated Oracle ERP system. Company B has several production plants within its boundary with a highly sophisticated warehouse. Procurement is one of the core functions within the management structure. Pharmaceuticals industry in Bangladesh is heavily reliant upon raw materials imported from abroad as the supply chain has not fully developed within the country (Bhadra, 2017). The procurement department is responsible for procuring a range of materials and services including chemicals, medicinal items, machineries, parts, packaging and bottling materials, and services. Company B has a highly sophisticated warehouse which is maintained by the procurement department.

### 4.3.2 Procurement Process

The first phase of interview with Company B took place where the key objective was to be able to generate procurement process map. The internal audit team is structured in a flat style with three Internal Audit Associates reporting directly to the Chief Financial Officer. All three Audit Associates took part in the semi-structured interview which was designed to gain information regarding procurement process and internal control system. The interview took place at the factory office of Company B in the outskirts of the city. It took place before data were extracted from the ERP System and analysed. The data gathered during the semi-structured interview was then analysed to generate BPMN diagram for Company B (Appendix – F: Session - 1).

Company B has a procurement department which is comprised of several sections. The procurement committee, which is comprised of several board members, CEO, and the Procurement Manager, is responsible for overseeing the activities of the department. The committee is also responsible for authorising procurement purchases worth over USD 100,000. The department is headed by the Procurement Manager who is responsible for managing the team and liaising between the committee and the procurement department. The Procurement Manager has the authority to approve any purchase which is USD 100,000 or less. There are 35 Procurement Specialists who work within the department. Each Procurement Specialist has expertise with respect to specific items that has to be procured. The total number of employees within the department is 120. There are two key methods of procurement which are relied upon by Company B. The most common procurement method is to obtain quotation for items which are already being supplied by enlisted suppliers. Tendering is the other method that is relied upon for procuring items which are new or significantly valuable. Both methods have their own processes path that is followed by the personnel working within the procurement department.

The procurement process is initiated by a requisition request (RR) from a department. The procurement team then analyses RR and assigns the RR to be dealt with a Procurement Specialist who has expertise regarding procuring that item. The Procurement Specialist will then evaluate the RR and select the appropriate procurement strategy. The item can be procured from an enlisted supplier by obtaining a price quotation or it can be procured by way of open tendering method. The procurement process for procuring from an enlisted supplier is comparatively simpler which involves few steps such as obtaining price quotation, price negotiation, and creating of purchase order (PO). Approval of the Procurement Manager is required for placing orders of value up to USD 100,000. Approval of the procurement committee is required for orders with a value of more than USD 100,000. The PO is sent out to the selected supplier once it is approved by authorized person or body. An inventory document is received from the supplier in due course which is then followed by a pre-shipment inspection of the goods. The approval of the technical expert, assigned for procuring the specific item, is the required. The technical expert approves the goods to be shipped if the goods pass quality check and then the accounts

department is notified. The accounts department then takes necessary actions for making the payment.

The Procurement Specialist can also select tender as the appropriate method for completing the procurement. Tendering involves several steps. Firstly, tender documents are prepared in consultation with technical expert. The tender is called for on various platforms. The tender then closes on a specific date once tenders are solicited from at least three suppliers. The Procurement Specialist then evaluates the tender documents with specific attention to quality and specifications of the required items. The lowest bidder is then short-listed and the tender documents are forwarded to financial experts for consultation. The tender is then awarded after having obtained the approval of either the Procurement Manager, if USD 100,000 or less, or by the procurement committee. The body who is awarded the tender is then responsible for sending inventory documents. The subsequent steps are then similar to that of procurement from existing supplier through quotation. The entire procurement process of Company B has been showed in Diagram 4.2 below which has been produced using BPMN.

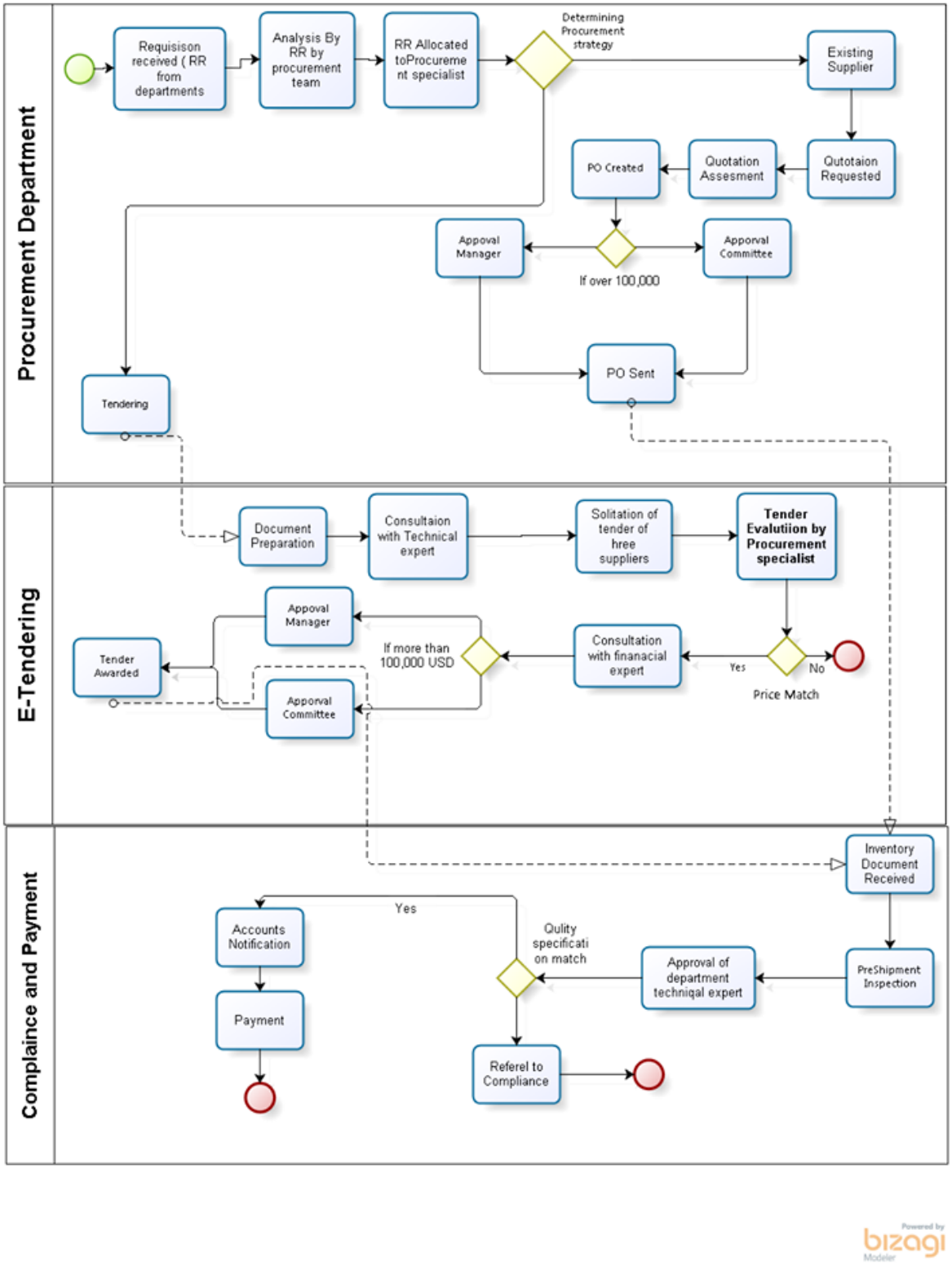


Diagram 4.2: Procurement process of Case-B represented on a BPMN Diagram

### 4.3.3 Fraud Risk based on Historic Frequency

The focus of external auditors is mainly related to the providing assurance for the financial statements prepared. Hence many details of operations and processes do not get the same level of attention from external audit, which is why internal audit is often termed as operational audit (Institute of Chartered Accountants in England and Wales, 2009). The Accounts & Finance Department of Company B has a three-member exclusive team of internal auditors, all of whom have had previous professional exposure of working in audit firms. The team carries out periodic internal audits round the year, randomly selecting departments and relevant committees for audit. The primary sources of information for the internal audit team are the logs generated by the Oracle ERP system and in-person interview of employees and committee members. At times, the team goes a step further by investigating external stakeholders such as suppliers, brokers and participants of tenders. The management of Company B adopted the paperless office format for its Head and Branch offices since 2012 and hence most of the documentations are available electronically within the ERP System. Hence the internal audit team has segregated the instances of process deviation and accounting and operational red flags into electronic ERP log and documentation data and qualitative interview data. For the purpose of this study only the electronic data are relied upon as the process mining artefact cannot effectively fit qualitative records within its working model.

In 2015, 227 procurement cases were randomly selected for internal audit throughout the year, among 29,546 actual cases of procurement in Company B for 2015 as logged in by the Oracle ERP System. The 227 cases generated 1,882 events within the event log of the ERP system. The 227 cases were originated by 13 employees and had got initial approval from 23 Procurement Specialists. Out of the 227 cases, 5 cases received authorisation from the Procurement Committee, 233 were authorised by the Procurement Manager and the rest were authorised by mid-level manager of the Procurement Department. Among the 227 procurement cases analysed, the internal audit team identified 32 instances of process deviation. These 32 cases were investigated on a case-by-case basis by the internal audit team, first by looking into the electronic documentations and interviewing internal stakeholders, and then, if necessary and possible, it concluded with interviewing external stakeholders. Upon investigation by the internal audit team it was found that 12 cases

among the 32 deviant cases presented evidence of fraud or attempt or intent of fraud. All these cases of fraudulent events were dealt separately and necessary actions such as warnings, termination and legal actions were taken for each case appropriately.

Though the process mining artefact of this research cannot identify directly if an event had been of fraudulent nature, it however, can find out an objective measure of susceptibility to fraudulence within a group of events by looking at the incidence of process deviation. The premise of this approach is that Rate of Process Deviation is an indirect measure of fraudulence, and depending on the capacity and intentions of an internal audit team, the all or part of the processes-deviant events could be forwarded for further investigation of fraud. Due to having a dedicated internal audit team, Company B is in a good position to perform a thorough check for all the process-deviant events for further investigations while still being ill-equipped to check for process deviance among all the events generated by the event log of the ERP System. This difference in capacities within the internal audit team is one of the facets where the process mining artefact can contribute value to a business.

For Company B the rate of fraud for 2015 was 5.29% (12 fraudulent events among 227 sampled events) and the rate of process deviation was 14.10% (32 events out of 227 sampled events). As revealed by the internal audit team the rates of fraud and process deviations were 3.86% and 15.02% for 2014, 3.81% and 15.71% for 2013, 6.11% and 15.56% for 2012, 9.71% and 22.29% for 2011, 7.98% and 23.94% for 2010 and 10.23% and 25.00% for 2009 (Table 4.3). As these data are compiled on an annual basis and record keeping of such data only began in 2009 after the implementation of ERP System, any statistically significant relationship between fraud rate and process deviation rate cannot be confirmed due to lack of data points. Only a nominal correlation of 0.90 was found. There were no cases of whistleblowing or any other out-of-sample identification of fraudulent activities for the period of study (2009-2015).

| Year | Sample Size | Process Deviations | Process Deviation Rate | Frauds | Fraud Risk | Fraud-to-Deviation Ratio | Correlation |
|---|---|---|---|---|---|---|---|
| 2009 | 176 | 44 | 25.00% | 18 | 10.23% | 40.9% | |
| 2010 | 188 | 45 | 23.94% | 15 | 7.98% | 33.3% | |
| 2011 | 175 | 39 | 22.29% | 17 | 9.71% | 43.6% | |
| 2012 | 180 | 28 | 15.56% | 11 | 6.11% | 39.3% | 0.90 |
| 2013 | 210 | 33 | 15.71% | 8 | 3.81% | 24.2% | |
| 2014 | 233 | 35 | 15.02% | 9 | 3.86% | 25.7% | |
| 2015 | 227 | 32 | 14.10% | 12 | 5.29% | 37.5% | |

Table 4.3: Fraud risk measurement statistics obtained manually

Among the 32 cases identified having process deviation, 17 events had multiple process deviating events; and among 12 fraudulent procurement cases, 4 had multiple fraudulent events associated. This indicates the risk of pockets of fraudulent events bundled together, which if missed in the sampling round would mean missing out on large chunks of fraudulent activities within and across departments. This risk was first identified in case of Company A and has also been found to be prevalent for Company B. One of the key drawbacks of conventional sampling, be it totally random sampling (as was the case of Company B) or be it random sampling with informed tweaking (as evident in case of Company A) is the presence of pockets of fraud in the population. In case of tweaked random sampling, there is an additional risk of biasness. In conjugation, one of the key purpose of a process mining artefact for assessing fraudulent risk is to remove such sampling pitfalls and focus the resources of internal audit teams towards investigations of cases of process deviations.

### 4.3.4 Results Obtained Through Process Mining

The process instances which have taken place in 2015 had been selected for the purpose of process mining. The time stamp selected for Company B was ‘Create PO’ as all procurement processes which lead to an order being placed with a supplier are initiated by creating a purchase order. The event logs were cleaned using ‘Pay’ as that is the final step with respect to majority of the procurement processes within Company B. The total number of procurement cases which were recorded in the Oracle ERP system during 2015 was 29,546. These cases were comprised of 300,423 events. The events had been classified into 13 types and the total number of originators involved were 325. The case with minimum number of events had 2 events whereas the highest number of events with a case was 126 events. The

average number of events for each case is 10. Process mining conducted using Prom6 software revealed that 267 different types of process path patterns. Process Sequence Analysis was conducted with respect to the selected processes. More than 78% processes matched with 14 patterns. Fuzzy mining algorithm was relied upon to deal with the level of noise caused by the large number of different types of process path (Gunther & Van der Aalst, 2007).

The Fuzzy Mining algorithm assisted in identifying the most frequent path that has been followed by majority of the processes. The most frequent process path is initiated with PO Created followed by 'Approval', 'PO Sent', 'Inventory Document Received', 'Pre-Shipment Inspection, 'Approval of Experts', and 'Pay'. This has been depicted in Figure 4.3. Some of the process have digressed as it can be seen that 'Pre-Shipment Inspection' and 'Approval of Experts' were not a step in some of the processes. It appears that the reason for such digression was that some of the purchase were not subject Pre-Shipment Inspection or Approval of Experts. The showed process path presented in the figure is in line with the process path that has been stipulated by the internal auditor as revealed during interview. The Fuzzy Mining algorithm in default setting of 0.20 reveals the most frequent process path which can be presumed not to be subject to fraud risk in light of the fraud risk literature.

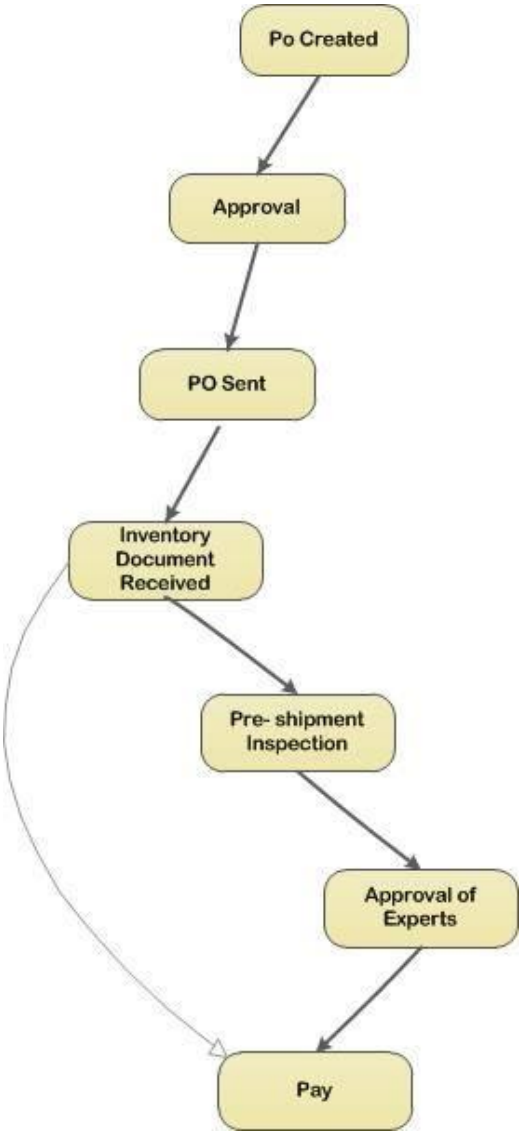


Figure 4.3: Fuzzy mining default settings screen shot for Company B

The Fuzzy mining algorithm is then run after having lowered the threshold. This has been done by adjusting the 'Cut-off' value downwards. The algorithm was run with the 'Cut-off' edge filter value adjusted to 0.80 which resulted in 4 extra flows appearing in the process path diagram as showed in Figure 4.4. The additional flows are: PO Created-PO Sent; Inventory Document Received-Approval of Experts; Inventory Document Received-Pay; and Pre-Shipment Inspection-Pay. These flows were not supposed to be present as these flows have resulted in process paths which did not match with any process path stipulated by the internal auditor. Some of these flows should have not been present. All purchases require approval either of the manager or the committee. However, PO Created-PO sent is a flow which indicates there are some cases which violated this fundamental norm. Therefore,

these cases demand investigation. Similarly, Inventory Document Received-Pay is a flow which should not have taken place as the general practice in Company B is to conduct pre-shipment inspection. Now the cases where this flow appeared might have legitimately occurred due to the nature of the items which were being procured but this should have been flagged up to the internal auditor.

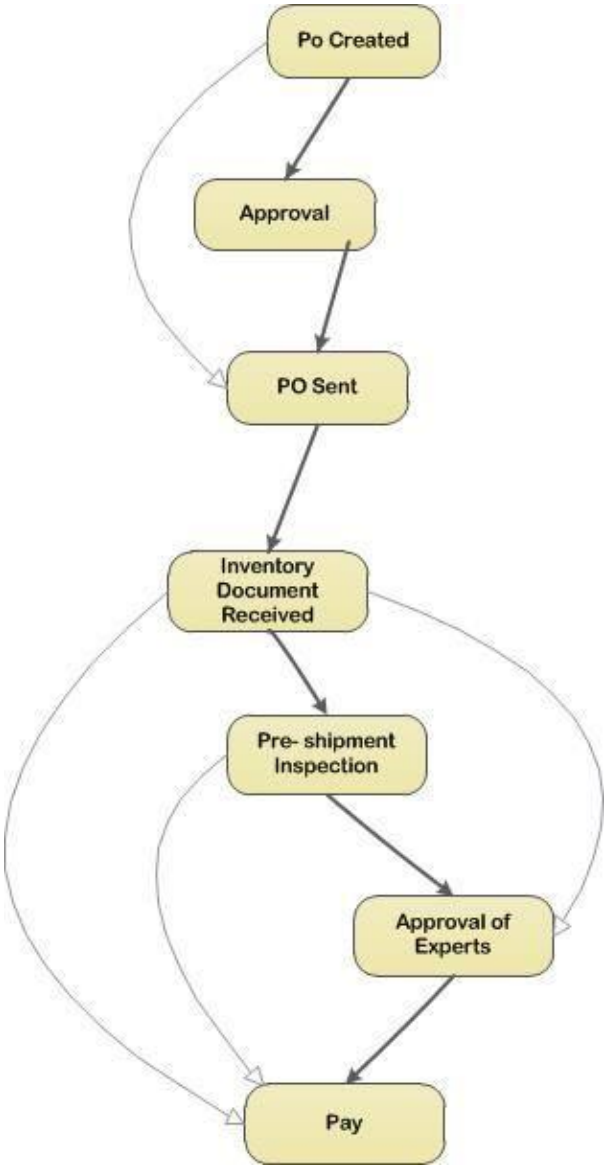


Figure 4.4: Fuzzy mining screen shot of 'cut of .80' for Company B

The additional flows which surfaced after having run the Fuzzy Mining algorithm has been presented to the internal auditor of Company B during the second interview. It has appeared that some of these flows have legitimately taken place. The Pre-Shipment-Pay flow can take place where the procured item is not a core raw material and is of nominal

value as Approval of Experts is not an essential step for such procurement process. Similarly, Inventory Document Received-Approval of Experts is a flow which occurs when physical inspect of items are not practicable to do. In that situation, a quality confirmation report is obtained either from the supplier or a third-party. Therefore, it can be assumed that some of the processes will exclude the 'Pre-shipment Inspection' step. However, it was revealed during the interview that PO Created-PO Sent and Inventory Document Received-Pay are two flows which should not have occurred with respect to any of the cases logged in the ERP system. PO Created-PO Sent is a flow that should not have occurred as approval is mandatory as per the internal control system. Inventory Document Received-Pay also should have not occurred as items which are not subject to physical inspections are likely to require approval of experts with respect to the quality control reports.

