AN IMPROVEMENT OF DATA ANALYTICS DETECTION RULES IN THE INTERNAL AUDIT OF THE PROCUREMENT AND INVENTORY PROCESSES

Miss Penpak Rangsipunyaporn

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering in Engineering Management
(CU-Warwick)
FACULTY OF ENGINEERING
Chulalongkorn University
Academic Year 2021

การปรับปรุงกฎการตรวจจับสำหรับการวิเคราะห์ข้อมูลในการตรวจสอบภายในของกระบวนการจัดซื้อและบริหารคลังสินค้า

น.ส.เพ็ญพักตร์ รังษิปัญญาภรณ์

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาการจัดการทางวิศวกรรม ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2564

Thesis Title	AN IMPROVEMENT OF DATA ANALYTICS DETECTION RULES IN THE INTERNAL AUDIT OF THE PROCUREMENT AND INVENTORY PROCESSES
By	Miss Penpak Rangsipunyaporn
Field of Study	Engineering Management
Thesis Advisor	Professor PARAMES CHUTIMA, Ph.D.

Accepted by the FACULTY OF ENGINEERING, Chulalongkorn University in Partial Fulfillment of the Requirement for the Master of Engineering

..... Dean of the FACULTY OF ENGINEERING
(Professor Dr. SUPOT TEACHAVORASINSKUN, D.Eng.)

THESIS COMMITTEE

..... Chairman
(Associate Professor JEERAPAT NGAOPRASERTWONG)
..... Thesis Advisor
(Professor PARAMES CHUTIMA, Ph.D.)
..... External Examiner
(Associate Professor Chuvej Chansa-ngavej, Ph.D.)

เพ็ญพักตร์ รังษิปัญญาภรณ์ : การปรับปรุงกฎการตรวจจับสำหรับการวิเคราะห์ข้อมูลในการตรวจสอบภายในของกระบวนการจัดซื้อและบริหารคลังสินค้า. (AN IMPROVEMENT OF DATA ANALYTICS DETECTION RULES IN THE INTERNAL AUDIT OF THE PROCUREMENT AND INVENTORY PROCESSES) อ.ที่ปรึกษาหลัก : ศ. ดร.ปารเมศ ชุติมาPh.D.

การวิเคราะห์ข้อมูล (Data analytics) เป็นเครื่องมือที่สำคัญในการเพิ่มมูลค่าแก่ผลการตรวจสอบภายใน เพราะช่วยลดเวลาปฏิบัติงาน รวมทั้งเพิ่มประสิทธิภาพ ประสิทธิผล และระดับความเชื่อมั่นเมื่อเปรียบเทียบกับผลจากวิธีการสุ่มตรวจสอบ และเนื่องจากกฎการตรวจจับ (Detection rule) เป็นเงื่อนไขที่ใช้เทคนิคการวิเคราะห์ข้อมูลเพื่อค้นหาความผิดปกติในรายการธุรกรรมทางธุรกิจ ดังนั้น โครงการนี้จึงมีวัตถุประสงค์เพื่อปรับปรุงกฎการตรวจจับในกระบวนการจัดซื้อ (Procure-to-pay) และสินค้าคงคลังขาเข้า (Inbound inventory) แก่บริษัทตรวจสอบแห่งหนึ่งในประเทศไทยเพื่อให้บริการด้านการตรวจสอบภายในแก่ลูกค้าในธุรกิจการผลิต ขอบเขตของกระบวนการย่อยประกอบด้วย 1) การกำกับกระบวนการ (Process governance) 2) การคัดเลือก การประเมิน และการจัดการฐานข้อมูลผู้ขาย (Vendor selection, evaluation, and master data maintenance) 3) การสั่งซื้อ (Ordering) 4) การตรวจรับสินค้า (Goods receipts) 5) การจัดการใบแจ้งหนี้ (Invoice processing) และ 6) การจ่ายเงิน (Payment)

การดำเนินโครงการนี้ประกอบด้วย 4 ขั้นตอน ในขั้นแรกผู้วิจัยทำความเข้าใจกระบวนการและธุรกิจการผลิตอาหารสัตว์ซึ่งเป็นธุรกิจของบริษัทกรณีศึกษา จากนั้นจัดทำร่างแผนผังกระบวนการทางธุรกิจ (Business process flow) ตารางความเสี่ยงและการควบคุม (Risk and control matrix) และกฎการตรวจจับ (Detection rule) จากฐานข้อมูลความรู้ของบริษัท กฎการตรวจจับที่บริษัทมีอยู่เดิมจำนวน 16 ข้อ เอกสารเผยแพร่ขององค์กรระดับสากล วารสารวิชาการ และประสบการณ์ด้านการตรวจสอบภายในมากกว่า 9 ปีของผู้วิจัยเอง ในขั้นตอนต่อมา ผู้วิจัยนำเอกสารทั้งสามรายการนี้ไปหารือกับผู้เชี่ยวชาญของบริษัทจำนวน 2 ท่าน เพื่อให้มั่นใจได้ว่า ความเสี่ยง การควบคุม และกฎการตรวจจับที่สำคัญได้รับการระบุอย่างเหมาะสม ผลจากการดำเนินการทั้งสองขั้นนี้พบว่า กฎการตรวจจับจำนวน 15 จากทั้งหมด 16 ข้อ สามารถประยุกต์ใช้ได้กับบริษัทกรณีศึกษาโดยไม่ต้องปรับปรุงเพิ่มเติม กฎการตรวจจับที่เหลืออีก 1 ข้อ ได้รับการปรับปรุงโดยเพิ่มขอบเขตของการตรวจสอบให้กว้างขึ้น นอกจากนี้ กฎการตรวจจับใหม่ได้ถูกระบุขึ้นจำนวน 18 ข้อ เพื่อให้การสอบทานกระบวนการจัดซื้อและสินค้าคงคลังขาเข้ามีความครบถ้วนสมบูรณ์