The attributes which could be present with respect to any given procurement process had been checked using the LTL Checker with the help of Prom6. The LTL Checker allows all the acceptable flows to be allowed to be accepted as compliance with stipulated process path. It was revealed that 4,978 cases among the selected cases deviated from the stipulated process paths as well as any additional flow that could be regarded to be acceptable by the internal control system of Company B. The cases which showed signs of deviation were filtered out from the total number of cases as opposed to from a limited sample size. It appears that 4,978 cases out of 29,546 cases which were logged during 2015 did not follow acceptable process path (Table 4.4). These 4,978 cases involved 27 originators who can be quizzed for the reasons of deviation. This has paved the way for measuring the process deviation rate from the total population of cases which are logged within the ERP system of Company B. The table below exhibits a comparison between the process deviation rate obtained manually and through process mining.

| Year | Sample Size | Process Deviations | Process Deviation Rate |
|---|---|---|---|
| 2009 | 176 | 44 | *25.00%* |
| 2010 | 188 | 45 | *23.94%* |
| 2011 | 175 | 39 | *22.29%* |
| 2012 | 180 | 28 | *15.56%* |
| 2013 | 210 | 33 | *15.71%* |
| 2014 | 233 | 35 | *15.02%* |
| 2015 | 227 | 32 | *14.10%* |
| PM | 29,546 | 4,978 | *16.85%* |

Table 4.4: Comparative process deviation statistics

### 4.3.5 Outcome of Case Study

The fraud risk as found by the internal audit team using conventional sampling methods was 5.29% for the year 2015. The process deviation rate, using the same method, was found to be 14.10%. The process mining procedures, with its theoretically more comprehensive and rule-based unbiased sampling method, however, has found the process deviation rate for 2015 to be 16.85%, a rate that is higher than what was believed to be true earlier. Since the process mining procedures do not directly measure fraud risk but susceptibility to fraud indirectly, the evidence of a higher than expected process deviation rate should be reflected within an updated figure for fraud risk. Here, the Bayesian theorem is used to update the probabilities for fraud risk. Hence the new fraud risk is found as:

Revised Fraud Risk = (Rate of Process Deviation $_{\text{Process Mining}}$ x Fraud Risk $_{\text{Conventional Internal Audit}}$) / Rate of Process Deviation $_{\text{Conventional Internal Audit}}$

Therefore, Revised Fraud Risk = (16.85% x 5.29%) / 14.10% = 6.32%

It can be seen that the revised fraud risk, at 6.32%, is higher than the earlier estimate of fraud risk at 5.29%. This is due to the fact that Rate of Process Deviation, as found using process mining, is evidenced to be higher than that found using sampling internal audit procedures. One crucial assumption implicitly made when utilising the Bayesian framework in this case is that Rate of Process Deviation and Fraud Risks are perfectly correlated. Though this may not be the case always, expert opinion from the internal audit team of Company B as well as other companies suggests a strong correlation between these two variables of interest.

## 4.4 Findings of Case Study 3

### 4.4.1 Overview of Company C

A third case study was conducted on an Airlines based in Bangladesh operating at both domestic and international routes. Like the previous case studies, the focus of this study was the procurements carried out by the airlines and the risk of fraud associated with the relevant processes. Airlines industry in Bangladesh currently has five players competing in the domestic as well as international routes. Though the number of industry participants suggests oligopolistic setting, due to small size of the industry compared to the economy, the competition is fierce. However, due to a growing economy and a growing per capita income the industry is seeing modest growth coupled with certain bottlenecks (Azad, 2016). Though the aviation sector is not one of great economic prominence for Bangladesh, especially compared to the Apparel and Healthcare sectors of the previous two cases, the reason for selecting a company from this sector is that in the past there has been a number of high profile corporate scandals and allegations of corruption within this sector in Bangladesh. Another reason for selection is the availability of data and technology-friendliness of the industry.

The selected company will be referred to as “Company C” from hereinafter. Though aircraft leasing is one of the crucial procurement and financial decision for any airlines, such decisions are infrequent and has special significance for the company and are under special set of scrutiny. More frequent cases of procurement are for tools and parts for scheduled and un-scheduled maintenance of aircrafts, together with regular consumption purchases such a fuel and other aircraft consumables and procurement of food and accessories for airline customer services as well as office supplies. Company C has an integrated ERP System from SAP SE, hereinafter mentioned as the ERP System. The system was installed in late 2011 and hence only four full years of data is available for the purpose of this study. During the four years there was no major purchase or lease agreement for new aircrafts, hence aircraft maintenance expenditures and customer services expenditure constituted most of the procurement activities in money terms.

### 4.4.2 Procurement Process

The first phase of interview with Company C took place where the key objective was to be able to generate procurement process map. The internal audit team is comprised of four members from the Accounts Department with two members rotated each year in a staggered manner and each member serving two years each. All the members are equally ranked for the purpose of internal audit. The team reports to the Chief Financial Officer and upon calling, directly to the Chief Executive Officer. The interview took place in the airlines' head office in the city. It took place before data were extracted from the ERP System and analysed (Appendix – G: Session - 1). The semi-structured interview had been designed to gain in-depth understanding of the business process and internal control system of the organisation. The data gathered during the semi-structured interview was then analysed to generate BPMN diagram for Company C.

Company C has a Purchase Committee consisting of three full-time executive members and two members from the company's Board of Directors, rotated every two years. The Committee is under the Supply Chain and Operations Department of the company, nonetheless the Committee has greater degree of autonomy compared to the rest of the departmental employees. The committee works more like an audit committee and is not involved in approving purchases. Company C usually procures under two distinct contractual structures. One is through Service Agreements with suppliers, where the service agreements are renewed annually by the Purchase Committee, and the procurements are usually passed and billed at the operational level, with periodic internal audit checks from the Accounts Department. The other contractual structure includes issuance of Request for Quotation (RFQ) to a list of suppliers pre-approved by the Procurement Committee; a list that is revised annually or more frequently in case of special circumstances. A Purchase Order has to be approved by the Procurement Manager before it can get to the next stage. Purchases amounting more than USD 50,000 require approval of the CEO whereas purchases over USD 500,000 require the approval of the board of directors.

For Company C, domestic flight includes 7 destinations excluding the hub. On its international routes, the offered destinations are concentrated in three regions, namely, South Asia, South East Asia and Middle East. The largest chunk of operating expense in Aircraft Fuel. For refuelling within Bangladesh there is just one National Monopoly in the country. For refuelling in overseas destinations Company C has Service Agreements with the

fuel suppliers of respective countries. The processes are routine and there has not been a change in Fuel Suppliers in the past 4 years.

Leaving Aircraft Fuel Purchase out of the equation, significant procurement activities which require revision or new procurement contract are mainly concentrated in Aircraft Maintenance through procurement of tools and parts and certain specialized services, and in Catering expenses as well as Administrative purchases for the various domestic and international offices of Company C. These procurements are usually done through the issuance of RFQ initiated by request from operational level. The RFQ documents are prepared by a team of technical and financial and legal experts. Technical experts contribute in setting the descriptions and attributes of the items to be procured whereas financial and legal experts deal with the compliance aspects. Company C follows a tendering procedure that includes solicitation of tenders, review of submitted tender forms, selection of a supplier, and awarding the tender to the selected supplier.

Aircraft Maintenance Tools and Parts as well as Catering Materials are inventorial costs, as per the financial accounts of the Company, while Administrative and Office Purchases are usually fully expensed. Hence, unlike Office purchases Tools and Parts and residual Catering materials are subject to an extra step of scrutiny of stock count during audit of the Company. The Maintenance, Repair & Overhaul (MRO) firms that are enlisted for providing Aircraft Maintenance Parts and Tools, as well as certain services, are mostly Small & Medium Enterprises (SME) and hence the list contains adequate number of firms entering in competitive bids when a RFQ is issued. While a competitive bidding environment provides competitive prices of the airlines, to make it to the list of trusted suppliers, the suppliers are required to fulfil some regulatory criteria including Airworthiness of Components provided, as per the requirement of the local Civil Aviation Authority. Hence making it to the enlisted supplier's group has a rigorous business process checks and balances form the Procurement Committee as well as the Internal Audit Team. Procurement of items which require approval of the regulatory body has to go through this additional step of obtaining clearance from regulatory body before a payment is released. The entire procurement process of Company C has been represented in Diagram 4.3.

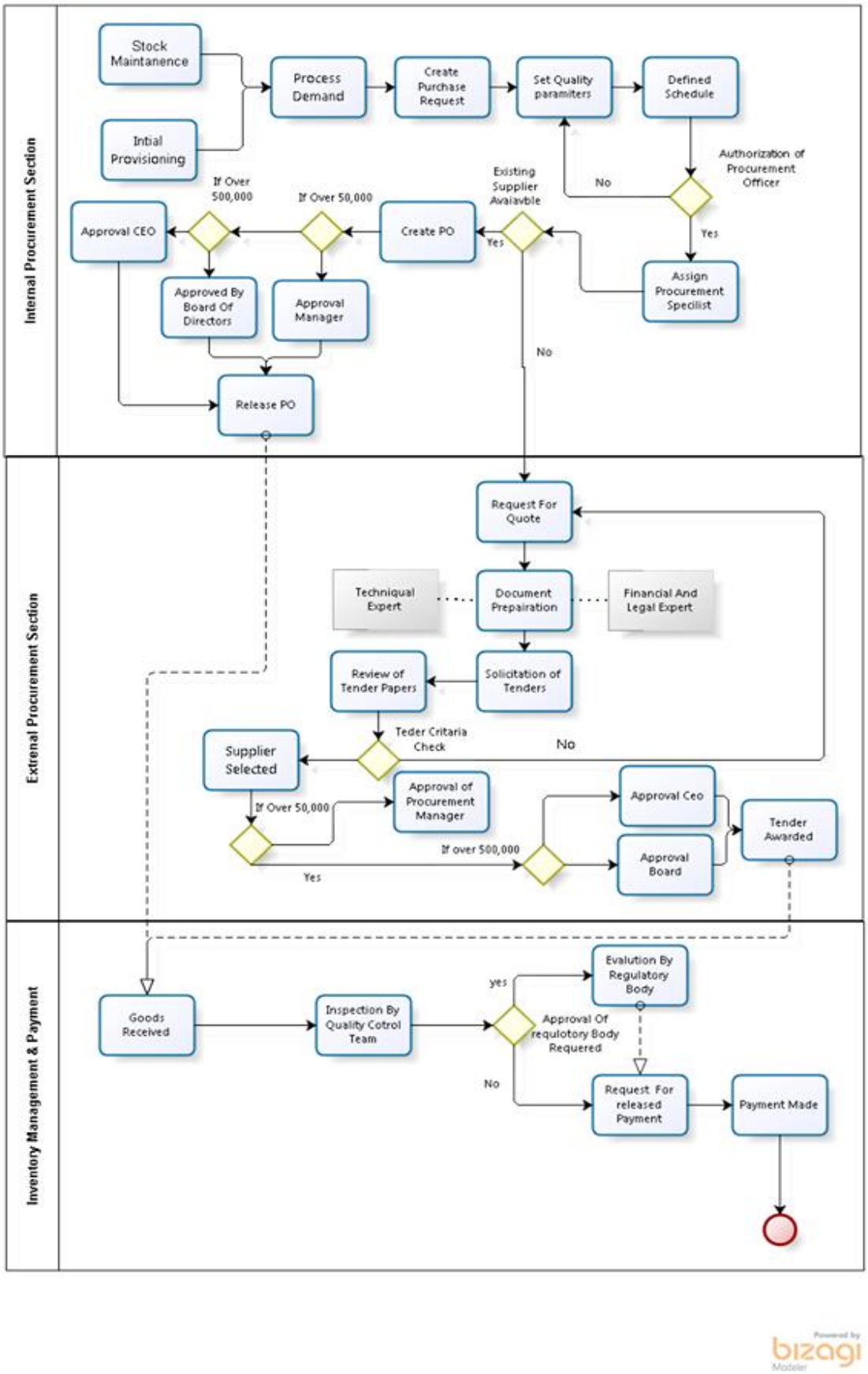


Figure 4.3: Procurement process of Case C represented on a BPMN Diagram

### 4.4.3 Fraud Risk based on Historic Frequency

Internal audit is carried out by the members of Accounts Department of Company C on periodic intervals and surprise visits as per the company's Internal Audit Policy. The internal audit team, formed annually with regular members from the Accounts Department, carry out routine and surprise checks for consistency in operational processes and authenticity of bills, vouchers and documents. Company C has SAP ERP System fully integrated with the processes of the Procurement Department since late 2011 and has full year data for the years from 2012 to 2015 for carrying out this research. The internal auditors have since been relying on mainly on the ERP System for data to carry out initial audit procedures. Also, the risk of any fraudulent activities within the organisation, and in association with any outside party, is assessed based on preliminary fraud check mechanisms employed by the Internal Audit Team carried out on the data given by the ERP System. Company C employs a similar strategy in finding out cases of fraud as Company A and B in the previous two Case Studies. That is, first the Internal Audit Team assesses the likelihood of fraud in certain cases through checking any deviation from Standard Operating Procedure Guideline (SOPG) of Company C and marks any case of process deviation as susceptible to fraud. The audit team further investigates the cases that were found to be deviant, among the sampled cases, in terms of the SOPG process routes for further internal audit checks and investigations on a case by case basis.

Being in a highly regulated industry, in recent years the Company has started to heavily on a system of checklist and flowcharts, as instructed in its SOPG, to maintain its rigorous compliance procedures. Indeed, the SOPG was formed only a year before implementing the ERP System. However, due to the recent implementation and lack of proper training among the operating members of the Company, the procedures have seen high degrees of process deviation due to human error or lack of understanding. This has plagued the business process compliance of the Company and has posed additional risk of fraud being hidden by the forces of unintentional error that is so well known across the Company. For the year 2015, the Internal Audit Team of Company C sampled 128 cases of procurement out of the 3,578 cases of procurement as supervised by the Purchase Committee throughout the fiscal year. Out of the 128 sampled cases only 3 were procurements costing more than USD 500,000 (and hence requiring approval of the board of directors). The sampled cases were

randomly selected through use of computerized Random Number Generator on the case number as logged by the ERP System. The total number of events the sampled cases comprised was 22,457. The number of originators was not disclosed.

The Internal Audit Team found 34 cases, out of the sampled 128 cases, to have deviant process routes. That is, the rate of deviant case was 26.6%. This is high compared the previous two case studies, and the rational for such high rate has been blamed on the complex nature of process design and incompetency of the employees. These 34 cases have then been first inspected for further checks and balances and finally full-fledged investigations. Investigations led to the discovery of 7 fraudulent cases among the sampled cases for the year 2015. This implies a Fraud Rate of 5.5%, which is comparable to our Case Study 2. Employing conventional sampling methods, the Internal Audit team of Company C thus found the following Process Deviation Rate and Fraud Risk for the Company respectively: for 2015 it was 26.56% and 5.47%, for 2014 it was 28.00% and 3.20%, for 2013 it was 35.25% and 5.74%, for 2012 it was 32.50% and 7.50% (Table 4.5). A nominal Pearson product-moment correlation coefficient between the Process Deviation rate and Fraud Risk across the years was found to be 0.52. There was no out-of-sample identification of fraudulent activities for the period of study (2012-2015). The Internal Audit Team employed a non-biased and yet a very grossly general approach towards sampling with no inclusion of years of accumulated Internal Control experience.

| Year | Sample Size | Process Deviations | Process Deviation Rate | Frauds | Fraud Risk | Fraud-to-Deviation Ratio | Correlation |
|---|---|---|---|---|---|---|---|
| 2012 | 120 | 39 | 32.50% | 9 | 7.50% | 23.1% | 0.52 |
| 2013 | 122 | 43 | 35.25% | 7 | 5.74% | 16.3% | |
| 2014 | 125 | 35 | 28.00% | 4 | 3.20% | 11.4% | |
| 2015 | 128 | 34 | 26.56% | 7 | 5.47% | 20.6% | |

Table 4.5: Fraud risk measurement statistics obtained manually

### 4.4.4 Results Obtained Through Process Mining

Process mining was carried out on the ERP System data for the year 2015 to reassess the risk of fraud through a comprehensive check of deviant process path frequency. In 2015 there were a total of 3,578 cases of procurements. Tender awarding process is not within the scope of study as it is not feasible to identify fraudulent activities associated with awarding tenders by analysing event logs. However, anomalies which occur at any other

stage of procurement are within the scope of this study as those can be revealed by analysing event logs and process paths. The number of distinct originators could not have been known during the study. The number of events, as recorded by the ERP System, was 22,457 for the year 2015. It means an average procurement case consisted of about 6 events. The highest and lowest numbers of events for the 3,578 cases were 64 and 3 respectively. Process mining conducted using Prom6 software revealed that 365 different types of process path patterns. Process Sequence Analysis was conducted with respect to the selected processes. More than 74% processes matched with 11 patterns. Like previous two case studies, Fuzzy mining algorithm was relied upon to deal with the level of noise caused by the large number of different types of process path (Gunther & Van der Aalst, 2007).

The Fuzzy Mining algorithm assisted in identifying the most frequent path that has been followed by majority of the processes. The most frequent process path is initiated with Create PO followed by 'Management Approval', 'Release PO', 'Goods Received', 'Quality Check', 'Regulatory Approval', and 'Pay'. This has been depicted in Figure 4.5. Some of the processes have digressed as it can be seen that 'Regulatory Approval' was not a step in some of the processes. It appears that the reason for such digression was that some of the purchases were not subject regulatory approval. The showed process path presented in the figure is in line with the process path that has been stipulated by the internal auditor as revealed during interview. The Fuzzy Mining algorithm in default setting of 0.20 reveals the most frequent process path which can be presumed not to be subject to fraud risk in light of the fraud risk literature.