ขั้นตอนต่อมา ผู้วิจัยทดสอบประสิทธิผลของกฎการตรวจจับทั้งหมด 34 ข้อ (กฎการตรวจจับเดิมจำนวน 15 ข้อ กฎที่ปรับปรุง 1 ข้อ และกฎที่ระบุขึ้นใหม่ จำนวน 18 ข้อ) ด้วยชุดข้อมูลที่จำลองขึ้นจากรายการธุรกรรมการจัดซื้อของผู้ผลิตอาหารสัตว์ หลังจากการทดสอบด้วยโปรแกรม Microsoft Excel พบว่ากฎการตรวจจับดังกล่าวค้นพบประเด็นจากการตรวจสอบ (Finding) เพิ่มขึ้นร้อยละ 100 และรายการผิดปกติ (Suspicious transaction) เพื่อการตรวจสอบเพิ่มเติมเพิ่มขึ้นร้อยละ 157 เมื่อเปรียบเทียบกับกฎการตรวจจับเดิม 16 ข้อ ตัวอย่างเช่น พบว่า เจ้าหน้าที่หน่วยงานจัดซื้อมีบทบาทหน้าที่ทั้งการรักษาฐานข้อมูลผู้ขายและการสร้างใบสั่งซื้อ ซึ่งจะเพิ่มโอกาสการยักยอกทรัพย์ได้ อีกตัวอย่างหนึ่งเช่น รายการซื้อสินค้าร้อยละ 0.46 ทำการตรวจรับสินค้ามากกว่าที่หน่วยงานผู้ใช้สินค้าร้องขอ ซึ่งเป็นการเพิ่มต้นทุนสินค้าคงคลังที่ไม่จำเป็นและเพิ่มความเสี่ยงต่อการเสียหายของวัตถุดิบอาหารสัตว์ อย่างไรก็ตาม กฎการตรวจจับที่ปรับปรุงใหม่นี้ไม่พบประเด็นเพื่อการปรับปรุง (Area for improvement) เพิ่มเติม และแม้กฎที่ปรับปรุงนี้จะเพิ่มผลการตรวจสอบว่าไม่พบความผิดปกติ (No exception) มากขึ้นร้อยละ 150 จากกฎการตรวจจับเดิม กฎใหม่เหล่านี้ช่วยเพิ่มระดับความเชื่อมั่นจากการทดสอบรายการจัดซื้อทุกรายการหรือรายการจำนวนมากเมื่อเปรียบเทียบกับจำนวนตัวอย่างที่สุ่มทดสอบ

จากข้อดีของการใช้กฎการตรวจจับด้วยเทคนิคการวิเคราะห์ข้อมูลที่กล่าวมานี้ งานวิจัยในอนาคตสามารถขยายการพัฒนากฎการตรวจจับไปสู่กระบวนการทางธุรกิจอื่น หรืออุตสาหกรรมอื่น รวมถึงอุตสาหกรรมเดียวกันแต่เปลี่ยนชนิดของผลิตภัณฑ์ ยิ่งไปกว่านั้นอาจทดสอบกฎต่าง ๆ ด้วยเครื่องมือการวิเคราะห์ข้อมูลที่ทันสมัยขึ้น หรือพัฒนาโปรแกรมเพื่อตรวจจับรายการผิดปกติได้โดยอัตโนมัติ อย่างไรก็ตาม การใช้กฎการตรวจจับนี้มีข้อจำกัดที่ควรพิจารณาบางประการ เช่น ข้อมูลและเครื่องมือที่สามารถเข้าถึงได้ รวมทั้งทักษะการใช้งานที่จำเป็น นอกจากนี้ ความสำเร็จในการตรวจจับความผิดปกติยังขึ้นอยู่กับการตีความผลการวิเคราะห์ข้อมูลของผู้ตรวจสอบ ตลอดจนความรอบคอบในการตกแต่งข้อมูลของผู้กระทำผิดอีกด้วย

สาขาวิชา	การจัดการทางวิศวกรรม	ลายมือชื่อนิสิต .....
ปีการศึกษา	2564	ลายมือชื่อ อ.ที่ปรึกษาหลัก .....

6272805121 : MAJOR ENGINEERING MANAGEMENT
KEYWORD:

Penpak Rangsipunyaporn : AN IMPROVEMENT OF DATA ANALYTICS DETECTION RULES IN THE INTERNAL AUDIT OF THE PROCUREMENT AND INVENTORY PROCESSES. Advisor: Prof. PARAMES CHUTIMA, Ph.D.