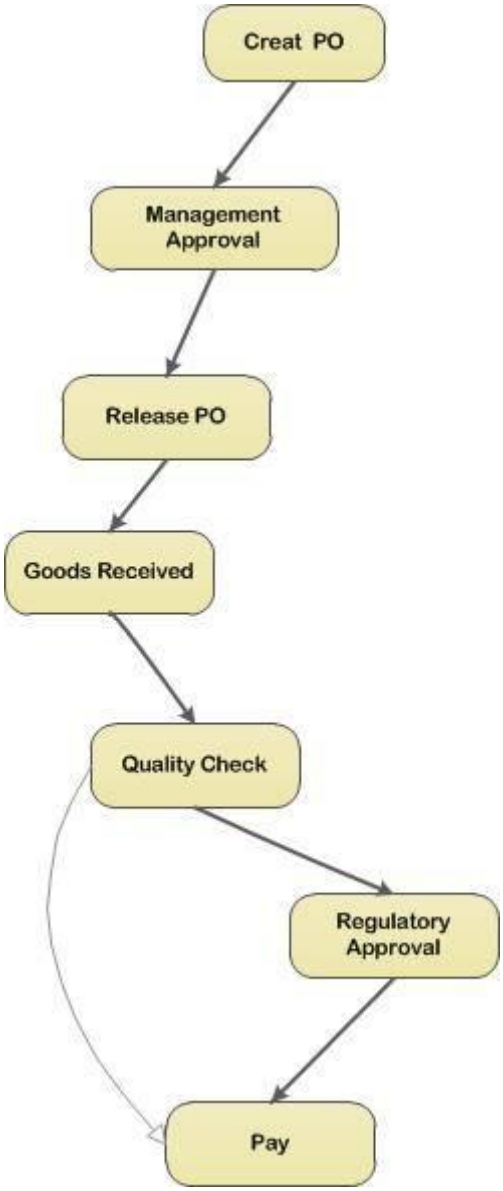


Figure 4.5: Fuzzy mining default settings screen shot for Company C

The Fuzzy mining algorithm is then run after having lowered the threshold. This has been done by adjusting the 'Cut-off' value downwards. The algorithm was run with the 'Cut-off' edge filter value adjusted to 0.80 which resulted in 5 extra flows appearing in the process path diagram as showed in Figure 4.6. The additional flows are: Create PO-Release PO; Create PO – Goods Received; Release PO – Pay; Goods Received – Pay; and Quality Check - Pay. These flows were not supposed to be present as these flows have resulted in process paths which did not match with any process path stipulated by the internal auditor. Some of these flows should have not been present. All purchases require approval either of the manager, CEO, or the Board of Directors. However, Create PO-Release PO is a flow which

indicates there are some cases which violated this fundamental norm. Therefore, these cases demand investigation. Similarly, Goods Received -Pay is a flow which should not have taken place as the general practice in Company C is to conduct a Quality Check. Now the cases where this flow appeared might have legitimately occurred due to the nature of the items which were being procured but this should have been flagged up to the internal auditor.

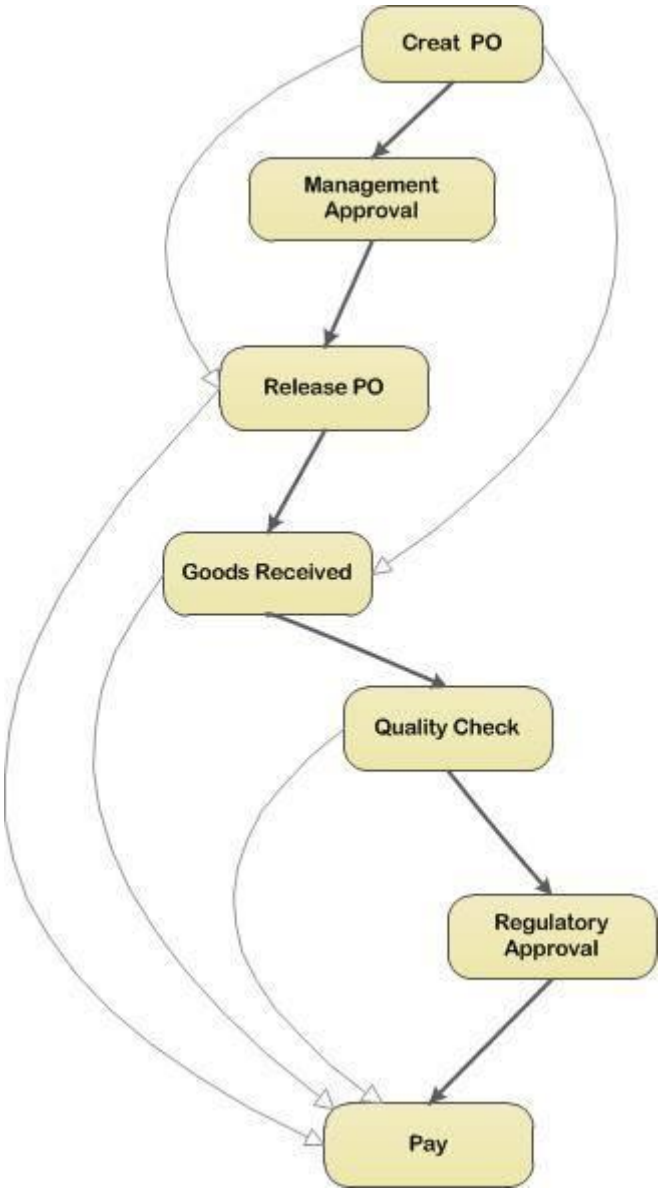


Figure 4.6: Fuzzy mining screen shot of 'cut of .80' for Company C

The additional flows which surfaced after having run the Fuzzy Mining algorithm have been presented to the internal auditor of Company C during the second interview. Internal Auditors have acknowledged that some of the flows may legitimately take place despite not

being a stipulated flow. One such flow is the Release PO- Pay which may occur when pre-payment was required by a supplier before delivery of goods. Similarly, Quality Check – Pay is also a legitimate flow with respect to purchase of items which are not subject to regulatory approval. However, Create PO- Release PO; Create PO – Goods Received; and Goods Received – Pay are flows which are not incompliance with the internal control system of Company C. Approval of either the manager, the CEO, or the Board is a mandatory step with respect to any procurement process. Hence, this flow flags red signal and can be regarded as a sign of potential fraud. Create PO – Goods Received is also a flow that has deviated from the requirement of approval of authorised person and thus gives rise to suspicion. Goods Received – Pay is a flow that violates one of the mandatory steps of quality control that has been made essential according to the internal control system of Company C.

The attributes which could be present with respect to any give procurement process had been checked using the LTL Checker with the help of Prom6. The LTL Checker allows all the acceptable flows to be allowed to be accepted as compliance with stipulated process path. After the Process Mining was carried out, an updated Process Deviation Rate of 24.57% was found as Process Mining revealed strong cases of deviations from the SOPG amounting to 879 cases out of total 3,578 cases (Table 4.6). For comparative rates of previous years, as well as for 2015 rate as found using conventional Internal Control methods, is given below:

| Year | Sample Size | Process Deviations | Process Deviation Rate |
|---|---|---|---|
| 2012 | 120 | 39 | *32.50%* |
| 2013 | 122 | 43 | *35.25%* |
| 2014 | 125 | 35 | *28.00%* |
| 2015 | 128 | 34 | *26.56%* |
| PM | 3,578 | 879 | *24.57%* |

Table 4.6: Comparative process deviation statistics

### 4.4.5 Outcome of Case Study

The fraud risk as found by the internal audit team using conventional sampling methods was 5.47% for the year 2015. The process deviation rate, using the same method, was found to be 26.56%. The process mining procedures, with its theoretically more comprehensive and rule-based unbiased sampling method, however, has found the process deviation rate

for 2015 to be 24.57%, a rate that is lower than what was believed to be true earlier. Since the process mining procedures do not directly measure fraud risk but susceptibility to fraud indirectly, the evidence of a higher than expected process deviation rate should be reflected within an updated figure for fraud risk. Here, the Bayesian theorem is used to update the probabilities for fraud risk. Hence the new fraud risk is found as:

Revised Fraud Risk = (Rate of Process Deviation $_{\text{Process Mining}}$ x Fraud Risk $_{\text{Conventional Internal Audit}}$) / Rate of Process Deviation $_{\text{Conventional Internal Audit}}$

Therefore, Revised Fraud Risk = (24.57% x 5.47%) / 26.56% = 5.06%

It can be seen that the revised fraud risk, at 5.06%, is lower than the earlier estimate of fraud risk at 5.47%. This is due to the fact that Rate of Process Deviation, as found using process mining, is evidenced to be lower than that found using sampling internal audit procedures. One crucial assumption implicitly made when utilising the Bayesian framework in this case is that Rate of Process Deviation and Fraud Risks are perfectly correlated. Though this may not be the case always, expert opinion from the internal audit team of Company C as well as other companies suggests a strong correlation between these two variables of interest.

## 4.5 Summary

This chapter contains detailed description of how case studies were conducted on three selected companies. The chapter has three sections where each section is comprised of four key steps which have been set out in the methodology chapter. The first step focused on producing a business process model of the procurement process of the selected companies. In the next step, information about the method which had been relied upon by the companies for measuring internal fraud risk has been stated along with process deviation rate of previous years. The third step involved extracting event logs for conducting process mining for quantifying process deviation. The final section focused on calculating revised fraud risk using Bayesian theorem. The key inputs for calculating revised fraud risk were rate of process deviation obtained using process mining; existing fraud risk percentage that has been calculated using conventional method by internal auditors; and rate of process deviation that has been calculated using conventional method by internal auditors.

# 5.0 Analysis of Case Studies

## 5.1 Overview

This chapter includes detailed analysis of the findings of the case-studies. Section 5.2 focuses on the business processes. Business processes are one of the key factors for analysing the method which has been developed in this research. Careful observations have been made about the nature of business and key aspects related to the procurement process of each of the case companies. Then the detailed procurement process has been analysed for understanding how procurement process varies from one organisation to another. Fraud prevention mechanisms which have been developed and implemented by the organisations have been critically analysed. Section 5.3 focuses on the results obtained through process mining. First of all, fraud risk rates which were measured historically have been considered. Then process deviation rates calculated using process mining have been analysed and compared with previous rates. Subsequently, the effects of Bayesian theorem in arriving at revised internal fraud risk rate have been critically evaluated. Finally, the feedback and observations of the business experts, i.e. the internal auditors, have been carefully considered for assessing the effectiveness of the new method objectively.

## 5.2 Analysis of Business Process

### 5.2.1 Observations of the Case Companies

The organisations which have been selected for conducting case studies for this research are operating in diverge business sectors. The first company, Company A, is operating within the export-oriented readymade garments industry. The procurement activities of this company are manufacturing focused where economy of scale is of great importance. The procurement department is significantly big with over twenty dedicated members of staff directly involved in procurement activities. The internal audit team is comprised of four members of staff who closely observe procurement related activities besides other functional areas. Strategic purchases involving significantly large investment are dealt with jointly by Finance and Procurement Department. The regular purchases are the main subject matter of this research. Company A has SAP ERP system in place for the past seven years and the internal control is primarily based on authorisation control and the control of the transactions carry out. The method relied upon in Company A for measuring fraud risk is conventional. Authorisation control plays a great role where role analysis is relied upon by internal auditors. ERP system offers the opportunity to conduct role analysis much more efficiently. However, control of the transaction carry-out is still based on random inspection of procurement related transactions conducted manually.

The second company, Company B, is operating in the pharmaceutical industry. This company is also manufacture oriented and thus the procurement related activities are similar in nature compared to Company A. However, the procurement activities of Company B are subject to rigorous quality control and high level of regulatory compliance. Company B has over thirty-five members of staff directly involved in procurement related activities. It has a Committee comprised of directors for directly overseeing the activities of the procurement functions. The internal audit team of Company B is comprised of three members. Company B has Oracle ERP system in place since 2012 and most of the documentations are available electronically. The primary function of the internal audit team is to check compliance of the business processes which is done by manual examination of logs for randomly selected process activities. The fraud risk is measured by investigating randomly selected transactions for identifying process deviation and then conducting further investigation to identify genuine cases of fraud.

The third company, Company C, is operating in the aviation industry. This company is not manufacturing oriented rather it is a service oriented company involved in transporting passengers and goods by air. The procurement functions of Company C vary from the other two case-companies due to the difference in its nature of business. However, the level of conformance to regulatory requirements is quite similar to that of Company B. Being in an oligopolistic market, the competitive pressures to survive and thrive is greater for Company C. Thus, to make its processes efficient, it has SAP ERP system in place since 2011 and has been going through organisational change to adopt to a modern data-centric business organisation, despite the hurdles it has been facing in the process of doing so. The company also has four-member internal audit team for round-the-year internal audit checks and reviews. Like the other two companies, Company C relies on assessment of process deviation and further investigation of deviated processes to estimate fraud risks. Sampling and traditional audit measures are relied upon for process deviation and fraud risks assessment.

### 5.2.2 Evaluation of Procurement Process

Business processes vary from organisation to organisation, and given the three case companies operate in diverse industries in manufacturing and services sectors, the business processes are naturally likely to be different not just superficially but significantly. These business processes are moderately flexible to allow for a dynamic business environment for meeting the requirements of various stakeholders and the risk management criteria. These flexibilities create what could be termed as perfectly allowable variability in business processes. Such flexibilities allow the businesses to adapt in various different circumstances and not be rigid, and can be found across all the three case study companies despite having significant difference in process design. This flexibility is distinct from process path deviation, an indicator of fraud risk in an organisation, which is a key variable in the measurement process of fraud risk for the purpose of this research. Hence business process flexibility is within the prescribed internal control system, while business process deviance is not. The flexibilities of procurement processes for each case company is described below.

At Company A, most procurement requests are triggered at the operational level and the requests are usually made by the current or prospective users of such assets. The requests are directed to the Subject Experts who evaluate the need for the assets and either decline

the request or authorise the request by issuing a Purchase Request Form (PRF) to a Procurement Officer. The PRF does not have a footprint within the ERP system. Procurement Managers create a preliminary Purchase Order (PO) into the SAP system when they receive a PRF. They are required to do this even if they intend to decline the request, and this is so for record keeping. Creating the PO is the first instance of event into the ERP system and marks the electronic record-keeping of a procurement request, though not ideally the beginning of a procurement event. The Subject Experts are also tasked with obtaining quotations for the purchases, usually through disbursing Expression of Interest for Purchasing (EIP) to enlisted suppliers. This step, however, may be shortened if the procured item is frequently purchased and a few suppliers have provided a standing quote rate as invitation to treat, in which case the lowest rate meeting the quality requirements is selected without issuing an EIP.

Next arises the issue of management approval. If the amount of disbursement is below USD 100,000 the procurement managers are allowed to approve the completed PO. If the value exceeds the said amount approval of the CEO is required. Once price, quality, quantity and management approval are collated, the PO is finalised and sent along with the invoice to the selected supplier. Once the shipment of the goods and invoice from the vendor is received, inventory record is updated and invoice is sent to the Accounts Department, followed by inspection for proper quality and quantity. Each of these steps has forked into different steps depending on the type of payment required, type of invoice supplied, etc. The details can be seen in the BPMN diagram of Case Study of Company A in Chapter 4. Each forked step in the diagram represents a degree of choice and flexibility, some operational and some related to risk-management.

Unlike Company A, Company B starts the process of electronic record-keeping from the beginning, that is at the very initiation of the procurement process. Again, unless being a strategic, capital and long-term investment purchase, most purchases begin at the operational level and individual departments, and begin with an employee creating a Requisition Request (RR) into the ERP system. Involving ERP system from the beginning to the end of a business process allows for greater collection of data and hence better business intelligence analysis. After a RR has been entered into the system, the request is

preliminarily filtered through a two-step process for checking the necessity of the asset requested and the feasibility of acquiring it by the company.

The first step is analysis by the procurement team, and the next step is analysis by a Procurement Specialist. After this the procurement can either follow an open e-tender or selection from quoted prices of enlisted suppliers. This choice depends on the procurement strategy and decided by the specialists; usually items of rare use and rarely purchased items are forwarded for an e-tender system, while frequently purchased or purchases of low value goods are forwarded for the enlisted supplier method. However, the procurement strategy may tactically change from time to time. Similar to Company A, Company B also has a cut-off amount of purchase above which requires approval from a higher authority, in this case the Procurement Committee. Otherwise, approval from manager suffices. From here is the processes follow a set path and forks at certain decision points as per the process design, which is similar to that found for Company A's procurement process. Details can be seen in Company B's BPMN diagram in the case study section.

Unlike Company A and B, Company C operates in the service sector. Company C, somewhat like Company B, is in a highly regulated industry due to the nature of the business. Hence, regulatory oversight is part of the business processes in many cases, including procurement. Procurement processes at Company C can be branched into two distinct families of processes depending on the nature of the good and relationship with an existing or potential supplier. These branches are Internal Procurement Section processes and the External Procurement Section processes, as seen in the BPMN diagram in Chapter 4. Apart from these, inventory management and payment related processes are common to both of these types of procurement process branches. Internal procurement means that the item requested for procurement can be procured from an enlisted supplier with whom the company maintains a service agreement. In these cases, the price negotiations are carried out beforehand within the scope of the service agreement, and hence only the requirements at the operational level and the quality of the items supplied, through routine checks, are assessed. This type of purchases falls within what can be categorised as fast-track purchases, as the whole process is streamlined. Being a service sector company is one of the reasons for having a fast-track purchase process, as frequent purchases of low quantity is often the norm in some service sector industries. Another interesting aspect to

the procurement process of Company C is the fact that most procurement request start as a call to replenish existing stock to a certain level. Though this may be somewhat true for all the businesses, the fact that it is recognised within the business process is a validation of risk-averse process design.

Like the other companies in the case studies, Company C also segregates authorisation based on transaction value. It goes a step further by making three different tiers of transaction by value. Purchases amounting less than USD 50,000 is approved by the Procurement Managers. Purchases and financial contracts with value between USD 50,000 and USD 500,000 require CEO approval, and those above the USD 500,000 mark require approval of the board of directors. Given the size of the company, purchases of USD 500,000 are very crucial for the survival of the business, and hence involving the board directly, rather than through a committee, is a rather strong way of ensuring corporate governance, especially given the long history of board involvement in the corporate governance history of the country. Other features of the procurement processes, such as authorisation, quality control and assurance, payment and tendering are similar to those found in parts in the other two case companies. Approval of regulatory body within the business process is a unique feature of the procurement process, as the industry has high degree of regulatory involvement in the country. Forked business process can be seen in this case too.

The flexibilities provided within the design of the businesses processes can be group into three broad categories, namely: decisional, operational and risk-management based. For example, the decision of a procurement manager to approve or disapprove a procurement request upon evaluation is a decisional flexibility. The term decisional flexibility is striking in a sense that it helps appreciate the fact that decision points are also sources of flexibility. Next source of flexibility is from the operational level of such business process. For example, whether to input a scanned copy of supplier's invoice into the ERP system or a digital copy (see Company A BPMN for reference) depends on what the supplier provides or is able to provide and hence is a largely operational flexibility. Operational flexibilities provide flexibilities to various internal and external stakeholders. Finally, there is a variety of process paths designed specifically to cater to risk-management perspective of a corporation. For example, the forked process paths for procurements over a certain amount of value of purchase often requires a higher or superior authority's approval. This ensures that large

scale investments are kept under the control and scrutiny of the top management or even under a Board Committee. This has vast risk-management implications, and can prove to be a crucial step for internal control.

### 5.2.3 Fraud Prevention Mechanism within Procurement Process

Fraud prevention mechanisms are part of the internal control mechanisms of a company, and it is no different for the three case companies. Internal control acts as a fraud prevention mechanism by primarily being a system of control on business processes to safeguard the wealth of the organisation, secondarily trough assuring the accuracy and reliability of accounting data (Manurung, et al., 2015, p. 1066). A system of control on business processes can be best assessed through evaluating the business processes themselves. Prominent internal control methods applied, especially in the case study companies, are the authorisation control and control of the transactions carry out. Apart from these methods, forked business transaction which require greater scrutiny for certain types of transaction are also of significance, as observed in the previous section.

One example of a good internal control practice is the higher degree of authority required for validating high-value transactions. Another example of good internal control practice is that of segregation of duty. Also, the simple act of record-keeping is a highly effective form of internal control, which is in turn greatly enhanced through the integration of the business processes into a company-wide ERP system. Essentially, physical security of the assets is an integral part of the internal control procedures. Finally, internal audit, a final key step in the internal control procedure ensures that the records are authentic and any differences are reconciled. All these mechanisms of internal control are implemented at varying degree in all the three case study companies.

For Company A, the procurement process is mostly covered by the ERP system, except for a few initiation steps. Use of the ERP system ensures control of transaction carry out and record keeping aspect of internal control. Requisitions are initiated at the operational level, whereas they are evaluated by Subject Experts, which ensures segregation of duty. The Subject Experts themselves, as well as the Procurement Officers or higher authority where required, are there to authorise procurement, this ensures a two-step authorisation aspect. The company provides adequate physical security at the warehouse and office premises,

this ensure physical security. Finally, the Internal Audit team provides assurance to the whole procurement processes through periodic internal audits.