Data analytics is a powerful tool to deliver value-added internal audit results as it reduces execution time and increases efficiency, effectiveness, and assurance level compared with the audit sampling approach. Because detection rules are criteria applied in the data analytics method to discover anomalies in the business transactions. Therefore, this project aims to improve the anomaly detection rules in the procure-to-pay and inbound inventory processes for an audit firm based in Thailand to provide internal audit services for clients in the manufacturing business. The sub-processes cover (1) process governance, (2) vendor selection, evaluation, and master data maintenance, (3) ordering, (4) goods receipts, (5) invoice processing, and (6) payment.

The project methodology comprises 4 steps. Firstly, the processes and the animal feed manufacturing business which is relevant to the case study company were understood. Then, the draft of business process flows, risk and control matrix, and detection rules were prepared. The information is based on 16 current detection rules of the TH office, TH office's knowledge management database, international institutes' publications, academic journals, and the author's 9-year internal audit working experience. In the second step, these materials were used for discussing with two subject matter experts in order to ensure that key risks, internal controls, and detection rules were identified adequately. As a result of understanding the processes and interviewing with the experts, 15 out of 16 detection rules of the TH office were applicable to the case study company and needed no adjustment. The remaining rule was improved by enhancing detection aspects. Furthermore, additional 18 rules were identified to complete reviewing the P2P and inbound inventory processes.

Next, all of the 34 improved detection rules (15 existing, 1 improved, and 18 new rules) were tested their effectiveness with the data set generated based on the animal feed producer's purchasing transactions. After testing the effectiveness of all rules in Microsoft Excel, they discovered more findings (100% increase) and suspicious transactions for further investigation (157% increase) compared with the existing 16 rules. For example, it appears that all the procurement staff is responsible for both vendor master data maintenance and PO creation roles which increase the opportunity of embezzlement. Another example is that 0.46% of purchasing transactions received goods over than user's requirements which raises unnecessary inventory cost and risk of the rotten feed ingredient. However, no additional area for improvement was found by the improved rules. Lastly, even though the improved rules found no exception by 150% increase from the original ones, these new rules escalate the confidential level through testing all or larger transactions than the small sample size.

From the above advantages of applying detection rules through the data analytics method, there are opportunities for future work to enhance the scope of detection rules development to other business processes, other industries as well as the same industries but other kinds of products. Moreover, there is an opportunity to test the rules with the other advanced data analytics tools or develop a programme to automatically detect anomalies. In addition, other researchers can link the rules with the ERP data for real-time data analytics. However, applying detection rules has some limitations that need to be considered such as availability of data and tools as well as required skills. In addition, success in detecting anomalies depends on interpreting data analytics results by the internal auditors and deliberately data manipulation to close the gaps by perpetrators.

Field of Study:	Engineering Management	Student's Signature .....
Academic Year:	2021	Advisor's Signature .....

ACKNOWLEDGEMENTS

I would like to appreciatively recognise the assistance of the following people who are important ones for my success: Assoc. Prof. Dr. Chuvej Chansa-ngavej who continues providing guidance and valuable feedback to my project, Prof. Dr. Parames Chutima who lets me clear the project methodology, Assoc. Prof. Jeerapat Ngaoprasertwong who asks me critical questions to improve the report, CUSE and WMG coordinators who answer any questions, two subject matter experts who review, recommend, and control the quality of work products from this project, my bosses who support me not only to make the dissertation but also throughout making the master degree, my dear friend who encourages and let me dare to leave from the jobs and concentrate making the best dissertation as much as I can, and last but not least, my family who is by my side and give me unconditional supports during this difficult time. A big thank you to all of you again.

Penpak Rangsipunyaporn

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1
INTRODUCTION

1.1 Business and industry overview

1.1.1 The company overviews

"**Company A**" or "**The Company**" is a professional service firm in the group of "Big 4" global accounting audit and business consulting, namely Deloitte, Ernst & Young (EY), KPMG, and PricewaterhouseCoopers (PwC). Almost 290,000 professional staff working in 155 countries worldwide, Company A provided services for clients with over $40 billion of gross revenue in the last fiscal year (2020).

For Thailand office of Company A (**TH office**), it has more than 2,000 staff delivering different expertise for clients as described in the table below.

Table 1: The TH office's lines of services

Line of service	Description
1. Assurance	The assurance is a major service of TH office. It can be separated into 2 divisions: 1.1 Core assurance: to certify client companies' financial statements and provide advice on the accounting standards. 1.2 Risk assurance: to perform internal audit, corporate governance review, and enterprise risk management consultation
2. Consulting	To develop the solutions in several areas; for example, strategy, technology, operation, people & change management, sustainability, and forensics.
3. Deal	To assist the clients in the merger and acquisition as well as other types of business deals.
4. Tax and Legal	To provide suggestions on corporate tax planning and compliance with business laws and regulations.

The TH office's clients are businesses. Most of them are large Thai or international companies having operations in Thailand. In addition to the private sector, the clients include government agencies, state-owned enterprises, and non-profit organisations. This customer base covers various industries such as manufacturing, energy, banking, retail and wholesale, telecommunication, and healthcare.

1.1.2 What is the internal audit?

According to the Institute of Internal Auditors (IIA) which is a global association of internal audit professionals, internal auditing is defined as an activity to provide the assurance and consulting services with independence and objectivity in order to develop or improve the business operations and contribute to achieving the organisation's goals (IIA, 2021). The **assurance** service is an objectively and independently examination of the evidence on organisation's corporate governance, risk management, internal control, and compliance processes. The **consulting** service is an advisory provided to clients as agreed. It includes but is not limited to counselling, knowledge sharing, and workshop facilitation (IIA, 2017).

Internal audit is an important part of organisation structure to build robust corporate governance and risk management. Because today's business environments are more uncertain, complex, and full of changes. The board of directors is entrusted by the stakeholders to oversight, allocate resources, and manage risks in order to achieve the goals. The management such as the Chief Executive Officer (CEO), president, or management committee is responsible to lead actions from directions approved by the Board. With independence from any interests, the internal audit can help the Board and management ensure that the company has appropriate risk mitigation plans, designs adequate internal controls, and effectively implements them for the company's success. These days, the internal auditors are expected to play the role of a trusted advisor by providing business trends and insights to continuously improve the business processes and promote innovation (IIA, 2020). Different from the external auditors, the internal auditors consider risks and controls on the operations also compliance with laws and regulations. These are larger scopes than reviewing financial and reporting issues that the external auditors are accountable for (Chartered IIA, 2021b).

1.1.3 The internal audit in Thailand market

The internal audit is a crucial activity of all organisations. For listed companies, the Stock Exchange of Thailand (SET) specifies that the companies are required to appoint an audit committee. And the audit committee normally has internal auditors to perform assurance and consulting duties. So, it can be said that most listed corporates have internal audit activities (SET, 2021). In addition, according to benefits described in Section 1.1.2, non-listed companies aim to have effective internal audit activities as well (IIA, 2011).

For these reasons, the TH office can seek opportunities for internal audit engagements in both listed and non-listed companies and all business industries. The possible engagement types are:

- Internal audit consultation: The professional service firm offers consultation services for organisations having full in-house staff

- Co-sourcing: The professional service firm provides subject matter experts to perform particular internal audit activities for clients
- Full outsourcing: The professional service firm performs all of the internal audit activities for clients.

(IIA, 2012)

The above engagement types are targeted by many consulting firms in the market. Accordingly, TH office does not only focus other three Big 4 companies as competitors but also the local companies which offer the internal audit service with a lower professional fee. In other words, the TH office is facing challenges both differentiation from opponents in the Big 4 group and low-price strategy from local firms. The example of internal audit strategies from the Big 4 companies are listed as follows.

Table 2: The marketing strategies of Big 4 in the internal audit services

Company	Internal audit service strategy
1. Deloitte	In order to make the right decision and mitigate clients' risks, Deloitte adopts agile internal auditing through its strength of insight-driven analytics embedded in all stages of its internal audit approaches (Deloitte, 2021).
2. EY	EY leverages the power of data to transform clients' processes and establish new business models. EY applies the data-driven methodology together with the emerging technology to deliver better value for internal audit engagements (EY, 2021).
3. KPMG	KPMG applies a risk-based internal audit approach called KPMG's internal audit methodology (IAM) for the outsourcing and co-sourcing engagements. With the developed audited data workflow, KPMG increases testing efficiency compared with manual work. The data is also used for visualised reporting to the clients (KPMG, 2018).
4. PwC	PwC aims to apply a data-enabled audit strategy combined with advanced technologies and techniques to improve the clients' internal controls and support in the agile business ready for changes (PwC, 2021)

As can be seen from the table, it is obvious that data analytics is a hot topic that key players have focused on.

1.1.4 The growing use of data analytics

Data analytics is now widely used in both external and internal auditing. The International Auditing and Assurance Standards Board (IAASB) which is an international working group setting the standards and best practices for the auditing and assurance profession explains how data analytics grows as below.

Previously, businesses operated in an unsophisticated context. So, the auditors tested the transactions manually without prioritising high-risk areas for scrutiny. Over time, the businesses were more complex with a larger number of transactions, an increase in laws and regulations, and a higher number of related parties. However, there were some constraints in the technology. So, the risk-based audit approach has been evolved. This method lets the auditors assess risks and internal controls in the business processes. Then, areas with high risks are selected for audit sampling. That is less than 100% of the population is examined, but results are concluded to the whole population. However, due to limitations in technology, this risk-based approach was suitable for audit execution at that time (Anderson et al., 2017; IAASB, 2016).

These days, technology has been developed at a rapid pace both increasing in capability and processing speed. Big data is also continuously generated especially from medium and large enterprises. As a result, data analytics becomes a powerful technique for audit execution which delivers the main benefits as follows.

- Improve assurance level: Because the entire population is tested, clients have greater confidence in the audit results.
- Increase efficiency: Detection rules and scriptwriting are required for data analytics. Although adopting the data analytics consumes time and resources in the initial phase, those rules and scripts can be used in other audit engagements or the next periodic testing.
- Increase effectiveness: Data analytics helps the auditors to flag suspicious transactions to further examine. This is different from the sampling tests that the auditors randomly select transactions and look for findings on them. Obviously, the latter method gives less possibility to detect anomalies than the data analytics approach.
- Reduce time spent on testing: Evidence testing is repetitive work and leads to human error. So, Data analytics filters suspicious records for the auditors to investigate and testing

(Chartered IIA, 2017).

1.2 Problem statement

According to the above sections, data analytics is used as a strategy for the internal audit services of professional service firms especially Big 4. Because of its advantages, data analytics is increasingly important. Nevertheless, the TH office does not practically adopt this powerful technique for internal audit engagements because of three reasons.