For Company B, the whole process of procurement is covered by the ERP system, starting from requisition request initiation. This provides an even better control of transactions carry out and record keeping compared to Company A. Procurement Specialists evaluate these requests, thus ensuring segregation of duty, and Procurement Manager or higher authority authorises the process, ensuring authorisation. There are physical security measures throughout the whole process, ensuring physical security. And, again, finally there are the routine and special internal audit procedures for ensuring validity of claims and assurance of internal control.

Likewise, for Company C the whole process of procurement is under the ERP system ensuring control of transaction carry out and record keeping. Unlike the other two case study companies, Company C does not have a separate team for evaluating the requisition request, hence segregation of duty is partially diminished relative to the other two companies. The Purchase Committee authorises the procurements, so it could be argued to provide certain level of segregation of duty, while ensuring full authorisation control. Finally, physical security and internal audit procedure are similar to that of the other two companies in the case studies.

All these internal control procedures act as fraud prevention mechanisms by acting as deterrence to potential fraudulent activities by internal members, as well as providing procedures to provide post mortem analysis of frauds already committed and making reparations to them. However, it can be observed that none of the case companies has any system in place that allows it to utilise the information available within the ERP system for detecting or preventing fraud. This marks the significance of the research that organisations with ERP systems in place are not actively relying upon techniques like process mining for measuring internal or any other types of fraud risks.

## 5.3 Evaluation of Process Mining Results

### 5.3.1 Fraud Risk based on Historic Frequency

The case companies rely upon some form of sampling for assessing fraud risk. Another common feature found in the internal audit procedures for all the three companies was associating deviant process paths with increased likelihood of fraud. Investigation of deviant process paths for fraudulent activities is one of the key steps for assessing fraud risk within a sampled dataset, and once again all the three companies use a similar investigative approach. For Company A, out of the total 15,256 cases of procurement logged into the system in 2015, a sample set of 157 cases were selected for checking non-conformity from stipulated process paths. These 157 cases were further made of 1,196 distinct events of employee-ERP system interaction. Cases that showed signs of significantly deviant process paths and hence high susceptibility to fraud were scrutinised at the individual event level for fraudulent activities. 16 cases out of the 157 sampled cases were further investigated, and 2 cases of confirmed fraud was found among the sampled cases. This represents about 10.2% process deviation rate and 1.3% of fraud risk rate.

The sample size of the cases represents a little of 1% of all the cases, and the absolute size of the sample is large enough to produce statistically significant results about the population. However, the sample selection was not totally random, but were biased towards historically high susceptibility towards fraud. Individual process paths and process paths from departments having historically higher frequency of fraud were overrepresented in the sample. This simple choice of sample selection has inflicted biasness into the internal audit procedure. Also, due to the nature of the bias in reinforcing itself, the biasness is likely to increase over repeated audit sessions. An upward bias of fraud risk due to the faulty procedure was highlighted during the process mining approach to fraud risk, when fraud risk was found to be lower; 1.3% from biased sampling method and 0.75% from process mining approach.

For Company B, out of the 29,546 cases of procurement record in the ERP system in 2015, 227 cases with 1,882 events were sampled. 0.77% of all the relevant cases were sampled. 32 cases with deviant processes were identified, which were further investigated for fraudulent activities. 12 of the cases were found to have association with fraud. This represents a 5.3% rate of fraud risk, and a process deviation rate of about 14.1% for the year 2015. In contrast

to Company A's procedure for a selective sampling, internal audit team at Company B tried to maintain a more or less random sampling approach. This filters out any biasness and prejudice held by the internal audit members. However, the cases of fraud that were identified during this routine procedure were found to have multiple events of fraud, forming a chain of fraud. This represents pockets of fraud, and hence requires a much bigger sampling size. Though a much better approach compared to the earlier case company's approach, a thorough approach to process deviation is likely yield a better assessment of fraud risk.

In 2015, audit team of Company C sampled 128 cases, comprising of 22,457 events, out of total 3,578 procurement cases for the year. The process deviance rate was higher, compared to the other two companies, at 26.6%, or 34 cases out of 128 sampled cases. 7 fraudulent cases were identified among the deviant cases upon investigation, giving rise to an estimated fraud risk rate of 5.5%. Company C used random sampling, with strict criteria of using a random number generator for sampling. This represents good practice in part of the audit team.

### 5.3.2 Process Deviation based on Process Mining

Correctly identifying the rate of process deviation in a population of business process cases is a key step in assessing fraud risk. Traditional audit procedures for measuring fraud risk usually opt for random sampling of business processes and finding non-conforming processes and hence further investigating the processes for actual evidence of fraud. The first step is hence finding the rate of process deviation through sampling. Process mining attempts to add value to this step by providing a comprehensive check for process deviance, rather than through sampling. A comprehensive check for non-conformance provides the complete picture for the population by providing a population parameter, rather than a sample statistic. This, therefore, constitutes a better input into the second phase of assessing fraud risk in an organisation. Inputting the population parameter as process deviance rate hence increases the accuracy of the fraud risk rate measurement.

Running process mining produced significantly different process deviations rates compared to the rates found through sampling. Though it must be mentioned that the assumptions applied in each methodology cannot be stated to be the same due to the vast difference in the nature of quantitative analysis of the two methods. While one method is a measure of

sampling statistic, the other is a population parameter. Whereas, sampling was carried out by human agents, the mining was carried out by computer. Lastly, and most importantly, the assumptions on what constitutes a deviant process cannot be directly translated from one method to another. While sampling procedure mainly depended on the past experience and cognition of the human agents on what constitutes a process to be deviant enough to be listed as a 'deviant process' during the audit procedure, the computer-generated information on process deviance is based on certain assumptions and parametric inputs into the system, one of the most important of which is the edge cutoff parameter. The final reported process deviance from process mining was based on an edge cutoff parametric value of 0.80, and this parameter and its assumed value for the final reporting has been acknowledged by the internal auditors of the respective companies.

The total number of procurement cases for 2015, the sample sizes used in case of traditional sampling-based process deviation tests used by internal auditors previously, the rates found by them, and the rates later found through the use of process mining technology has been listed below for each of the three companies in Table 5.1:

| Company | Total Cases | Sample Size | Process Deviation Rate (PM) | Process Deviation Rate (Sampling) |
|---|---|---|---|---|
| Company A | 15,256 | 157 | 5.9% | 10.2% |
| Company B | 29,546 | 227 | 16.8% | 14.1% |
| Company C | 3,578 | 128 | 24.6% | 26.6% |

Table 5.1: Comparison of deviation rates calculated using process mining and random sampling

It can be seen that the rates found using process mining were lower than that found through traditional audit methods in two of the cases, and was higher for the other case company. For Company A, the rates were significantly different, mainly due to the nature of biased sampling employed by its internal audit team during the audit procedures. As the other two companies used more or less random sampling, their rates are closer to the process mining rates later found. Finally, being a population parameter, the process deviation rates found through process mining are definitely an improvement over the rates found though traditional audit procedures. Hence, the use of these rates, be it in assessing fraud risk or otherwise, is surely to add value to any process which requires the use if these.

### 5.3.3 Use of Bayesian Theorem for Updating Fraud Risk

Bayesian theorem was used for updating the fraud risk after the arrival of the revised rate of process deviation through using process mining on ERP system data. Bayesian theorem can be made subject to reasonable adaptation based on the nature of risk which requires to be measured as has been observed in many researches discussed in Chapter 2. The process for deriving at the formula that has been adapted in this research has been discussed in Chapter 3. The formula used for updating the fraud risk is as below:

Revised Fraud Risk = (Rate of Process Deviation $_{\text{Process Mining}}$ x Fraud Risk $_{\text{Traditional Internal Audit}}$) / Rate of Process Deviation $_{\text{Traditional Internal Audit}}$

After considering the rate of process deviation found using process mining, the revised rates of fraud risk for the three companies are shown below in Table 5.1:

| Company | Fraud Risk (Traditional Internal Audit) | Revised Fraud Risk |
|---|---|---|
| Company A | 1.3% | 0.75% |
| Company B | 5.29% | 6.32% |
| Company C | 5.47% | 5.06% |

Table 5.2: Comparison of fraud risk rates calculated conventionally and using new method

As expected, the revised fraud risks were found to be higher for Case Company B for which the rate of process deviation was found to be actually higher than that found through sampling procedures. For the other two case study companies, the revised fraud risk was lower.

The Bayesian theorem, here, presents a mathematical and statistical basis for updating the perceived fraud risk based on new evidence for process deviation. Hence, the theorem could be argued to be the key in propagating the newly discovered knowledge through process mining into an actual, usable form of risk assessment rate to be used by the internal auditors and other stakeholders of these companies. The application of Bayesian theorem has allowed evidential reasoning to be incorporated into the method. The revised fraud risk rate is arrived at by using new information obtained through process mining without completely disregarding the historic information which was available to business and system experts. This has added to the effectiveness of the method which has been applied on the case companies.

### 5.3.4 Perception of Internal Auditors about the Method

Among the defining features of the method prepared by this research for revising and updating fraud risk rate within an organisation, the role of process mining, and the use of Bayesian theorem to incorporate the revised rate of process deviance stands out as the vital steps for utilising this method. Internal auditors in all the three case companies have shown enthusiasm for using process mining to generate value additive findings for the efficient operations of the respective companies. They have indicated that the effective use of ERP system data is the one of the avenues for such value addition. Among the three companies, only one company has completed certain groundworks for adopting process mining, data mining and other big data initiatives as part of their internal audit procedures. It transpired that organisations with ERP system in place have not embraced various techniques and tools that can be utilised which reinforced the usefulness of the artefact which has been developed as a result of this research.

Also, auditors from all the three case companies were satisfied with the efficiency of process mining in terms of utilising ERP data, computational power, time and other resources of their respective companies. They also regarded the accuracy of the results to be reasonable and reliable. About the use of Bayesian theorem for updating fraud risk of the companies, internal auditors in all the three case companies were in favourable position, although auditors from only two of the case companies were actually familiar with the Bayesian theorem concept from beforehand. Overall, internal auditors from all the three case study companies held positive perception about the use of the developed framework for fraud risk assessment in real life uses, including its use in their own companies. The feedback received from the internal auditors have been carefully considered in deriving at the final method which has been presented in the next chapter.

## 5.4 Summary

This chapter contains in-depth analysis of the findings of the case-studies. It has been observed that the business process of each company varies from one another to some extent. Each of the case companies has some key internal controls mechanisms in place but the method relied upon by the internal auditors in calculating internal fraud risk is common which is reasonable given the regulatory environment in which the companies operate. All the case companies have been relying upon random sampling conducted manually for measuring internal fraud risk. The process deviation rates calculated using process mining have varied to a great extent compared to traditionally calculated deviation rates with respect to all the companies. Similarly, the revised fraud risk rates have also varied with respect to all the case companies. These findings are reasonable as careful analysis has revealed that the significant differences in the sample size of processes considered for calculating deviation rate could reasonably have such implications upon fraud risk rates. Internal auditors of the case companies offered valuable feedback about the new method. They all have reinforced the effectiveness of the new method which has been critical for the purpose of this analysis.

# 6.0 Discussion

## 6.1 Overview

This chapter includes detailed discussion on combined overview of analysis of the case - studies. Section 6.2. focuses on comparison of the frequentist method and the new method for measuring internal fraud risk in terms of effectiveness, accuracy, and reliability. It also includes detailed discussion on how process mining and evidential reasoning have been incorporated in the new method that has been applied on the case companies for measuring internal fraud risk. Section 6.3 focuses on evaluating the method that has been applied in the case studies from critically. It highlights how the applied method became complicated due to lack of standardised business process, the complexities associated with conducting process mining, and how the method is unsuitable to be applied on organisations which have not information about internal fraud risk rate and process deviation rate calculated using frequentist method. Section 6.4 denotes the new method that has resulted after having the analysis of the method applied on the case-studies taken into consideration. A step-by-step guidance for measuring internal fraud risk of an organisation has been stated in detail in Section 6.5.

## 6.2 Synthesis of the Analysis of Case Studies

### 6.2.1 Comparison between Frequentist Method and the Applied Fraud Risk Measurement Method

It has to be taken into consideration that all the case companies selected for this research have been relying upon random sampling for measuring fraud risk. It is in line with the literature available with regards to methods relied upon by internal auditors in measuring fraud risk. The estimation made by internal auditors about process deviation, using benchmarking, systems analysis, ratio analysis, mathematical modelling, or exception reporting, has been referred to as frequentist method or conventional method. The frequentist method, which has been relied upon by all three case companies, has been represented in Figure 6.1. The representation is a consolidation of the information obtained during the first phase of interviews with Company A, Company B, and Company C (Appendices – E, F, and G). The case companies were not following identical method for conformance checking but the key theme in all three companies were similar. It can therefore be commented that deduction of a general frequentist method is both reliable and valid.

The limitation of this method is that it does not allow business experts to quantify the total number of processes that have not followed an ideal or stipulated path or sequence. The key difference between the frequentist method and the method applied in the case studies, also referred to as Bayesian method, is that the latter allows the processes which have deviated from stipulated process paths within an ERP system to be quantified with greater accuracy by using process mining. It appeared that all three case companies were unable to utilise their ERP systems in the fullest sense with regard to managing internal fraud risk as an effective method for incorporating process mining results into the calculation of internal fraud risk. This gap has been filled in this research which is discussed in greater detail in the latter part of this chapter.

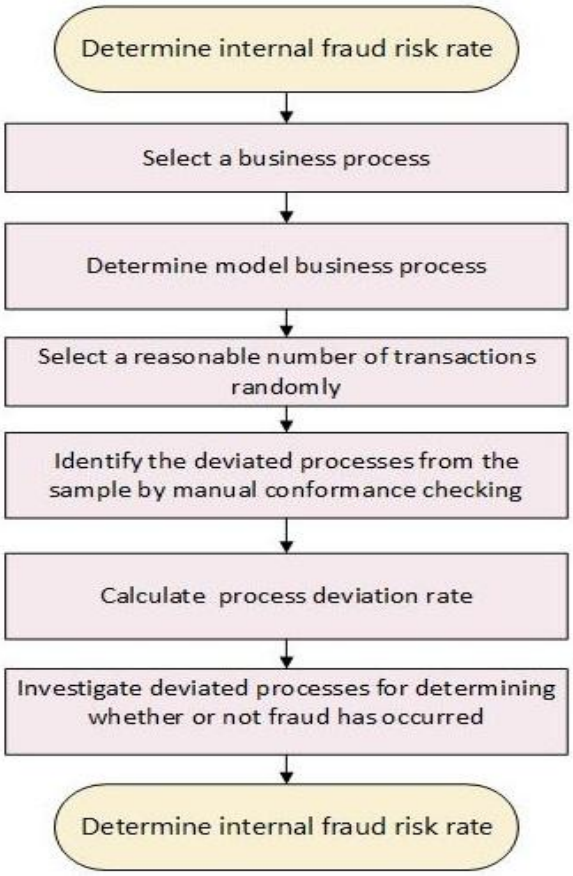


Figure 6.1: Steps followed in frequentist method for calculating internal fraud risk rate

Process mining is a technique that allows deviated processes to be identified with great efficiency as it relies upon IT rather than manual observation. Therefore, the rate of process deviation can be calculated much more accurately which is a crucial information in measuring fraud risk. It has been observed during the analysis of the case study findings that the process deviation rates are much more reliable due to the inclusion of all the logged processes by way of process mining which resulted in greater accuracy in determining the internal fraud risk rate. This can then be utilised in the Bayesian formula which allows new knowledge, i.e. the more accurate process deviation rate, to be applied in arriving at a revised internal fraud risk. The key difference between the frequentist method and the method applied in the case studies is that the process deviation rate used in the latter method is much more accurate. The frequentist method relies on random sampling where handful of processes are chosen randomly for identifying whether or not process deviation has occurred.

The method applied on the case companies, developed in this research, relies on process mining which allows process deviation rate to be calculated by considering all the processes which are logged in the ERP system of an organisation. Analysis of the case studies have revealed that business experts, i.e. the internal auditors, of all the participating case companies are of the view that being able to encapsulate all the processes for quantifying process deviation renders the new method much more accurate and reliable compared to the traditional method of relying upon handful of random sampling. However, it should not be noted that actual measurement of actual number of fraudulent activities within the deviated processes is dependent upon manual investigation of a handful of cases even in the new method. This impedes with the ability of the new method to be completely independent of relying upon small samples. The application of process mining for more accurate quantification of process deviation rate and Bayesian theorem as an attempt to incorporate evidential reasoning have been dealt with in detail in the following sections.

### 6.2.2 Incorporation of Process Mining in Measuring Internal Fraud Risk

The method which has been applied on the case companies for measuring internal fraud risk employs process mining for calculating process deviation rate. This is different from the frequentist method that has conventionally been relied upon by internal auditors. In the frequentist method, rate of process deviation is calculated by selecting a few transactions randomly for determining whether or not stipulated process paths were followed. The method applied in the case study takes all the relevant transactions into consideration, as opposed to picking up few sample transactions, for identifying processes which have deviated from the stipulated paths. It is apparent that the applied method is capable of calculating the rate of process deviation with greater accuracy. Incorporation of process mining has enabled the applied method to become efficient as process mining technique can allow to undertake conformance checking much more conveniently. The ability to consider all the relevant transactions present in the event log makes the applied method much more effective as well by enhancing the accuracy. Application of process mining for checking conformance is not new but none of the existing methods for measuring internal fraud risk employs process mining for calculating process deviation rate which can be utilised in measuring the internal fraud risk rate. Analysis of the case studies has revealed that process mining has been conducted with great success as process deviation rates were

successfully calculated in all three cases. The comparison of the process deviation rates calculated manually and calculated through process mining has also revealed that process mining has allowed deviation rates to be calculated with greater accuracy and reliability.

### 6.2.3 Incorporation of Evidential Reasoning in Measuring Internal Fraud Risk

The method that has been applied on the case-companies for measuring internal fraud risk relies upon Bayesian theorem for arriving at the internal fraud risk rate. This has paved the way for evidential reasoning to be incorporated. The adapted Bayesian formula that has been relied upon for calculating internal fraud risk rate requires information about the historic fraud risk rate and process deviation rate calculated using the frequentist method. The key aspect of Bayesian formula is that it does not disregard historic information completely and allows previous findings to be updated based on new information. This is evidential reasoning and the method applied in the case-studies has paved the way for evidential reasoning to be incorporated. The case companies all had internal fraud risk measured using frequentist method as conventionally done by internal auditors in most countries. The applied method took the historic information into consideration and incorporated the new information with regards to process deviation rate obtained through process mining. Analysis of the case-studies has revealed that the method applied has allowed evidential reasoning to be incorporated with great success. The internal fraud risk rates of all three case-companies were revised and the results were considered to be much more accurate and reliable by the respective business experts i.e. the internal auditors.

## 6.3 Critical Evaluation of the Method Applied in Case Studies

### 6.3.1 Lack of Standardised Process

The method which has been applied for measuring internal fraud risk in this study can quantify the process deviation rate and then measure fraud risk using Bayesian theorem. One of the most important steps in applying the method was to capture the model business process. Modern businesses are comprised of complex processes. It is expected that business processes offer flexibility as inflexible process models may result in bottlenecks resulting in loss of productivity. It is therefore a highly complicated task to capture a map of any of the business processes that a modern organisation is comprised of. It has been observed that organisational processes vary to a great degree. The chosen business process for the study was procurement process. The method involved mapping business process by interviewing business experts with a view to produce a BPMN diagram. A business mapping can be done by solely relying upon process mining software which involves identifying most frequent paths. Since the method aims at quantifying process deviation by conducting process mining against a stipulated process map, it can be argued that comprehending the model process paths by consulting business experts is of great importance. Mapping business process by consulting business experts can be regarded as highly subjective and thus it affects the reliability of the internal fraud risk measurement method. Conducting interviews of business experts was quite complicated part of the case-studies. In-depth interviews of internal auditors allowed initial model of the process to be developed which was reinforced at later stages.