Firstly, even though the TH office has developed some detection rules, these rules do not complete from the beginning to the end of key business processes. In addition, as mentioned earlier, the initial phase of data analytics requires an amount of investment. So, with a limited budget and time, these rule bases are not continually developed. Consequently, the clients cannot see the whole picture of value-added from the data analytics that the TH office is willing to propose. Secondly, other competitors have already invested in developing data analytics. Thus, they have some used cases as illustrations for the client's consideration during the bidding process. As a result, they have more winning rate on the internal audit opportunities. And they also increase the number of used cases for their credentials. Lastly, because of price competition from the local professional service firms, the TH office cannot propose the data analytics scope and choose the sampling test approach for clients.

The following sections explain the current internal audit framework of the TH office and give an example of ineffective internal audit results from applying the traditional method in an engagement.

1.2.1 The current internal audit framework

The full scope of the TH office's internal audit service is summarised in the framework below.

Table 3: The current internal audit framework of the TH office

Internal audit stage	Areas of focus	Approach
1. Foundation	Stakeholders' expectations	• Identify and understand stakeholders' expectations
2. Risk based audit plan development	Internal audit plan and programme	• Review and adjust audit universe to cover all client's business processes • Define risk assessment factors and rating scales • Assess risks and prioritise the risk level of each audit universe • Develop internal audit plan and audit programme *Remark: Audit universe means the collection of auditable units in the organisation as an entire internal audit's scope of works (Anderson et al., 2017).*
3. Execution	Internal audit fieldwork	• Kick-off meeting with process owners • Walkthrough the business processes to understand the existing internal controls • Evaluate internal control design • Sampling transactions for testing • Evaluate operating effectiveness • Discuss with process owners about findings and recommendations (if any) • Follow-up remediation of audit findings • Close meeting with the process owners

Internal audit stage	Areas of focus	Approach
4. Reporting	• Internal audit report • Management and audit committee's feedback	• Prepare internal audit report • Present existing control, findings, and recommendations to management and audit committee • Revise the internal audit report (if any) • Walkthrough or testing in additional areas according to management or audit committee's concerns (if any)
5. Quality control	Process owners' feedback	• Get feedback from stakeholders for improvement

According to the execution stage in the above table, internal auditors in the TH office will review the client's business processes according to the audit programme. The audit programme begins with understanding the processes and existing internal controls through interviewing with the process owners, studying the policies and procedures, performing process walkthroughs, or other appropriate methods. After understanding the processes, the internal auditors evaluate the adequacy of internal control design to mitigate risks. Then, the internal auditors identify high-risk areas and perform sampling tests to ensure that the designed internal controls are implemented effectively to mitigate those risks. In other words, not all transactions can be reviewed because of a large number of transactions.

1.2.2 Ineffective results from traditional internal audit execution

Take a project of revenue process testing for illustration. The TH office was engaged with a manufacturer to verify the accuracy and completeness of cash collection in the revenue process. The testing period was December 2020 with approximately 20,000 sales records. According to Table 4, 25 sales records (0.13% of the population) were randomly selected to examine. Then, the relevant documents and supporting information for each transaction throughout the process were requested. Example of documents were customer orders, invoices, customer payment evidence, receipts, and account receivable report. During the testing, each sample was reviewed in terms of the segregation of duties, accuracy of the transaction records, and other internal controls as identified in the audit programme. The testing results were documented in the working papers and discussed with the team before confirming findings with the process owners.

Table 4: Sample size for internal audit testing

Internal control frequency	Population	Number of samples for testing
Annually	1	1
Quarterly	4	2
Monthly	12	2
Weekly	52	5
Daily	250	20
Multiple times per day	More than 250	25

After testing 25 samples, the TH office did not find any findings. Although the team increased the sample size to 340 samples (1.70% of the population), no significant issue was found.

Focusing on the approach of sampling and testing transactions, this traditional methodology cannot ensure that significant findings are detected. Because the selected sales transactions may occur in the normal situation without exceptions. The remaining massive transactions which are not tested may contain manual adjustment, override authority, or backdate records. Thus, this sampling test is not effective for today's businesses which have higher complexity and lots of data.

In conclusion, the overall TH office problem is that the company has no detection rules library for the end-to-end of key business processes. It mainly focuses on the risk-based audit approach with sampling transactions for manual testing. Apart from ineffective results delivered from this sampling test methodology, it is not aligned with the Company's direction for internal audit service and also the trends expected from the professional institutes. This will lead to the insecure market positioning of internal audit service compared with other competitors and trust from the stakeholders' perspective.

1.2.3 The pilot processes

As described above, anomaly detection rules are crucial for providing internal audit services for clients. And they are also a significant factor for the market strength of the TH office. So, to select the pilot processes for improving the rules, various views are considered.

Anderson et al. (2017) define a business process as a set of linked activities established for particular objectives. Harper (2020) explains that the pivotal business processes are the source of major impacts to the company's goals. The key processes are mostly what the company focuses on and makes the investments for. A subject matter expert in the TH office describes that Procure-To-Pay (P2P) and Order-To-Cash (O2C) are key processes in which most clients engage the TH office to perform internal audits. A former senior manager in the TH office explains his experience that the most challenging in

the supply chain especially for a manufacturing business is activities among procurement, inventory, and production. For instance, surplus procurement does not cause problems to the production but inventory. Insufficient procurement impacts the production plan but does not increase the inventory cost. Production breakdown impacts material flows in the warehouse and procurement plan. So, when problems occur, they place the blame on the other two departments. CIPS (2021) reveals that procurement is an important activity. The company generally spends over two-thirds of its income on procurement. Therefore, although a few procurements cost reduction, it brings a considerable impact.