Each organisation designs its business process according to specific needs. It is therefore difficult to encapsulate business process models. It is also a matter of judgement when business experts have to decide whether or not a deviation from a normative process path can be regarded as necessary. This has been reflected in third phase interviews with internal audit teams of case companies (Appendices – E, F, & G). All the interviewees acknowledged that there is a risk in equating deviation with fraud. Flexibility is key to smooth operation of procurement function and as such any presumption that deviation indicates fraud would be devoid of practical consideration. Process mining can assist human experts to single out processes which deviated from the stipulated process paths but it is for the human agents to decide what can be regarded as an ideal process paths. The procurement process of each

of the case companies exhibited great diversity. Each of the case companies has its unique business process and internal control system. The business processes develop organically within organisations over time and this is evident in the case companies. It can hence be stated that businesses lack standardised business process. However, the impact of lack of standardised business process was minimised by mapping the ideal business model rigorously. This was achieved by conducting interviews of business process experts and obtaining their approval once the model was developed as BPMN diagram.

### 6.3.2 Complexities in Conducting Process Mining

Process mining is the key information technology that has been relied upon in applying the method on case companies. One of the key aspects of this method is that it utilises process mining for identifying deviated processes and calculating process deviation rate. The primary focus has been on automating the processes which has led to insufficient attention being paid to issues like flexibility and diagnosis (Aalst & Weijters, 2004). It was therefore a complicated task to conduct process mining on event logs of an organisation with a view to identifying processes which have deviated from stipulated paths. ERP systems are often implemented in organisations that do not offer adequate flexibility for meeting the business needs. Internal control systems are thus relaxed for ensuring that the system is operating efficiently which creates obstacles for diagnosing the system. The situations were quite similar with the case companies. For this reason, model business process of the case companies was not produced using software in this study as that would not allow process deviations which are regarded as necessary to be considered as all the case companies did not have adequate measures for ensuring flexibility. This made it difficult to conduct process mining with utmost consistency.

Selection of cut-off point for identifying deviated processes by conducting process mining has been identified as one of the major challenges. Review of the phase 3 interview with interviewees from all three case companies reveal that selection of cut-off point is a common concern. It has been specifically commented by some of the team members within internal audit team that selection of cut-off point is a subjective decision and as such the objective nature of the proposed method is comprised due to this issue. While the selection of optimum cut-off level for identifying deviated processes will vary from organisation to organisation, the default cut-off rate of .20 used in testing the method developed in this

research has produced acceptable results. None of the interviewees was of the view that the use of the default rate had produced unreliable results. It can therefore be stated that use of default cut-off rate is capable of acceptable results. However, the effectiveness of the method will enhance if optimum cut-off rate is used while conducting the process mining. It can be stated that inability to address the issue of determining optimum cut-off level is a limitation of the proposed method.

One of the key challenges for identifying deviated processes by conducting process mining is to mine hidden tasks. It is presumed that each event has been recorded in the log but this may not be the case as there are tasks which are intentionally or inadvertently not recorded (Aalst & Weijters, 2004). It can therefore be argued that process mining may not be capable of identifying all the deviated processes as there may be processes which have not been registered in the system. These issues transpired with regards to the case companies. The issue of duplicate tasks, which refer to the situation where two nodes refer to the same task, created complications for conducting process mining. The perspective that has been embraced for conducting process mining can also have significant impact upon the results. In this study, the process mining has been conducted from a control-flow perspective which focuses on ensuring order of tasks. However, there are other perspectives such organisational perspective and informational perspective which focus on issues that may result in different outcomes of process mining conducted from control-flow perspective. There is incorrectly logged information, known as noise, in the system and it is challenging to deal with noise by determining an accurate threshold value to cut-off incorrectly logged behaviours (Maruster, et al., 2001). The cut-off values were selected carefully in consultation with experts from respective case companies during this research.

### 6.3.3 Dependence upon Historic Fraud Risk Rate and Historic Process Deviation Rate

The method applied on the case companies for measuring internal fraud risk requires historic information with regard to fraud risk rate and process deviation rate. The Bayesian formula which has been adapted for calculating internal fraud risk input of the historic fraud risk rate and the historic process deviation rate in percentage. All three case companies had internal fraud risk measured by employing conventional frequentist method (Appendices – E, F, & G). The internal audit teams relied upon frequentist method which involved calculating internal fraud risk based on process deviation rate calculated manually from

randomly selected transactions and then identifying fraud by conducting forensic investigation. The method which has been applied in conducting the case studies required the information of historic fraud risk rate and historic process deviation rate. It was therefore possible to have all the required information for arriving at a revised internal fraud risk using the Bayesian formula.

It appeared that this method cannot be applied on any organisation which does not have information about historic fraud risk rate or process deviation rate. This method would not be applicable had the case companies not have previously determined their respective internal fraud risk rates. However, the interviewees from all three case companies have revealed during the third phase of the interview that combining historic data and with newly acquired data for arriving a revised information is a positive aspect. All the participants agreed that reliance on historic data has enhanced the credibility of the proposed method as a new set of internal fraud risk rate arrived at only based on data retrieved by way of process mining would not be acceptable to be used in internal auditing due to the concept being a novice one. It can therefore be commented that reliance on fraud risk rate measured using conventional method has increased the reliability of the method that has been used in this research. These observations have been carefully considered while deriving at the new method for measuring internal fraud risk rate which has been described in the next section.

## 6.4 Deriving at a New Method for Measuring Internal Fraud Risk

The aim of this research was to develop a new method for measuring internal fraud risk (IFR) of business organisations with ERP systems. The case studies have been conducted with a view to evaluating the functionality of the method. The methodological considerations paved the way for generating a unique method that can be applied for measuring internal fraud risk in an effective and efficient manner. Five key steps were identified for conducting the case-studies. The case-studies have been conducted by strictly adhering to each of those five steps with respect to each of the case companies with a view to ensuring consistency. The final step involved evaluating the method based on the feedback from business experts. This allowed the views of the business experts to be incorporated before deriving at the final method. The final internal fraud risk measurement method has derived from the method applied in the case-studies after having taken the analysis of the case-studies into consideration. The final method, as presented in Figure 6.2, is more generic nature as some technical issues can be left with users to be decided such as choice of process mining software and selection of appropriate algorithm. The derived method is comprised of four steps: comprehension of the selected business process and internal control system; extraction of fraud risk rate and process deviation rate calculated default method of the organisation; determination of process deviation rate using process mining; and calculation of revised internal fraud risk using Bayesian formula.

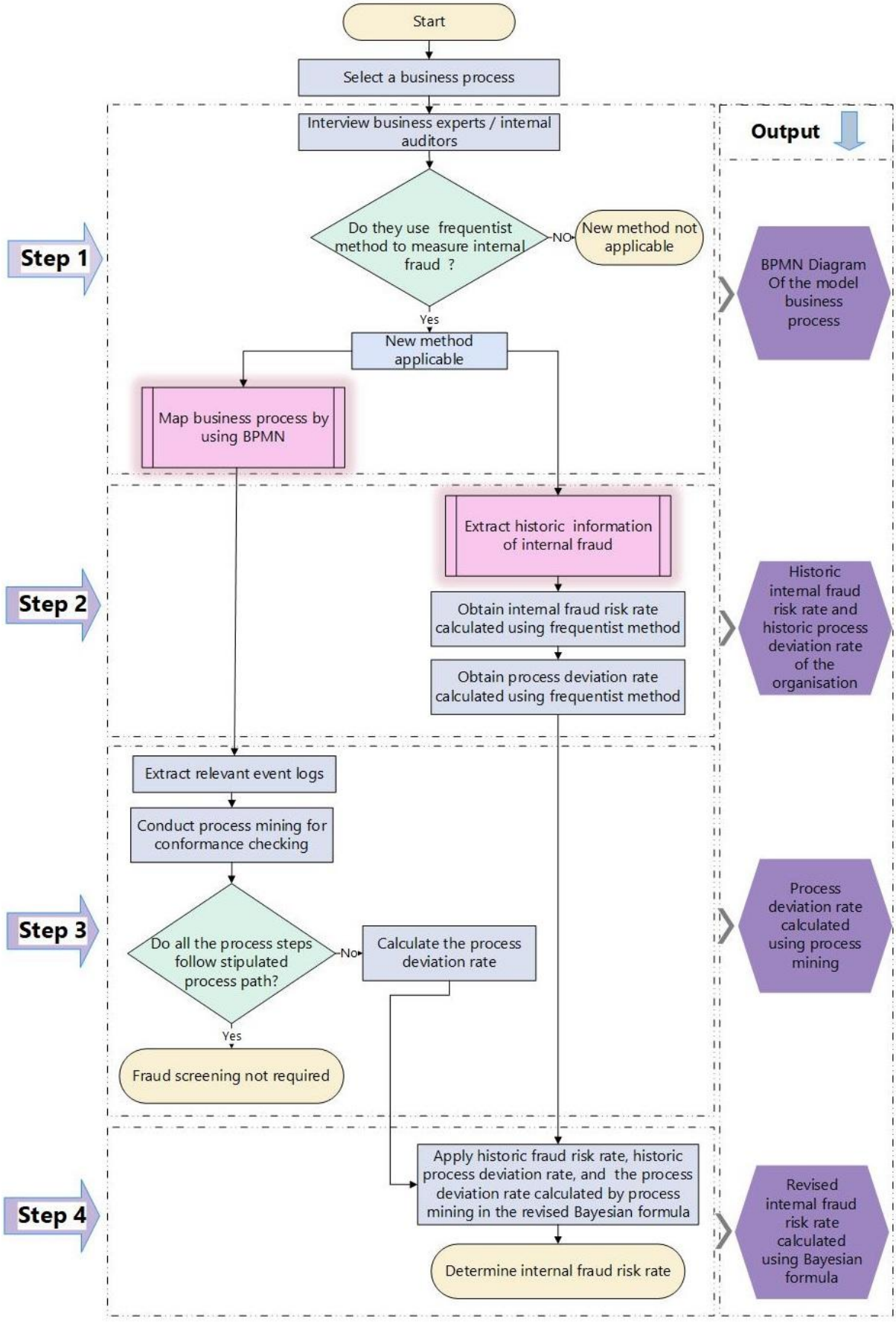


Figure 6.2: New internal fraud risk measurement method

The business process and internal control system of the chosen organisation must be comprehended by interviewing business experts and system experts. The method requires business process model to be represented using BPMN diagram as use of BPMN diagram allows input of human agents to be included in generating business process model. Then the internal fraud risk, as well as the process deviation rate, of the organisation which have been calculated using a conventional method will have to be obtained. The method requires the historic fraud risk rate and historic process deviation rate to be obtained as it employs evidential reason for arriving at a revised internal fraud risk. The next step is to determine the process deviation rate by extracting event logs and then conducting process mining with regards to the data set. This process deviation rate is the key information as this allows internal fraud risk to be calculated using more accurate and reliable data. The final step is to calculate revised internal fraud risk by applying historic fraud risk rate, historic process deviation rate, and process deviation rate calculated using process mining in adapted Bayesian formula. The key attribute of this method is that it allows IS to be utilised for building on the existing knowledge that is available to the users rather than producing completely new results. The outcome obtained after completing each stage of the method is described in Table 6.1.

| Stages | Outcome/Artefact | Description |
|---|---|---|
| Step 1 | BPMN Diagram of the model business process | The model or stipulated process path of the chosen business process is presented in a BPMN diagram. The conformance check is conducted against this model business process. |
| Step 2 | Historic internal fraud risk rate and historic process deviation rate of the organisation | The internal fraud risk rate and process deviation rate which were calculated previously using frequentist method are obtained. These rates are required for determining revised internal fraud risk using Bayesian formula. |
| Step 3 | Process deviation rate calculated using process mining | The process deviation rate of in the logs of events for the chosen process is calculated using process mining. This rate is required for determining revised internal fraud risk using Bayesian formula. |
| Step 4 | Revised internal fraud risk rate calculated using Bayesian formula | The revised internal fraud risk is arrived at by applying historic internal fraud risk rate, historic process deviation rate, and process deviation rate calculated using process mining in Bayesian formula:<br>Revised Fraud Risk = (Rate of Process Deviation $_{\text{Process Mining}}$ x Fraud Risk $_{\text{Conventional Internal Audit}}$) / Rate of Process Deviation $_{\text{Conventional Internal Audit}}$ |

Table 6.1: Description of the outcome of each stage of the new method

## 6.5 Step by Step Guide to Measuring Internal Fraud Risk Using the New Method

The new method for measuring internal fraud risk that has been developed as a result of this research is an artefact that can be relied upon by researchers and practitioners for measuring internal fraud risk of a given business process of any commercial organisation that has an effective ERP system in place. Internal fraud risk can be measured in light of the new method by following four steps. The four steps will allow the method to be applied with ease while ensuring that no single step is comprised of tasks which require expertise in multiple fields. Each of these steps has been described in great detail in this section:

### 6.5.1 Comprehending Selected Business Process and Internal Control

The first step of the new method involves comprehending the chosen business process of an organisation along with the internal control system that are embedded in the model process. It is of crucial importance to determine the steps which are expected to be followed which is referred to as the process design. This method requires business process to be mapped by way of interviewing business experts/internal auditors. It is advisable that semi-structured interview is conducted by taking the nature, size, and complexity of the operations of the organisation. This method offers flexibility with respect to conducting interviews which is essential for being able to generate accurate business process map in dynamic environment. One of the key factors that determines internal fraud risk in this new method is the rate of process deviation. Accurate process deviation rate can only be calculated using process mining if the model business process can be determined with great proximity. The model business process must be produced using BPMN under the new method as BPMN allows model business process to be understood from the perspective of the business expert. It can therefore be stated that application of this method will require the user to be able to produce a BPMN diagram. However, this model can be developed and customised further in the future which may allow business process of an organisation to be produced using other process mapping notations or tools. Determining model business process using process mining may not allow process deviation rate to be calculated accurately. The method requires business experts and system experts to be interviewed for producing the BPMN diagram of the chosen business process. In-depth interview must be conducted where the key objectives will be to determine the flow of the process and the

internal control mechanisms which are in place. The model business process will then be converted into machine readable language against which the event logs will be run for identifying deviated paths.

### 6.5.2 Extracting Information regarding Historic Fraud Risk and Process Deviation Rates

The second step of the new method involves determining the fraud risk rate and process deviation rate of the organisation which were calculated historically using conventional frequentist method. It is important to extract this information from the business experts, i.e. the internal auditors, as the new method calculates revised internal fraud risk by incorporating evidential reasoning. The key attribute of evidential reasoning is that it allows to revise outcome on the basis of the newly available information while taking the historic information into consideration. Two key information which are required for determining revised fraud risk under the new method using Bayesian formula are the historic fraud risk rate and historic process deviation rate. The methods relied upon by the internal auditors for arriving at those rates can vary but the information can be utilised in the new method as long as both the rates can be presented in percentage. The required information can be obtained while interviewing internal auditors for determining model business process. However, this is regarded as a sperate step as this information can also be extracted by conducting an additional interview due to the confidential nature of the information.

### 6.5.3 Determining Process Deviation Rate using Process Mining

The third step of the new method involves conducting process mining on the logs which are relevant for the selected process with a view to identifying the processes which did not conform with stipulated process path. First of all, all the relevant event logs have to identified by fixing the granularity, period, data attributes, and data orientation. The relevance of the data extracted from the selected logs will then have to be verified by process expert as part of data processing if required. These logs of events will be then utilised in process mining. Process mining can be conducted using any appropriate software that allows flow of process to be evaluated against stipulated process path with a view to identifying deviations. The algorithm must be selected cautiously as the accuracy of process mining result will depend upon the choice of algorithm. It is advised that Fuzzy miner is chosen. Process mining will then lead to quantification of the processes which have deviated from stipulated process path. Afterwards, the rate of process deviation will have to be

calculated. The rate will have to be presented in percentage which will be applied in the Bayesian formula for determining the revised fraud risk rate.

### 6.5.4 Calculating Revised Internal Fraud Risk

The final step of the new method involves calculation of revised internal fraud risk by applying all the relevant information in the adapted Bayesian formula. The three inputs, which are determined during the preceding three steps, are the historic fraud risk rate, historic process deviations rate, and process deviation rate calculated using process mining. The inputs are all presented in percentage and as such the result will also be arrived at in percentage which is the revised internal fraud risk rate. This internal fraud risk rate can then be utilised by business and system experts for improving the internal control system and improving the business process model. The adapted formula is presented below:

$$Revised\ Fraud\ Risk = (Rate\ of\ Process\ Deviation_{Process\ Mining} \times Fraud\ Risk_{Conventional\ Internal\ Audit}) / Rate\ of\ Process\ Deviation_{Conventional\ Internal\ Audit}$$

## 6.6 Summary

The analysis of the case studies has been synthesised in this chapter. The frequentist method and the method applied on the case companies have been critically evaluated with a view to determining the effectiveness and usefulness of the applied method. The limitations which have been faced while applying the new method in the case studies have been carefully considered so that a new method could be produced which can be presented as a useful artefact. The practical issues which were faced while conducting this research offered significant insight into the method and paved the way for presenting the applied method as an outcome of the research. The new method which derived has been discussed in great detail in this chapter. A step-by-step guide has been denoted that allows the new method to be applied with respect to any business organisation for determining internal fraud risk.

# 7.0 Conclusion

## 7.1 Overview

This chapter includes conclusive statements with regard to this research. Section 7.2 focuses on the key contributions of the research. This research has contributed in several ways which have been discussed from various perspectives. The aim of the research was to develop a new method for measuring an internal control and as such the research has significant methodological contribution besides theoretical and practical contributions. Section 7.3 has highlighted how the objectives of the research have been attained and any aspects which the research have failed to attain. The limitations of the study have been highlighted in Section 7.4. This study is subject to several shortcomings owing to constraints of resources and methodological limitations. These limitations have been discussed elaborately. Section 7.5 focuses on the potential for building on this research in the future. This research can be utilised in a number of ways and there is immense potential for building on this research for conducting further research and also for developing new artefacts. Section 7.6 contains conclusive remark on this study.

## 7.2 Contributions of the Research

### 7.2.1 Key Contribution

The key contribution of this research is that it has resulted in a method which can practically be employed by internal auditors for measuring internal fraud risk of business organisations with ERP systems, by utilising process mining technique and evidential reasoning in the form of Bayesian theorem, in a much more effective way compared to conventional frequentist method. The novelty of the new method is that it has combined application of process mining technique and evidential reasoning in measuring internal fraud risk. Evidential reasoning has been relied upon by a number of researchers in areas such as operational risk, financial risk, and IS security risk but none of the researches has applied process mining technique and evidential reasoning combinedly for measuring internal fraud risk (Alexander, 2000) (Kirkos, et al., 2007) (Srivastava, et al., 2009). A combination of ER and process mining technique within a method for measuring risk is unique. This research has applied evidential reasoning for effectively measuring internal fraud risk where process mining has been used for obtaining new evidence.

It has been observed that internal auditors heavily rely upon on frequentist probability for measuring internal fraud risk by manually calculating process deviation rate from random samples. In this research process mining has been applied for identifying deviated processes within an ERP system which offers a much more accurate quantification of the rate of process deviation. Moreover, the new method relies upon Bayesian formula for incorporating ER for measuring the fraud risk which is a superior prediction model. Thus, the new method which has been developed in this research has greater effectiveness and reliability in measuring internal fraud risk as it utilises an improved formula and an efficient technique. It can be stated that this approach has the potential to lead to a new area of research where evidential reasoning can be combined with various IT techniques and tools, especially process mining, for addressing phenomena prevailing in the commercial world. Enhanced efficiency and reliability are the two key attributes of the new method. Moreover, this method can be adapted to be applied in addressing a wide range of issues which arise out of complexities associated with business processes within complex organisations.

### 7.2.2 Other Contributions

This research has made a number of other contributions in addition to key contribution of producing a novel method for measuring internal fraud risk of business organisations with ERP systems. The research has paved the way for different theoretical frameworks from a range of academic fields to be considered together for creating new knowledge. A body of literature relevant to internal fraud, evidential reasoning, and process mining have been taken into contribution. Evidential reasoning, along with probability theories, has previously been combined for assessing operational and cyber security risk but the notion of utilising evidential reasoning and process mining for measuring internal fraud risk has not been attempted previously. This research has paved the way for combining evidential reasoning and process mining technique in other areas of internal control such as measuring compliance risk and effectiveness of operations. This research has also significantly contributed into the body of knowledge by offering a basis for incorporating evidential reasoning, i.e. the Bayesian theorem, into the application of IT techniques and tools like process mining and data mining in addressing phenomena prevalent at organisational level. There is detailed discussion on how general Bayesian theorem can be adapted for being applied in dealing with specific problems form theoretical perspective. It must be asserted that this research did not aspire to develop an existing theory but it has significantly contributed by evaluating theories from across a number of fields with a view to introducing an enhanced probability theory into the field of internal fraud risk in association with IT.

This research has made significant methodological contributions as detailed analysis of methodological aspects has been undertaken. This research has been conducted following DSRM which required the research to develop an artefact as an outcome. A practice related investigative methodology has been developed in this research for addressing a problem faced by practitioners. The main objective was to develop a method for measuring internal fraud risk that can be relied upon by business experts and internal auditors. This research has not been conducted following a previously prescribed method and as such it can be stated that the research has contributed in creating a new knowledge from methodological perspective. DSRM has paved the way for being flexible in selecting appropriate research strategy. The method adopted in this study has been validated by conducting case studies which involved analysis of both qualitative and quantitative data. The methodological

contribution of this research can be claimed to be of great significance for future IS researchers who intend to deal with issues which are being faced by practitioners in organisational context by introducing application of IT.

This research has also made significant practical contribution as the aim of the research was to develop an artefact that can deal with a practical problem being faced by business experts at organisational level. The new method that has been developed for measuring internal fraud risk of business organisation with ERP systems can be utilised by internal auditors for practically measuring the internal fraud risk. It can therefore be stated that this research has made significant contribution in addressing a practical issue. It can also be asserted that the nature of this research allows its outcomes to be of great relevance to practitioners, like internal auditors and ERP system experts, as much as to academicians and researchers. This research can also be taken into consideration for addressing other practical issues being faced at organisational level by applying process mining technique in innovative ways. It can therefore be claimed that this research has made significant practical contribution. The contributions have been showed in Table 7.1.

| **Contribution** | **Area of Contribution** | **Justification** |
|---|---|---|
| Theoretical | ➢ Empirical examination of evidential reasoning and probability theories in measuring risk<br><br>➢ Empirical examination of role of process mining technique for conformance checking | ➢ Adapting Bayesian theorem<br><br>➢ Exploring the role of process mining in ensuring internal control system |
| Methodological | ➢ Validating applicability of DSRM in developing an artefact using process mining technique<br><br>➢ Combining qualitative and quantitative methods in case-studies | ➢ Application of DSRM<br><br>➢ Application of mixed method |

| | | |
|---|---|---|
| Practical | ➢ Developing an artefact for business experts and ERP system experts<br><br>➢ Combining evidential reasoning with process mining for addressing practical issues | ➢ Development of new internal fraud risk measurement method<br><br>➢ Application of Bayesian formula and process mining for measuring internal fraud risk |

Table 7.1: Summary of key contributions of the research

## 7.3 Attainment of Research Objectives

This study aimed to develop a method for measuring internal fraud risk of business organisations with ERP systems using process mining and Bayesian theorem. Five objectives were considered of significant importance to be achieved for attaining the aim. The research has been carried out by applying the method on three cases from a pragmatic standpoint following DSR methodology. The case study findings have been analysed carefully for evaluating the effectiveness, reliability, applicability, and limitations of the new method. Attainment of objectives are discussed in greater detail against each of the research objectives elaborately below:

### 7.3.1 Objective 1

The first objective of the research was to comprehend the literature regarding prevalence of internal fraud, role of process mining in ERP systems, and applicability of Bayesian theorem in measuring fraud risk. A wide body of literature related to fraud within organisational settings, information systems, business processes in modern business organisations, methods which are being employed in measuring fraud risk, process mining, and probability theories have been considered. It has transpired that fraudulent activities are prevalent in business organisations. Many studies have taken place on fraud within organisational context but majority of such researches focus on financial statement fraud as opposed to transactional fraud. Transactional fraud is regarded as internal fraud and internal control system within an organisation plays crucial role in tackling internal fraud. The review of existing literature indicated that organisations that have embraced ERP system have now the opportunity to enhance the internal control system by utilising various features of IT. All the business process activities which take place are logged digitally as event logs. A careful consideration has revealed that currently the potential of ERP system in tackling internal fraud risk are not being fully utilised in business organisations as tools like process mining are not being integrated for lack of innovative methods.

In-depth research on internal fraud revealed that procurement related activities are highly susceptible to internal fraud. One of the most effective way to comprehend specific business process of an organisation is to apply business process modelling techniques. It

appeared that Business Process Modelling Notation (BPMN) is a suitable tool for capturing procurement process of a business organisation. Review of relevant literature revealed that internal fraud risk is conventionally measured by internal or external auditors at entity level by analysing individual nodes. However, it transpired that it is possible to conduct process level analysis by utilising process mining. The number of processes which deviated from a stipulated process can be measured by relying upon appropriate process mining tool and algorithm. The literature review also focused on understanding the role of probability theories in anticipating risks and it appeared that Bayesian probability can capture the risk of internal fraud with an organisation more effectively due to it being subjective to the entity. Review of existing literature thus assisted in reaching the conclusion that a method for measuring internal fraud risk using process mining and Bayesian theorem has both the novelty and the potential to contribute greatly in IS research.

It can be stated that review of existing literature related to the areas that were identified has been conducted with great success as development of the new method and its subsequent application on three cases have not proved anything contradictory. BPMN has been allowed to comprehend business process of each of the case company in an effective manner. Process mining has allowed deviated processes to be quantified and that information has been successfully applied in Bayesian theorem for measuring internal fraud risk. Analysis of the outcomes of the case studies have not revealed any discrepancies in the new method. It can therefore be stated that the literature review has allowed the objective to comprehend the literature regarding prevalence of internal fraud, role of process mining in ERP systems, and applicability of Bayesian theorem in measuring fraud risk to be achieved.

### 7.3.2 Objective 2

The second objective of the research was to develop a preliminary method of internal fraud risk measurement based on Bayesian theorem and process mining. This objective encapsulates the fundamental feature of this research. Review of literature related to the associated areas led to a methodological framework to be developed. The methodological framework has led to an initial method that has been applied on three different case companies. The methodological framework involves reliance upon frequentist method,

process mining, and Bayesian theorem. The frequentist method has been relied upon by all case companies for measuring internal fraud risk. The conventional frequentist method for measuring fraud risk did not utilise information technology rather it involved measuring fraud risk based on manual compliance checking of randomly selected process activities. The method which has been developed in this research employed process mining for quantifying the number of deviated process path which allowed compliance of all the processes to be checked against a stipulated model rather than relying upon a small number of randomly selected process activities. The method also paved the way for Bayesian theorem, which is a more effective probability theory for capturing entity specific risks, to be applied for measuring internal fraud risk.

The method offers the opportunity to utilise information derived from both conventionally measured fraud risk and from application of process mining to be relied upon in measuring internal fraud risk using a more appropriate probability theory. Analysis of the case studies has revealed that the method is functional and it can allow system experts to arrive at a revised measure of internal fraud risk in an organisation with an ERP system. Views of the business and system experts from the case companies have been captured by way of interview. It has been observed that all the participants are of the view that the newly developed method is capable measuring internal fraud risk within an ERP system more effectively compared to conventional methods. It can therefore be stated that the objective to develop a preliminary method of internal fraud risk measurement based on Bayesian theorem and process mining has been achieved with great success.

### 7.3.3 Objective 3

The third objective of the research was to evaluate the applicability of the method against multiple case studies. The chosen methodology for this research was to conduct a multiple case studies. Three organisations were selected for conducting case studies. The chosen companies were operating in three different business sectors and as such the developed method was exposed to variance in business process. The method was applied with respect to only a specific type of business activity which is procurement process. This allowed comparison to be made between findings from all three different cases regarding specific business process. The methodological framework led to a set of steps which could be

followed with regards to a chosen business organisation and come with measurable outcomes. This set of steps paved the way for a method to be developed. Outcome of the application of the method on each of the case companies were analysed and the findings discussed with the team of business and system expert of the case companies in great details. Specific and measurable results were of obtained from each of the case companies after having applied the method for measuring internal fraud risk.

The major steps which the method is comprised of are to encompass the procurement process of the case company, to learn and obtain data about the conventional method for measuring fraud risk, to conduct process mining for identifying and quantifying deviated processes, and to arrive at a revised measurement of internal fraud risk using historic measurement of internal fraud risk along with process mining results on number of deviated processes in Bayesian theorem. The analysis of the case study results is consistent and the reliability of the findings are mathematically sound. The views of the business and system experts of the case companies have also been captured which upheld the reliability of the results. The case companies are operating in different business sectors with certain degree of variability in procurement process and as such the general applicability of the method has also been tested. It can therefore be stated that objective of evaluating the general applicability of the method has been attained.

### 7.3.4 Objective 4

The fourth objective of the research was to analyse effectiveness of the new internal fraud risk measurement method across organisations with ERP systems. This is one of the most important objectives of this research as the aim is to develop a new method which has enhanced effectiveness owing to the application of IT in measuring internal fraud risk of business organisations. The effectiveness of the method in measuring internal fraud risk has been evaluated against the historical internal fraud risk rates of each of the case companies which were measured using conventional methods. One of the key inputs in arriving at revised internal fraud risk using the new method is the process deviation rate calculated using process mining. It has been observed that all the case companies relied upon random sampling conducted manually for calculating the process deviation rate. The calculation of process deviation rate could only take limited number of actual processes into consideration

as this was analysed manually. The method developed in this research applies process mining for calculating process deviation rate which allows a large number of actual processes to be considered while calculating the process deviation rate.

The effectiveness of the method has been analysed by considering the historically measured internal fraud risk with the internal fraud risk that has been calculated using the new method. The analysis process involved the business experts from each of the case companies. They have been made aware of how the new figures were arrived at including the application of process mining as a tool and application of Bayesian theorem as a way for incorporating evidential reasoning. It has been observed by all the interviewees that application of process mining for calculating process deviation rate has the ability to enhance the effectiveness of the method as it allows a large number of samples to be analysed. It has also been observed that application of Bayesian theorem has allowed to arrive at a revised fraud risk without the need to investigate greater number of deviated process for ascertaining whether or not fraud has actually occurred due to the strengths of associated with Bayesian theorem as a probability theory that is capable of incorporating evidential reasoning. It can therefore be stated that the objective to analyse the effectiveness of the method has been achieved and it has been showed that the method has the potential to be effective compared to random sampling method relied upon by internal auditors.

### 7.3.5 Objective 5

The fifth objective of the research was to represent the developed method as a potential artefact for being used in measuring internal fraud risk of business organisations with ERP systems. This objective is of significant importance as this research has been conducted following DSRM which requires an artefact to be produced as a result of the research process. The artefact that has been produced in this research is the new method for measuring internal fraud risk of business organisations with ERP systems. The method produced in this research is comprised of a set of steps which lead to a result and as such it can be stated that the method has all the attributes of a DSRM artefact. The derived method has been presented in the following section which is the outcome of the research. The derived method can be applied with respect to any business organisation with ERP systems

in place for calculating internal fraud risk. The model assumes that the business organisation which is being applied to has a default method for calculating internal fraud risk using conventional random sampling method. However, this method can be applied to a business organisation which does not have an internal fraud risk rate measured using random sampling. In that case, the organisation can measure internal fraud risk using conventional method of random sampling and then rely on the new method for improving the accuracy and reliability of the results.

The derived method has all the attribute of a DSRM artefact as it has been developed by relying upon design science. The method offers a technology-based solution to a business problem as it has paved the way for process mining to be applied in measuring internal fraud risk. The method has been evaluated by way of conducting case studies. The research rigour has been ensured in both constructing and evaluating the design artefact. Most importantly, the method has been presented effectively both to technology-oriented audience, i.e. the system experts, and management-oriented audience, i.e. the business experts. The artefact has been tested on three case companies as the method has been produced in light of the method which has been relied upon for conducting the case studies. The analysis of the case studies has revealed that the method is capable of measuring internal fraud risk more effectively compared to conventional random sampling method although it has some limitations which has also been considered carefully. It can therefore be claimed that the objective of the research was to represent the developed method as a potential artefact for being used in measuring internal fraud risk of business organisations with ERP systems has been achieved.

## 7.4 Limitations of the Study

This research has been conducted by following DSRM where an artefact has been developed for measuring internal fraud risk of business organisations with ERP systems. An artefact has been successfully developed in the process of undertaking this research but it must be acknowledged that this research has several limitations. It is therefore important to consider the limitations which this research is susceptible to and to take necessary actions for minimising the impacts of such limitation upon the usefulness of the outcome. First of all, the reliability of the artefact that has been developed has to be evaluated. It is of great importance to evaluate how well the artefact that has been developed works (Geerts, 2011). The produced artefact of this research is a method that allows the internal fraud risk of organisations with ERP system in place.

This research involved multiple case studies where the initially designed method has been applied to three different case companies. Then feedbacks were obtained from the potential users of the methods by way of in-depth interviews. It can therefore be said that the bias of the researcher is a matter of concern as conducting the case-studies involved a great level of subjectivity (Denzin & Lincoln, 2011). It was important to embrace an open-ended type of interview questionnaire due to the discovery-oriented approach of this research. It has been commented that the researcher as instrument can often become a threat to the trustworthiness of a qualitative research (Poggenpoel & Myburgh, 2003). Conducting a pilot study and interviewing the investigator are the widely accepted ways for dealing with researcher bias (Chenail, 2011). Researcher bias has been dealt with to a great extent by conducting pilot studies although the investigator was never interviewed by a colleague. It can therefore be said that the issue of researcher bias could have been dealt with more effective by conducting interview of the investigator.

The second limitation which this research suffers from is the applicability of the new artefact to a range of organisations. It has been observed that the new method is applicable with respect to business organisations operating across different business sectors. Case companies were selected from garments manufacturing industry, pharmaceutical industry, and aviation industry. The case companies also had varying regulatory and compliance requirements to fulfil. The existing methods for measuring internal fraud risk in the case

companies were similar which is justifiable as internal auditors are operating as per their professional standard. It can therefore be commented that the method has general applicability to a great extent on business organisations with ERP systems in place operating in various industries. However, the limited number of cases limits the reliability of the artefact that has been developed in this research and the findings of this research.

There are also limitations with respect to the applicability of the findings upon other areas of business apart from the procurement activities. The chosen business process with respect to all the companies were same that is procurement. The study was conducted on procurement process as it would have been outside the scope of this research to conduct process mining on a range of business processes of each case companies. It therefore cannot be presumed that the method can be applied with respect to any business process for measuring internal fraud risk. However, the procurement process of each case company varied to a great degree. Each company had a varying degree of regulatory requirements to fulfil. The procurement methods relied upon by the companies were also diverse. Despite such differences, the newly developed method has been able to quantify the process deviation rate from a large pool of event logs and calculated revised fraud risk with greater reliability. It can be commented that the method has general applicability irrespective of the type of business process on which it is being applied as the method allows the business process in question of a given organisation to be encapsulated by interacting with the human agents which allows it to be adaptive.

Finally, the research has some theoretical and methodological limitations. This research has been conducted by taking probability theories into consideration. Probability theories are a complex are of study and any application of probability theories in a practical area requires rigorous adaptation. An adapted Bayesian formula has been relied upon for the purpose of this research and such adaptation is likely to suffer from limitations. The methodological limitations are that the research has been conducted following DSRM which is novice methodology and has been a topic of debate among IS researchers. The research strategy which has been embraced, that is case study, is also subject to a number of limitations (Bandara, et al., 2005). The limited number of case study has rendered the validity of the research outcomes questionable at least to some extent. It can therefore be said that this

research is subject to some limitations. However, it can be commented that the awareness of such limitations has worked as a safeguard against those.

## 7.5 Scope for Building on the Research

There are several aspects of this research which are expected to become subject of further research. A method has been developed in this research for measuring internal fraud risk using Bayesian theorem and process mining. The underlying objective was to utilise process mining, which is an IT technique, in combination with evidential reasoning. The research has considered only one business area, which is procurement process, for measuring internal fraud risk. There is a scope for investigating how the method can be applied with respect to other business functions, such as marketing and sales and human resources. The research has relied upon on Bayesian theorem for incorporating new information that has been extracted by way of process mining into the evidential reasoning for arriving at a more accurate measurement of internal fraud risk. There are other probability theories which can be considered for incorporation of evidential reasoning.

Conducting workshops can also be considered for developing this new model. Group model building and soft system methodology are relied upon for developing models using workshops which allow a subject analysis of a given phenomenon (Tako & Kotiadis, 2015). The technique applied for capturing business process model against which process deviations are to be assessed is BMPN. However, there are other techniques that can be relied upon for determining business process model. One of the key developments that can be made regarding this research is that a basic form of Bayesian formula has been relied upon for measuring internal fraud risk here. There are scopes for building upon this basic adapted formula with a view to incorporating additional factors that may increase risk of internal fraud, such as complexity of business processes or level of bureaucracy in an organisation, for arriving at a revised internal fraud risk rate.

## 7.6 Concluding Remarks

This research has attempted to develop a new method of internal fraud risk measurement based on Bayesian theorem and process mining. The novelty of the research is that it has attempted to address the complexities associated with measuring internal fraud risk by applying process mining technique while incorporating evidential reasoning by way of Bayesian theorem. This makes this research a significant one in the field of IS as the main objective of IS researches is to address real life problems by using IT. The research has been conducted following DSRM and as such an artefact had to be developed. There are limitations associated with the method which has been followed for conducting the case studies for developing an artefact in compliance with DSRM requirements, but conscious efforts have been made to minimise the effects of those limitations. There are several aspects of the newly developed method which demand further evaluation and improvements. The research has attempted to make incremental development on how process mining can be utilised more effectively for dealing with real-life problems faced in organisations with ERP systems in place. This research has successfully made a bridge between evidential reasoning and process mining for measuring internal fraud risk which has the potential to be replicated in other functional areas of business organisations.

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# Appendix A – Ethical Approval

College of Engineering, Design and Physical Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

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7 October 2015

**LETTER OF APPROVAL**

Applicant: Mr Imran Dayan

Project Title: ERP Internal Fraud Risk Measurement Framework

Reference: 0186-LR-Oct/2015-84

Dear Mr Imran Dayan

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority, is satisfied that the amendments accord with the decision of the Committee and has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee.
- Please include a contact email address in the last part of your participant information sheet.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor Hua Zhao

Chair

College of Engineering, Design and Physical Sciences Research Ethics Committee
Brunel University London

## Appendix B – Participant Information Sheet

**Information Sheet**

I, Imran Dayan, am doing my PhD in the field of Information Systems in the Department of Electronics and Computer Engineering at Brunel University, London, United Kingdom.

My research topic is '**A Method for Measuring Internal Fraud Risk (IFR) of Business Organisations with ERP systems**'. The aim of the research is to develop a method for measuring internal fraud risk (IFR) of business organisations with ERP systems using process mining and Bayesian theorem. The research aims to develop the method by conducting case studies. The designed method will be applied on participating organisations and the final method will be developed based on the findings of the case studies. Participating in the case studies will involve interviewing business experts, internal auditors, and ERP systems experts. Historic event logs will also be required for conducting process mining. The study is fully confidential and the participating originations will remain anonymous.