Procurement and purchasing are different. Wild (2017) explains that procurement comprises strategic activities linked to decision-making in sourcing the products or services for business. Procurement impacts diverse business aspects like quality, budgeting, also marketing. For purchasing, it is more day-to-day activity such as need identification, supplier selection, and negotiation. This order-by-order process focuses on achieving good composition of price, quality, and delivery. Nonetheless, Monczka et al. (2014) describe that the procurement still needs to control the purchasing activities or referred to as the P2P process to ensure efficiency. The reason is that the companies usually acquire competitive advantages if these day-to-day transactions are effectively managed than competitors. That means, the purchasing results to the company's strategy in turn. P2P covers all procedures from requirement identification until the company receives the orders and makes payments to suppliers.

In short, regarding Table 3 that internal audit involves reviewing the process transactions together with the importance of purchasing discussed above, the P2P process in the manufacturing business is selected as a scope for this project. In addition, to extend the internal audit in material flow, the inbound inventory process is added to the project scope as well.

1.3 Research objective

The research objective is to improve the anomaly detection rules to effectively detect the anomalies including internal control weakness in the P2P and inbound inventory processes as a pilot scope of the TH office.

1.4 Scope of research

This project focuses on the improvement of anomaly detection rules for the internal audit of P2P and inbound inventory processes in a manufacturing business, particularly the animal feed manufacturing which is a business of case study company in this project. The sub-processes are (1) process governance, (2) vendor selection, evaluation, and master data maintenance, (3) ordering, (4) goods receipts, (5) invoice processing, and (6) payment.

1.5 Expected outcomes

At the end of this project, it is expected that improved detection rules will help the TH office discover more findings, areas for improvement, and suspicious transactions in the P2P and inbound inventory processes. As a result of this new detection rules library, the TH office can deliver the value-added internal audit report and save audit execution time. This is, the TH office can propose a lower professional fee to clients. It is also anticipated that these detection rules can be developed as a sample use case for the pursuit of new clients and develop additional rules for other business processes.

Remark: Value-added means value to increase opportunities to accomplish the organisational objectives, improve the operation, and mitigate risks (Anderson et al., 2017).

CHAPTER 2
REVIEW OF LITERATURE

2.1 Data analytics in the internal audit

Data analytics is a technique using systematic analytical methods to examine data, flag suspicious transactions, figure out the relationship of data generated from different sources in the end-to-end process, understand the overview of internal control effectiveness, and discover fraud trends (IIA – Australia, 2020).

Because of the above advantages, PwC (2016) proposes that data analytics can be incorporated throughout the internal audit lifecycle. It does not replace but supports the risk-based audit approach. For instance, the data analytics technique helps the auditors assess the risk level of each activity in the business process instead of only relying on the manual internal control walkthrough results. Each activity is then prioritised as a plan to audit with appropriate frequency. At a specified period, the entire transactional data from individual and relevant processes are analysed. Lastly, the data analytics can be presented in visualisation like graphs and statistical graphics for management decision-making.

Due to the ability to process a large amount of data, the data analytics model enables the internal audit to change from periodic review of sample transactions to the ongoing assessment of a larger or whole population of transactions. In other words, data analytics contributes to continuous auditing (Chartered IIA, 2017)

To perform data analytics effectively, there are 3 rights that the auditors need to know.

1. Right people: Skilled data analysts are required to understand the data, foresee the potential issues or trends, apply scepticism when analysis, and be able to use data analytics tools.
2. Right process: Clear objectives should be set. Then, the right and complete data must be obtained. Moreover, the internal auditors have to apply the right ways to derive value from single data set or connect it to other data sets to meet the audit objectives. For instance, to find the duplicate of payments, the invoice number, invoice details, and account payable aging report.
3. Right technology: The appropriate tools should have enough capacity and capability to process the data set in various criteria to achieve the goals. The Power BI is not chosen for text analysis, and the Excel spreadsheet is not typically used for analysing data over 1.5 million rows.

(IIA – Australia, 2020: Chartered IIA, 2017).

Gepp et al. (2018) reveal that today's businesses generate transactions with high volume, velocity, variety, and veracity. However, both external and internal auditing of companies in the market including the big 4 firms rarely applies the big data analytics technique for delivering value to their clients. This technique is now widely used in developing models to (1) prevent and detect financial failure, (2) detect financial fraud, and (3) predict the stock market trends. For internal audit activities, big data analytics is potentially used to predict, prevent, and detect suspicious transactions for further investigation. It allows the auditors to test the full amount of data which brings greater customer satisfaction and improves the degree of assurance. Eventually, this technique leverages the internal audit maturity level as the trusted advisor for strategic decision-making. Accordingly, for future research, there are opportunities to assess the effectiveness of big data analytics techniques in auditing. In addition, there should be an appropriate way to integrate this technique with the decisions from experts.

Because the TH office is in the initial phase of data analytics, this project chooses the rule-based approach to detect the anomalies in the business transactions. Anomaly detection rules are predefined criteria from abnormal cases which are expected to occur in a specific process (Baumann, 2021). Although advanced technology like machine learning can discover irregularities without identifying rules, the TH office has limitations to apply them. Because different clients implement different ERPs. And the maximum range of data obtained for each engagement is the last 12 months. So, the TH office has insufficient data for model training. As a result, unsupervised models cannot detect accurate anomalies. In addition, the internal auditors cannot explain to the clients why outliers and some data patterns resulting from the advanced analytics programme are spotted as issues. Therefore, a rule-based approach is now appropriate. In the future, the TH office may gather and feed the data files and investigation results to the programme (Alessa, 2020).

Regarding Chartered IIA (2017) and Gepp et al. (2018), the anomalies found from applying detection rules with the data analytics technique need further investigation. The purpose is to seek the root causes like they are noncompliance acts with intention, internal control weakness, or human errors. Then, the internal auditors can provide incisive recommendations. Cascarino (2017) classifies evidence for examination into different types. The applications for P2P and inbound inventory processes are listed in the following table.

Table 5: Example of audit evidences for P2P and inbound inventory processes

Adapted from: Cascarino (2017)

Audit evidences	P2P	Inbound inventory
Inspection/ observation	• Inspect staff in creating POs, recording invoices, making approvals, and proceeding with the payments	• Physical count • Inspect staff in recording goods receipts into the ERP
Recalculation	• Recalculate the total purchasing amount from the information of price per unit, order quantity, and other criteria stated in the contract	• Recalculate the total receipt amount from many deliveries per the schedule and compare against the order quantity
Re-performance	• For suspicious transactions, ask the staff to demonstrate how to recheck the accuracy and completeness of the purchases before making payments	• Ask the staff re-perform how to prepare documents and get approval from authorised person when the receipt transactions are greater than the maximum inventory level
Inquiry	• Ask the process owners or other responsible persons about the causes of abnormalities found from the data analytics	
Documentation	• Obtain written information like policy, work instruction, or the document set of transactions to examine	

2.2 P2P and inbound inventory processes

The above section has mentioned P2P and inbound inventory processes. Thus, this section will discuss them in detail.

P2P is defined as all steps in the sourcing products and services beginning with requirement identification, to the purchasing of them, through the receipt of the goods, and lastly to paying suppliers for what is received (Monczka et al., 2014). Due to various activities, many researchers and organisations differently identify sub-processes. For instance, Rendon & Garrett (2005) present the Contract Management Maturity Model (CMMM) which is a tool to evaluate organisation's contract management capability in six key process areas:

1. Procurement planning: to identify the business needs
2. Solicitation planning: to prepare the documents requesting for quotation, information, or other specific requirements

3. Solicitation: to request for quotation, information, or proposal as a document prepared in the previous step
4. Source selection: to evaluate and negotiate with vendors before deciding the appropriate vendor(s) for the contract
5. Contract administration: to control and monitor the vendors against agreed terms and conditions
6. Contract closeout: to ensure the products or services are complete according to the contract.

The above working steps provide the overview of the P2P process specifically in a contractual purchasing agreement to transform the administrative function to strategically contribute to the company's competitive advantage.

Gollapinni (2019) describes the P2P cycle in the SAP running in a closed loop through eight steps:

1. Requirement determination: the loop starts here to request materials, products, or services.
2. Source determination: to determine the vendors awarded in the history purchases, approved vendor list, or available agreements recorded in the system to request for quotation
3. Vendor selection: select the proper vendor(s) for the requirement
4. PO processing: create and submit agreement like a contract or Purchase Order (PO) to the vendor
5. PO monitoring: control receive quantity, quality, and other aspects per agreement
6. Goods receipt: to inspect goods against the agreement then create goods receipt transactions in the system
7. Invoice processing: to process the invoice sent from vendors
8. Payment processing: to make payments to vendors

In addition, looking at internal audit services proposed by a key player. Deloitte (2019) introduces P2P sub-processes in three stages:

1. Stage I: vendor negotiation, vendor master data establishment, and vendor master data change management,
2. Stage II: request for quotation, PR creation, PO creation, and goods receipt
3. Stage III: invoice receipt, and payment.

Within each stage, there are points of approval as quality gates before proceeding to the next steps.

Noticeably, the P2P cycle is diverse scope. Nevertheless, this project generates purchasing data based on an animal feed manufacturer's transaction to test the effectiveness of detection rules in

identifying the irregularities. This case study company implements the SAP. And the detection rules are identified from the data sets related in the ERP. Chapter 3 will describe the project methodology in detail. For these reasons, in this project, sub-processes are mainly divided per those of SAP and rechecks the scopes with the CMMM and Deloitte which is an example of offerings in the market as follows.