**Important Notices**

- It is not compulsory for you to take part in this study/interview. However, if you agreed to participate in this study, you still have your right to withdraw at any time without any consequence.

- Your personal or organisational details will be kept anonymous. In other words, you will not be referred to by name or other personal information in any report concerning the study.

- Data collected in the process of the study will not be disclosed. Only the outcomes of the study will be revealed with the attributing to any individual or entity.

- If you have any concerns or complaints regarding this project, please imran.dayan@brunel.ac.uk

## Appendix C – Consent Form

Title of study: The influences of employees' adaptation strategies on subsequent system usage and IT performance at the individual level: A Case Study of the Computerised Work System

Name of Researcher: Imran Mohammed Dayan

| | |
|---|---|
| I confirm that I have read the researcher participant information sheet. | ☐ |
| I have had an opportunity to ask questions and discuss this study. | ☐ |
| I have received satisfactory answers to any query I asked. | ☐ |
| I am aware that my participation is voluntary and I can withdraw anytime I so desire without giving reason. | ☐ |
| I understand that this research is part of a thesis for a PhD program and therefore any information I provide can be disclosed to concerned academic supervisors for review purposes | ☐ |

**Tick all applicable**

| | |
|---|---|
| I agree to be interviewed. | ☐ |
| Be taped during interview. | ☐ |

Name of Participant_____

Name of Participating Organisation_____

Signature_____

Date_____

## Appendix D – Sample Interview Questions

**Session 1 Questions**

Q1 What kind of system do you have in procurement function?

Q2 Who are the participants of a procurement process?

Q3 How does the process start?

Q4 Who can initiate a procurement process?

Q5 What are the subsequent steps in the procurement process?

Q6 How does the process end?

Q7 How do you ensure that procurement process is being complied with?

Q8 What are the factors that may require a deviation of a standard procurement process?

Q9 What control mechanisms are there for ensuring accountability?

Q10 Is there any recognised procedure for assessing how many procurement-related transactions are taking place without complying with due process?

Q11 What percentage of procurement transactions deviate from stipulated process?

**Session 2 Questions**

Q1 Is the business process model generated conforms to the stipulated process path from a technical standpoint?

Q2 Is the business process model conforming to the internal controls?

Q3 Among the filtered process paths, which paths do not conform to business process standard and cannot be added to the list of exceptions?

**Session 3 Questions**

Q1 How would you judge your understanding of the method of measuring risk of fraud using process mining and Bayesian theorem?

Q2 How do you perceive process mining as a method of finding out process deviation in terms of efficiency?

Q3 How do you perceive process mining as a method of finding out process deviation in terms of accuracy?

Q4 What is your opinion regarding the reliance upon Bayesian theorem for arriving at revised fraud risk?

Q5 What do you think are the potential risks associated with measuring fraud risk using process mining?

Q6 What is your opinion regarding the overall effectiveness of the framework in your organisation?

## Appendix E - Interview at Company A

***The following conversations were mainly conducted in Bengali, which was then translated with help from a professional translator.***

### *Session 1*

*This is an interview between the interviewer and the internal audit team at Company A. The internal audit team composed of 4 members: Senior Internal Audit Officer (SO), two Junior Internal Audit Officers (JO1 & JO2) and a Trainee Officer (TO). The Trainee Officer was present during the interview but did not actively take part in it. The interview took place at the head office premises of Company A. It took place before data were extracted from the ERP System and analysed. The translated transcript is given below:*

**Interviewer to Everyone:** Hello everyone. Thank you very much for giving me your valuable time for this interview and also arranging it here at your office board room.

**(Q1) Interviewer to SO**: Now, would you please enlighten me about how procurements are handled in this company? What kind of policies, controls and systems are in place with regard to procurement, be it for working capital or long term investments?

**SO**: Yes, we have a strong procurement policy in place. It ensures not only efficient and effective procurement process, but also procurements free from fraudulent activities. First of all, we have a separate Procurement Department, consisting of 20 Subject Experts and 3 Procurement Officers. While the Subject Experts oversee the technical and financial aspects of procurement requests, the procurement officers oversee the administration, commercial, contractual and legal aspects.

As for the internal controls regarding procurement, it is mainly based on authorisation control and the control of the transactions carry out. Finally, the whole system is integrated with the SAP ERP system, which has been in place for over 7 years and has been upgraded once.

**(Q2) Interviewer to SO:** Thank you. Could you please mention the key stakeholders in a typical procurement transaction?

**SO:** Typically, a procurement is initiated at the operational level for small amount purchases. For strategic procurement such as long-term investments and big purchases, it is up to the Finance Department and our Chief Financial Officer. A Purchase Request Form (PRF) is filled up at initiation, which is handed over to the Procurement Officers. They forward it to respective Subject Expert. Subject Experts assess the need for requirement and provide a green signal if the procurement is justified. I should mention it at this point, the Subject Experts' work does not constitute these officers' main task, but rather Subject Experts are chosen from various managerial and technical level of operations. Hence, they do the Subject Expertise part as a part time duty. This ensures specialising and yet efficiency of officers as the job of Subject Experts do not require full-time

attention. All these are, however, managed by the full-time Procurement Officers, so that initiators of a procurement do not have to worry about these things.

**(Q3) Interviewer skipped this question as it was answered earlier to Q2.**

**(Q4) Interviewer skipped this question as it was answered earlier to Q2.**

**(Q5) Interviewer to JO1:** After the Subject Experts gives a green signal, what happens next?

**JO1:** As Sir (SO) has told you, the Procurement Officers manage the commercial side of procurements. After a Subject Expert deems the purchase necessary, the Procurement Officer forwards Expression of Interest for Purchasing (EIP) to enlisted suppliers. The returned price and quality quotations are assessed by the Subject Experts and selected for purchase. The Procurement Officers create a Purchase order (PO) and maintains correspondence with the supplier. Upon receiving the shipments in the warehouse, the subject Expert checks the items for quality and marks them received. The invoice is forwarded to the accounts department and the good is delivered at the point of requirement. These are managed by the Procurement Officers.

**SO:** One point to note is if the purchase is valued at over USD 100,000 authorization from the CEO and CFO are required.

**(Q6) Interviewer to JO2:** So, how does the process essentially ends?

**JO2:** If everything goes fine and the procured goods are installed or placed for use, the accounts department makes the payment and the Procurement Officer marks the Procurement Request (PR) as complete.

**(Q7) Interviewer to SO:** How is the compliance with procurement processes ensured?

**SO:** As you can see, we maintain segregation of duty at many levels. Our internal control mechanism of authorisation control and the control of the transactions carry out are obviously there. Then there is the SAP System itself, it has certain tools and modules for ensuring certain basic level of compliance. Finally, the internal audit team is always on the lookout for any sign of non-compliance or fraudulent activities.

**(Q8) Interviewer to SO:** Can deviations from these processes occur without being fraudulent? How?

**SO:** Yes, definitely. 'Company A' is a large company with multiple lines of operations, many departments. It is not always possible for processes to be maintained strictly. Sometimes deviations

will have to be tolerated for the sake of efficiency. Since meeting deadline is part of the job, we have to sacrifice internal compliance at certain times. I will give you an example of such instance in case of procurement. Suppose, a line manager asks for certain spare parts for a machinery which we do not have at our store. But let's say the Subject Expert for that type of machine is on leave or absent for some reason. If the production schedule is tight, the Procurement Officer might just ask the initiator to fill in the place of a Subject Expert. There are many other examples, but the main essence is that meeting deadline is often more important in this business.

**(Q9) Interviewer to SO:** How do you ensure accountability? What control mechanisms are used?

**SO:** The main mechanism is authorisation and record keeping. The processes are designed to have an initiator and often multiple levels of authorisation and quality control and quality check. When we receive a procured good, the Subject Expert marks the goods received as fit. If the initiator or any other employee later finds the goods to be unfit, we have the person who can be questioned. Obviously, most such issues arise due to negligence rather than fraud, and often the negligence can be traced back to multiple personnel, which then becomes a difficult situation to hold someone accountable.

**(Q10) Interviewer to SO:** Is there any recognised procedure for assessing how many procurements related transactions are taking place without complying with due process?

**SO:** The internal audit team periodically assesses the process deviation rate through sampling. At least quarterly sampling is done, and an annual rate of process deviation is circulated internally. In fact, we are planning to mention reduction in process deviation as a company administrative goal for next fiscal year. Apart from sampling for process deviation, we also investigate deviated processes within a sample for cases of fraud. If found, the cases of fraud are dealt appropriately according to company policy.

**(Q11) Interviewer to SO:** What is a typical rate of process deviation?

**SO:** well, it varies from year to year. But generally we have seen diminishing rate, which is a good news for the state of internal control of the company. Last year the rate was 10.2% and this rate typically hovers around 10%, give or take 2%.

**Interviewer to Everyone:** Thank you gentlemen. I hope to see you soon when I meet and discuss on my research progress after I have extracted the necessary data from your ERP System.

## *Session 2*

*This is an interview between the interviewer and a Junior Internal Audit Officer (JO2) and the Systems Analyst (SA), who is in charge of the ERP System maintenance. The interview took place at the head office premises of Company A. It took place after data were extracted from the ERP System and partially analysed. The translated transcript is given below:*

**Interviewer to Everyone:** Hello everyone. I have extracted the business process model for procurement at your company. There were about 15,000 cases made up of roughly 120,000 events for procurement in 2015 as shown by the event log. I have simplified the many process paths of the actual model generated using the event log through abstraction suing the edge cutoff feature of the fuzzy miner algorithm used in the software ProM 6. Please have a look.

**(Q1) Interviewer to SA:** Could you please brief me with the starting and ending events of a typical procurement process and if it matches with the model extracted?

**SA:** Typically, the first entry in the ERP System with regard to a procurement process starts with 'Create PO' event class and ends with a 'Pay' event class. As you simplified model shows theses nodes at the start and end of the business process tree, it confirms to the most typical of cases of procurement process.

**(Q2) Interviewer to JO2:** Does the process map conform to the typical business process model prescribed by your internal control standards?

**JO2:** Let's see. Here we have 'Create PO' followed by 'Signed' by the authorisation personnel and then we have 'Release'. This is followed by 'Invoice Received' and then 'Goods Received' if the vendor allows deferred payment, and finally payment. There are certain cases where an upfront payment is required, I think it is shown by the lighter arrows in your diagram if I am not wrong.

**Interviewer:** That is correct.

**JO2:** Then I believe this is a correct representation of a typical case of procumbent.

**(Q3) Interviewer to JO2:** Now, upon tweaking with the edge cutoff parameter, I have identified four process paths that require certain clarification in your part. Let me know if these process paths are approved or are allowed in extenuating circumstances. These ae the cases with subsequent events that involve Create PO-Release; Release PO-Pay; Release PO-Invoice Received; and Create PO-Goods Received.

**JO2:** I can tell you the processes that start with 'Create PO' should almost always be followed by 'Signature' as authorisation is a core internal control mechanism. The other two cases are allowed under certain conditions.

**Interview:** Why do you say almost always?

**JO2:** Only if the procurement value is above 'X' there may be allowed cases of such instances, as these brings up additional process paths and or more complex process paths, or sometimes just due to discretionary power of the senior management to streamline the processes for these bulk purchase cases.

**Interviewer:** In that case I would use these rules and expectations in the LTL Checker. It is a module in the ProM 6 for adding list of exception that are allowed a process deviation scenario.

**Interviewer to Everyone:** Thank you for your kind cooperative. I think that will be all. I might knock you again if any other issues come up soon.

## *Session 3*

*This is an interview between the interviewer and the Senior Internal Audit Officer (SO). The interview took place over videoconferencing. It took place after the case study on Company A was completed and a report regarding the case study was sent to Company A. The translated transcript is given below:*

**Interviewer to SO:** Good afternoon, good to see you Sir.

**SO:** Good afternoon. Good to see you too.

**(Q1) Interviewer to SO:** I have used Bayesian theorem and process mining to evaluate fraud risk at your organisation. What is your view on this approach?

**SO:** I think the approach is fresh and something new. The quantitative and objective nature of the test presents a strong case for its use.

**(Q2) Interviewer to SO:** What do you think of process mining as an approach to assessing process deviation? Is it efficient?

**SO:** The comprehensive nature of process mining is definitively a positive. I think this is a better approach than random sampling. Though selecting the cut-off remains to be a challenge and it should become better through experience. As an approach, it is surely efficient in the sense that it is utilising the data created by the ERP system.

**(Q3) Interviewer to SO:** In terms of accuracy?

**SO:** In terms of accuracy of process deviation? Sure. But I am doubtful about its accuracy in terms of assessing fraud risk.

**(Follow-up question) Interviewer to SO:** Why?

**SO:** Fraud has many dimensions, and process deviation is just one of them. Sure, random sampling has its problems, but you cannot definitely say process mining provides a better picture of fraud risk than random sampling.

**(Q4) Interviewer to SO:** What is your opinion on the use of Bayesian theorem for evaluating fraud risk?

**SO:** Personally, I am not that much familiar with Bayesian theorem. But what I have seen, it seems plausible. I need study on the topic to really comment on this.

**(Q5) Interviewer skipped this question as it was answered earlier to the follow-up question of Q3.**

**(Q4) Interviewer to SO**: What is your opinion on the framework of fraud risk test that we tried?

**SO:** It is definitely an interesting use of technology and theory. Upon further research, we might implement similar approach it in the future at our company.

**Interviewer to SO**: I would like to conclude the interview by thanking you and your team for all the kind cooperation during my research. Thank you.

## Appendix F - Interview at Company B

***The following conversations were mainly conducted in Bengali, which was then translated with help from a professional translator.***

### *Session 1*

*This is an interview between the interviewer and the internal audit team at Company B. The internal audit team is structured in a flat style with three Internal Audit Associates (IAA1, IAA2 & IAA3) reporting directly to the Chief Financial Officer. The interview took place at the factory office of Company B in the outskirts of the city. It took place before data were extracted from the ERP System and analysed. The translated transcript for the interview is given below:*

**Interviewer to Everyone:** Hello. First of all, I would like to thank you all for arranging the time and place for this interview in between your busy schedule. The interview is being audio-recorded for the purpose of writing and translating a transcript of the conversation for the purpose of academic research.

**IAA1:** It's entirely our pleasure. We hope to be useful to your research and we hope that our company will also be benefited through its findings.

**(Q1) Interviewer to IAA1:** Let's hope so. Let us begin our discussion of internal control and risk of fraud in 'Company B'. Let's focus on procurements. How would you describe the internal control systems with regard to procurement or purchases for this company? How are procurement done?

**IAA1:** As you know, we are one of the largest pharmaceutical companies in Bangladesh. Naturally, we have to carry out numerous procurements each day. Managing them without any proper guidance or system would be very tough. One of the enabling factors for managing the vast levels of business process, including procurement, is the presence of our Oracle ERP System. We have had this since 2008, and since 2012 we have had successfully implemented a paperless office administration format. These technologies, together with the high standard internal control systems that we have in place enable us to monitor business processes very tightly. Over the years, we have successfully reduced the risk of fraud to a great extent.

**(Continuation of Q1) Interviewer to IAA1:** How about the internal control and the business processes with regard to procurement? Tell me about your Procurement Department?

**IAA1:** Our Procurement Department central to our philosophy of maintaining sustainable relationship with our supplier through Supplier Relationship Management. Maintaining sustainable relationship and getting the best quotes for our purchases are the two key central tenets of our procurement philosophy. The department is headed by our Procurement Manager who oversees the work of 35 Procurement Specialist, each specialising in particular lines of work and production. The Procurement Specialists assess the relevance of a Requisition Request (RR) and approves them.

Upon deliver they also check for Quality Control and provide Quality Assurance. Procurement Specialists also manage liaison with the Accounts and Finance Department. Apart from these staff, the Department also has other staffs, together making a 120 personnel strong department. But this is not the only tier of control., we also have a Procurement Committee composed of mainly our Board Members, the CEO and the Procurement Manager. They mainly oversee purchases that go beyond the USD 100,000 mark and also supervises the Procurement Department. We follow two distinct processes of procurement, depending on the nature of the goods being procured. First, if the item is of little value and is a regular purchase for the company, we ask quotations from our enlisted suppliers privately. The department chooses the lowest quotes with satisfactory quality. The second process applies to items of high value and which are relatively less frequently bought. For these goods we publish a public tender invitation. Usually the Procurement Committee is involved, however, goods that are bought infrequently but are of low value may be dealt directly by the department.

**(Q2) Interviewer to IAA2:** Who are the personnel you would identify as key stakeholders in a procurement process?

**IAA2:** Well, first we have to count the staffs involved with generating a Requisition Request. The initiator of the RR is the central personnel in terms of procurement, as the process starts with him or her initiating the process and ends with him or her using the procured item. Then comes the Procurement Specialist, as they are the one to evaluate the requests in most cases and approve them. The Procurement Manager and his team provides the support services to this process. Then comes the involvement of Accounts and Finance Department and the warehouse staff. The Procurement Specialists do the QC/QA part and delivers the goods to the initiators. This process takes a little bit different route of the good is worth USD 100,000, that is when the Procurement Department also gets involved. It can be noted that many of these high value purchases are initiated at the Office of Business Intelligence at the Accounts and Finance Department.

**(Q3) Interviewer skipped this question as it was answered earlier.**

**(Q4) Interviewer to IAA2:** Can you please summarise, who can initiate a Requisition Request?

**IAA2:** Anyone from Operations, or any other department for that matter. As long as it is justified, there is no restrictions on initiating a RR. And, as I have said earlier, the strategic investments and the related purchases are usually initiated at the Office of Business Intelligence, or sometimes directly by the senior management such as CEO and CFO.

**(Q5) Interviewer skipped this question as it was answered earlier.**

**(Q6) Interviewer skipped this question as it was answered earlier.**

**(Q7) Interviewer to IAA3:** So many steps, all of them, as you say, digitized and passing through the ERP System. How do you ensure this? How do you ensure compliance?

**IAA3:** Here internal control comes to rescue. The business processes are designed to ensure controls of authorisation of multiple personnel. This ensure traceability as well as segregation of duty. At each step there is records in the ERP System. Since all the processes are digitized, no step is carried out without recording in the ERP System. Our IT Department ensures smooth functioning of the ERP System and the associated input and output system, such as barcodes and RF readers. For receipts and papers works produces by external stakeholders, the IT teams together with Internal Audit teams and the respective departments involved work together to digitize the records and upload it in our system. Last of all, the surprise, monthly and quarterly internal audits and the yearly external audits ensure compliance. In case any non-compliance is found we apply our company policy strictly, and even take help from law enforcement and the legal system. Lastly, the most important system for ensuring compliance at 'Company B' is one of incentive, not repercussion. Our management tries to steer the workforce with motivation, through personal growth, achievement recognition and also other hygiene factors.

**(Q8 & Q11) Interviewer to IAA3:** Don't business processes deviate? Could you please provide me with the any such statistics, deviation rates and measures of fraud risks?

**IAA3:** Yes, and no. yes in the sense that at such a large and complex organisation not every business process can be modelled with strict requirements and deviations from standard business processes do occur. And no in the sense that whatever the deviations, they are authorised by multiple people and recorded electronically even more carefully than normal processes. Hindrances do occur, we cannot deny it, but that is small compared to the number of transaction. Over the past few years have been highly successful in reducing the rate of process deviations and associated perceived fraud risks. I will let you know the numbers if you hold on for a while. Here, since installation of the ERP System in 2008, our process deviation rate has dropped from 25% in 2009 to 14.1% in 2015. In 2010, it was 23.94%, followed by 22.29%, 15.56%, 15.71% and 15.02% for the years 2010 to 2014 respectively. Going paperless has especially helped us reduce process deviation, reducing it from 22.29% in 2011 to 15.56% the following year. The calculated fraud risk also follows a similar trajectory, going from 10.23% in 2009, followed by 7.98%, 9.71%, 6.11%, 3.81%, 3.86% and 5.29% for the years 2010 through 2015. The last fiscal year has been an exception, showing a sudden spike in fraud, the reasons for which are under investigation by the Audit Committee of the Board.

**(Q9) Interviewer to IAA1:** What control mechanisms are used to ensure accountability?

**IAA1:** Since we use authorisation of some form for each procurement process, and also maintain records at each stage electronically, accountability is ensured through these mechanisms. Of course, accountability does not end there, accountability as a concept goes far beyond tracing authorisation.

There is a hierarchy of authority, and hence a hierarchy of accountability. If something goes wrong in terms of a fraudulent activity or something, the internal audit team is also accountable. If a line of production breaks down, the supervisor, line manager and the Production Engineers, each of them is accountable to different degrees and nature.

**(Q10) Interviewer to IAA2:** What procedures do you employ to measure process deviation and fraud risk?

**IAA2:** Good old sampling and investigation does the trick here. However, recently we have been trying to implement new technologies such as data mining. We have talked about outsourcing the process of data mining information from our ERP System, that however, remains to be a tricky decision yet to be taken. Business secrets are obviously one of the biggest problems in outsourcing such crucial information in terms of Business Intelligence perspective. Helping you out for an academic pursuit is a different thing however, because we know the confidentially that you will provide and also, we are sharing a small part of the business data for this research.

**Interviewer to Everyone:** Thank you everyone, it has been a very informative and energetic session with your team. In my next visit, I would want to have a sit in with ERP System in-charge and one of you for certain clarifications that I may need.

## *Session 2*

*This is an interview between the interviewer and an Internal Audit Associate (IAA1) and the Business Intelligence Analyst (BIA), who is in charge of the ERP System maintenance. The interview took place at the factory office of Company B. It took place after data were extracted from the ERP System and partially analysed. The translated transcript is given below:*

**Interviewer to Everyone:** Good afternoon. Thank you for joining me. I have progressed a little with the data that I received earlier with the help from 'BIA'. In the event log that I had received detailing procurement cases, there were about 30,000 cases with a massive 300,000 constituent events. These cases helped me to develop the business process model which is typical of the procurement function at your company. I have greatly simplified the original process model using the fuzzy miner algorithm and the edge cutoff feature. Please have a look at the model.

**(Q1) Interviewer to BIA:** Now I would like you to please detail me a typical process path from beginning to the end and check if my model conforms to it.

**BIA:** At 'Company B', under normal circumstances without applying the exceptions, a simple procurement case begins with creating PO. Then we need some kind of approval. All these are fed

into the ERP System, which I maintain. Then PO is released and goods received. When it reaches the warehouse, it is checked for quality and then the Accounts Department releases payment. Yes, you model conforms to the simple process path that I usually see in the ERP System. Also, there is part for Regulatory Approval in your model, which is often needed for certain items.

**(Q2) Interviewer to IAA1:** Does this model conform to the internal control standards?

**IAA1:** Indeed, it does. But I am worried about the cases which does not meet the standards.

**(Q3) Interviewer to IAA1:** Yes, more on that. Upon tweaking my model, I found four extra paths multiple times, which I believe is deviant from this normal path. The paths start and end with the following nodes: Create PO-PO Sent; Inventory Document Received-Approval of Experts; Inventory Document Received-Pay; and Pre-Shipment Inspection-Pay. Can you explain any of these with the guidance of the exceptions that apply to the typical procurement path?

**IAA1:** Yes, certainly. You see the Pre-shipment flow, that can be explained by procurement of stores and spares cases. These are usually not part of the core raw materials and are of little nominal value, and hence do not require expert approval. Document Received-Approval of Experts is a similar process where physical inspection is not practical and the supplier or a third party provides confirmation report. The other two looks suspicious and unnatural to me.

**Interviewer to Everyone:** Thank you for these vital formation and will update my model with these. I hope to contact you once I am done with the rest of the case study. In case I would need any intermediate assistance I hope I can reach you.

**IAA1:** We will be a call away. Happy to help.

## *Session 3*

*This is an interview between the interviewer and two Internal Audit Associates (IAA1 & IAA2). The interview took place over videoconferencing. It took place after the case study on Company B was completed and a report regarding the case study was sent to Company B. The translated transcript is given below:*

**Interviewer to Everyone:** Hello to both of you. Nice to talk to you again.

**(Q1) Interviewer to IAA2:** I have conducted process mining on the data that I retrieved from your ERP System related to procurement using ProM 6. First of all, I would like to ask you about the process mining that I have applied to your data as you can see in the report I prepared for you. And, please also comment on the use of the Bayesian theorem.

**IAA2:** If you could remember from our previous conversation, we were looking for vendor for data mining. Process mining seems to be a more evolved and tailored product for analysing business process data. The structure of the research is definitely helpful for internal audit at 'Company B'. The use of Bayesian theorem come naturally we believe. It good to see both these concepts being utilised for arriving at a better measure of fraud risk. Looks like our company is fully prepared for implementing such a procedure.

**(Q2) Interviewer to IAA1:** How efficient do you think process mining is?

**IAA1:** It seems very efficient if you are taking about efficiency in terms of resources used. We have had all these data laying around without having a very useful use of the data. Process mining uses these data and analyses the data using existing computational power. It looks like a very impressive utilisation of unused capacity, both in terms of data and computational power. So, its efficient.

**(Q3) Interviewer to IAA2:** How accurate do you think the results are?

**IAA2:** For process deviation, the mining tool uses comprehensive data, so the output should be pretty accurate. However, since the cut-off is set subjectively, the accuracy becomes a subjective thing. Fraud risk is another thing. Since fraud risk calculation still uses fraud-to-deviation ratio, this is still reliant on the sampling that we do, and hence its accuracy is closer to sampling than the [accuracy of] process deviation.

**(Q4) Interviewer to IAA2:** What would be your opinion on using the Bayesian theorem to revise fraud risk?

**IAA2:** The use of the theorem is pretty neat and intuitive. We have the rate of fraud among a group of deviant processes and we have an updated process deviation rate, what we do is use Bayesian [theorem] to update our perceived fraud risk. Good job!

**(Q5) Interviewer to IAA1:** What are the potential risks of using process mining for measuring fraud risk?

**IAA1:** Potential risk could be over-reliance on it once it becomes an established practice. Good old internal control checks and balances could never be out of use, so a new technology, however complete and precise it may seem, should be used carefully and in conjunction with other measures.

**(Q6) Interviewer to IAA1:** What is your overall opining on the framework for assessing fraud risk, especially in regard to your organisation?

**IAA1:** The framework definitely adds value. The use of such a framework in our internal control system would definitely be a step forward. As we were already on the lookout for such technology at our company, exposure to your research should steer our efforts to a better direction.

**Interviewer to Everyone:** Thank you all. It has been a pleasure making your company a case study for my research. Thank you for your kind cooperation.

## Appendix G - Interview at Company C

***The following conversations were mainly conducted in Bengali, which was then translated with help from a professional translator.***

### *Session 1*

*This is an interview between the interviewer and the internal audit team at Company C. The internal audit team is comprised of four members (M1, M2, M3 & M4) from the Accounts Department with two members rotated each year in a staggered manner and each member serving two years each. All the members are equally ranked for the purpose of internal audit. The team reports to the Chief Financial Officer and upon calling, directly to the Chief Executive Officer. The interview took place in the airlines' head office in the city. It took place before data were extracted from the ERP System and analysed. The translated transcript for the interview is given below:*

**Interviewer to Everyone:** Good afternoon. It is good to have your worm welcome at your office here. The interview is being audio-recorded for the purpose of the academic research. Thank you all for cooperating once again.

**(Q1) Interviewer to M1:** Let us start our discussion with the topics of internal control. What systems do you have in place for managing procurement? What are the business processes related to procurement?

**M1:** Procurements, just like any other business process, follow a standard approach in 'Company C', as described in the Standard Operating Procedure Guideline (SOPG). We have deigned the business processes with internal control and productivity in mind. Sometimes there may be trade-off between the two, however, certain level of internal control is required for keeping operational risks at check. Let me describe you the procurement processes, and you will have an idea of the process as well as the controls. There are two distinct types of procurements done at 'Company C', one is the regular procurement from supplier with whom we have a service agreement. This is required for the many aircraft parts that we have to import ion a continuous basis. Since this is a highly regulated industry, our suppliers have to pass through many steps before being approved by our management and often by the Civil Aviation Authority. Hence, a service agreement is often the best model to follow for procurement. The other type of procurement is for items which are relative infrequently purchased. For these types of goods, we follow the RFQ or Request for Quotations model. In case of purchases from regular suppliers the requests are passed and billed at the operational level by a mid to senior level manager. For procurement requiring RFQ, the Purchase Committee comes into use. The Purchase Committee is made up of three full-time executive members and two Board members who are rotated every two years. The committee is nominally administered by the Supply Chain and Operations Department, yielding greater autono0my than the rest of the department. One thing I must mention that even the RFGQs are sent to a pre-approved list of suppliers, as this greatly saves precious time. Both the services agreement and this list is updated and revised annually by the

Purchase Committee. For purchases amounting to 1 million Taka or more, the approval from the Purchase Committee must be unanimous. For any other amount any two members from the purchase committee can approve, given that it is not purchase from one of our service agreement holders, in which case the issues are dealt at the operational level, of course.

**(Q2) Interviewer to M1:** Can you please tell us a bit more about the participants involved in a procurement process?

**M1:** For purchases from vendors with Service Agreements, anyone from the officer grade can request for a purchase. It has to be approved by a managerial level staff and forwarded to the Accounts office for carrying out the transactions. This is dealt at the operational level, and usually do not come forward to the Purchase Committee or executive level. This is done on a need basis, any staff or a group of employee who assess any need for supplies for carrying out his or her duty diligently can order for its requisition. Purchases outside the vendor-agreement, are however, usually more of a strategic nature. They are usually also of large monetary value. Usually the executive level decides on the procurements of such items and the Purchase Committee approves and inspects them upon arrival. The prices are set by the RFQ method, and most often than not the lowest quotes are selected. The quality issue is usually dealt beforehand when selecting firms for enlistment into trusted suppliers list. Selecting a trusted supplier is a more complicated step, where not only the executives and the Purchase Committee get involved, but sometimes members of the Board and often the regulatory authorities are also involved.

**(Q3) Interviewer skipped this question as it was answered earlier.**

**(Q4) Interviewer skipped this question as it was answered earlier.**

**(Q5) Interviewer to M2:** So, after an employee or an executive decide on a purchase, what subsequent steps are made? What are the steps in case of regular purchase from vendors? How do the processes differ in case of a purchase requiring Purchase Committee approval?

**M2:** When an employee requests a requisition, he or she lets it know to the line manager casually. After that a standard form is filled up and submitted to the line manager, who then analyses the need in light of existing operational needs in his or her line of service. Then the manager forwards the requisition request to the Accounts Department, who forward the order to the supplier. Sometimes payment is made beforehand, and sometimes afterwards, depending on the service contract terms. Upon receiving of the goods at the warehouse, it is placed in custody of the requisition originator.

**(Continuation of Q5) Interviewer to M2:** Could you please state the role of ERP system in this procedure?

**M2:** Sure. The ERP System is involved from the beginning. Upon receiving the standard requisition form from the originator, the line manager makes an entry into the ERP system. After that the Accounts Department makes entries for payment, and receipt of shipment for the goods, and finally the line manager makes an entry for the clearance of the pending process, marking an end to the requisition request. So the only people getting involved with the ERP system are the line manager and one or two personnel from the Accounts Department.

**(Continuation of Q5) Interviewer to M2:** And in case of procurements requiring Purchase Committee approval?

**M2:** These purchases are usually made as part of strategic decision-making at the executive level. An executive level office lets the Purchase Committee know the need for such an investment. From here, the Purchase Committee takes over. All the entries to the ERP system are made with the knowledge of the Purchase Committee. The Purchase Committee issues a Request for Quotation to the pre-approved list of suppliers. Upon receiving the quotations and quality specifications, the purchase Committee decides and selects a vendor for the purchase. From here on, the Accounts Department takes over and maintains liaison with the vendor. Since these type of purchases often takes weeks to months, the Purchase Committee oversees all the aspects of the procurement from time to time. Upon delivery the Procurement Committee checks for any quality issues, and if installation is required the quality checks extents until being operational. During this phase the Purchase Committee may call upon internal staff or external experts for quality assurance. If everything goes well, the requisition request is marked clear in the ERP system.

**(Q6) Interviewer skipped this question as it was answered earlier.**

**(Q7) Interviewer to M3:** So how do you ensure that all these steps are being followed and some or all of them are not being skipped in few cases?

**M3:** Well, that is the job of the internal audit team. We ensure compliance with SOPG through random checks as well as regular vests and cross-checks. We work closely with our Accounts Department, warehouse staff and Business Analyst in charge of the ERP System maintenance. And obviously, we assist the external auditors in their yearly round of financial audit.

**(Q8) Interviewer to M3:** Amidst all these control, doesn't process deviation occur? Is not there justified reasons for deviating from the SOPG?

**M3:** Well the SOPG is designed to be a guidance onto business process in the most typical of cases. Oftentimes different routes of business processes are required for functionality of efficient business as well as for regulatory requirements and orders. Those are dealt as exception to our process deviation and fraud risk measurement audits.

**(Q9) Interviewer to M3:** How do you ensure accountability?

**M3:** Mainly authorisation and formal chain of command maintains the accountability of an action in 'Company C'. See, at each stage there was someone authorising the procurements and its steps. For example, after requisition, whether a good was indeed needed was approved by the line manager. Payment was approved by the Accounts Manager. Quality is ensured by the Procurement Committee or by the originator upon use. Shipment is acknowledged by the line manager, etcetera.

**(Q10) Interviewer to M1:** How do you assess rate of process deviation and underlying fraud risk?

**M1:** Assessing process deviation and fraud risk is part of our scheduled job, and that is done quarterly. Any surprise checks and audits are incorporated in the quarterly report, unless is it of urgent importance, in which case it is conveyed to the CFO directly. We do our process deviation assessment through sampling. Cases of prospective frauds are investigated thoroughly. 'M2' will provide later today a report on the guidelines we follow in preparing the assessments on process deviation and fraud risk. It will have the details that you would need for analysing our fraud assessment process. There is obviously some confidentiality clause which 'M2' will let you know in due time.

**(Q11) Interviewer to M1:** Could you give me a general idea about the historical rates regarding process deviation and fraud risk?

**M1:** Sure. Over time, both our process deviation rate and fraud risk rate has shown a declining trend. Let me show you the numbers. Process deviations was 32.5%, 35.25%, 28% and 26.56% for the years 2012 through 2015. You can see general decline; you could give credit to strengthening the internal control system. The fraud risk rate was 7.5% followed by 5.74%, 3.2% and 5.47% for years 2012 through 2015. The last fiscal year saw a little spike in fraud risk, but that is most likely a statistical fluke. The report that 'M2' will provide you will contain the details on these historical data.

**Interviewer to Everyone:** Thank you all for your kind cooperation. I hope to talk to you shortly after I have extracted the data from the ERP System.

## *Session 2*

*This is an interview between the interviewer and a member of the internal audit team (M1) and the Business Analyst (BA), who is in charge of the ERP System maintenance. The interview took place at the head office of Company C. It took place after data were extracted from the ERP System and partially analysed. The translated transcript is given below:*

**Interviewer to Everyone:** Good to see you two again. I have made a bit progress which I gathered earlier. Have a look at this process map that I have made from the event log data. Please keep in mind, this a simplification of the original log, and the abstraction is there only to make things more understandable and ready to be analysed. Behind this model there are over 3500 procurement cases comprised of over 22,000 events.

**(Q1) Interviewer to BA:** As you are in-charge of maintaining the database and system and from your capacity as a Business Analyst, could you please guide me if the start and end nodes of the business process model that I have derived is up to the mark for a typical case of procurement at your company?

**BA:** Well, I can see it starts with creating PO and ends with payment. Which is true, I think for almost all cases. Overall the model looks close to reality I believe.

**(Q2) Interviewer to M1:** Now form an internal control perspective, do you think the model is up to the mark?

**M1:** Indeed. I have been looking at the model, and I can see all the major control items included. For example, we have the authorisation of the management, handing of the PO, quality check and regularity approval. All the events for a typical purchase case you can say.

**(Q3) Interviewer to M1:** The algorithm used to model the business process is called Fuzzy Miner. This algorithm has a parameter known as 'edge cutoff' which lets you modify the level of abstraction in the model. Upon tweaking, I found four new process paths that are less frequent. These paths start and end with Create PO-PO Sent; Inventory Document Received-Approval of Experts; Inventory Document Received-Pay; and Pre-Shipment Inspection-Pay. Do you believe any of these less typical paths are deviant or are accepted within the norms?

**M1:** All these paths you just mentioned, none of them really totally conform to the SOPG standards. I am sure many of these paths are due to mistake, negligence, but some may also be cases of fraud. This needs to be further investigated.

**Interviewer to Everyone:** Alright the. It was nice talking to you and thank you for cooperating. I hope I can come up with some results soon.

## *Session 3*

*This is an interview between the interviewer and a member of the internal audit team (M1). The interview took place over videoconferencing. It took place after the case study on Company C was completed and a report regarding the case study was sent to Company C. The translated transcript is given below:*

**Interviewer to M1:** Hello, nice to see you again. I have nearly completed the case study that I conducted on your company. I have already sent a copy of the report on your company, and I hope you have seen it.

**M1:** Thank you, nice to see you too. Yes, I have received and seen the report.

**(Q1) Interviewer to M1:** So, what do you think of the concepts that I have used to assess fraud risk, specifically the concepts of process mining and Bayesian theorem?

**M1:** Process mining is really a novel and new concept to me. The concept seems pretty good on paper. About its use in the practical field, I would need some assurance from my fellow colleagues and friends in this field. Also, personally I am looking forward any professional courses available on the use of process mining in internal audit.

**(Continuation of Q1) Interviewer to M1:** And Bayesian theorem?

**M1:** Bayesian theorem also seems good approach. My colleague 'M2' was actually praising its innovative use, but since I am not much familiar with the concept myself, I think I will have to reserve my judgement.

**(Q2) Interviewer to M1:** How efficient do you think the use of process mining is?

**M1:** Definitely much more efficient than sampling. Sampling is a manual process while process mining is automatic. This saves a lot of time. However, to my understanding sampling would still need to be done to assess fraud risk, and the use of process mining is only an additive one in making the fraud risk rate more accurate. But definitely, on its own, it's an efficient process.

**(Q3) Interviewer to M1:** And how accurate do you think the process is?

**M1:** Again focusing on just process deviation rate, using process mining is much more accurate than traditional approach. Traditional sampling just takes a sample of data, while process mining takes all the event log data into consideration. It's bound to be more accurate.

**(Q4) Interviewer to M1:** For revising the fraud risk rate, is the reliance on Bayesian theorem alright?

**M1:** it seems pretty alright to me. You have to incorporate the new and improved process deviation rate into the mix for the new fraud risk rate. Me and my colleagues think Bayesian theorem is adequate in this case.

**(Q5) Interviewer to M1:** What could be the risks in relying on process mining?

**M1:** Well, since the new fraud risk stills incorporates sampling, all the cons of sampling are transferred to the new process, but maybe to a lesser extent. As for process mining itself, I am a bit sceptical about the selection of a cut-off. If there was some authoritative guidance on selecting the cut-off it would make its use in professional life much easier.

**(Q6) Interviewer to M1:** What do you think of the overall effectiveness of the framework?

**M1:** I tell you, the framework looks goods. Maybe it needs refinements, but overall it looks promising.

**Interviewer to M1:** Thank you (M1). This has been a fruitful research and has been possible because of you and your team. Thank you again.