Table 6: Sub-processes in the P2P process

CMMM Rendon & Garrett (2005)	**SAP** Gollapinni (2019)	**Example P2P scopes offered in the market** Deloitte (2019)	**Sub-processes in this project**
Procurement Planning	Requirement determination	-	**1. Process governance**
• Solicitation Planning • Solicitation • Source Selection	• Source determination • Vendor selection	• Vendor negotiation • Vendor master data establishment • Vendor master data change management • Request for quotation	**2. Vendor selection, evaluation, and master data maintenance**
• Procurement Planning • Contract Administration	• Requirement determination • PO processing • PO monitoring	• PR creation • PO creation	**3. Ordering**
Contract Closeout	Goods receipt	Goods receipt	**4. Goods receipt**
	Invoice processing	Invoice receipt	**5. Invoice processing**
	Payment processing	Payment	**6. Payment**

The sub-processes in the right-most column will be used in this project. Not only they are consistent with three references, but they also add value for internal audit services through two different and explicit scopes from competitors' offerings: process governance and vendor evaluation. Because the TH office has no clear P2P sub-processes currently, these six key areas will help identify risks, internal controls, and detection rules pertinently as well.

Similar to P2P, many researchers describe the inventory process in different scopes. For instance, Berg et al. (2013) study and introduce five inventory sub-processes for improvement:

1. Forecasting: to anticipate the future demand for planning or scheduling POs
2. Purchase: to order the goods or services per desired requirements
3. Goods receipt: to check the goods or services at the delivery location

4. Storage: to record the receiving transactions and move the goods to the stock. For instance, checking quality, quantity, and price against the user's request
5. Goods issue: to retrieve the items from the storage for production or sales orders.

Moreover, Carvel (2021) explains the inventory management module in the SAP. It begins with receiving of supplies, then SAP emphasises their movement in the warehouse until they are issued from the storeroom. In other words, there are three key activities:

1. Goods receipt: to accept the items from vendors or other company's locations
2. Goods issue: to process items for production, deliver finished goods to customers, or release damage items from the shelf
3. Internal movements: to transfer inventories from a location to another location such as for production, laboratory test, or delivery to customers.

As indicated above, the goods issue is the outbound inventory process. And internal movement is to manage items after the inbound inventory operation is completed. So, only the remaining steps are relevant to this project scope. After reviewing the inventory with P2P sub-processes, Table 7 proves that these six P2P sub-processes already include the inbound inventory.

Table 7: Sub-processes in the inbound inventory process

An improvement in the inventory management Berg et al. (2013)	**SAP inventory module** Carvel (2021)	**Sub-processes in this project**
-	-	**1. Process governance**
-	-	**2. Vendor selection, evaluation, and master data maintenance**
• Forecasting • Purchase	-	**3. Ordering**
• Goods receipt • Storage	Goods receipt	**4. Goods receipt**
-	-	**5. Invoice processing**
-	-	**6. Payment**

To sum up, the inbound inventory process continues from the point of goods receipt in the P2P chain and continues to storage them. And above six sub-processes adequately cover both P2P and inbound inventory processes.

2.3 Detection rules development

Singh et al. (2017) reviewed fraud detection rules in the procurement system of the biological science company and devised a data analytics model to identify the anomalous transactions for examination in the next step. The anomalies occurred from many causes such as human or system errors, exceptional cases, or fraud. For this paper, researchers aimed to prove that the data analytics approach brings faster audit results with greater quality work products. Because the auditors could better allocate resources to investigate what is likely to be the issues instead of a large amount of manually sampling tests. The research methodology began with inquiry five auditors to identify risks in the procurement process in the context of a case study company. Then, they considered how the data analytics could be applied in that process. The **risk register comprising details of process areas, risks, fraud scenarios, and process controls** was the result of this step. Next, the transactional data from the ERP and legacy systems of the case study company were obtained. The data sets like the list of invoices and the list of receipts were understood to find out their linkages. These **relationships were set as rules** before inputting to the model. After testing the model with several fraud scenarios, the results were summarised.

From the above methodology, Singh et al. (2017) detected anomalous data to investigate. For example, it was found that some procurement records have the same purchasing order number. Some invoice amounts were more or less than the purchasing orders. In addition, some purchasing orders were mismatched from the purchasing requests that were already approved by the department head. Singh et al. concluded that this data-driven process reduced internal auditor time and flagged many issues from analysing a large amount of data.

Changchit & Holsapple (2004) also developed the internal audit expert system to evaluate the design and operating effectiveness of internal controls over the revenue cycle of a medium-sized trading company. Apart from being a decision tool to help managers realise the adequacy of existing internal controls, this system was expected to be the knowledge management database for the organisation. The frequent or continuous evaluation of the internal controls enabled the company to take action promptly.

The system development on the GURU artificial intelligence platform was the last stage of their project. The steps of preparing inputs for the system started with knowledge acquisition by asking the experts to **list the risks or possible weaknesses** in the sales and receivables processes. For each risk, the experts were inquired to reveal **how to discover those weaknesses**. Their techniques were embedded in the expert system as rule sets. During these steps, Changchit & Holsapple found that the experts considered the **transaction flows** throughout the revenue process before the **weaknesses, controls, and rule sets were identified**. The rule sets resulted from the internal control objectives: segregation of duties, appropriate authorisation of transactions, adequate documentation, physical control of assets, and independence check. The examples of rules presented in their research were finding the same person who was responsible for preparing and recording sales invoices, and recording collection and counting the collection. After the rule sets were prepared, the expert system was developed by identifying the variables

for each detection rule, drawing the diagram of variables as a draft of the expert system algorithm, entering data from the case study to validate the expert system, assessing the utility of the system, and concluding the results.

Changchit & Holsapple concluded that the expert system embedded rule set could not replace the internal auditors but help them effectively detect anomalous records and solve them more rapidly. It encouraged the company to have healthy internal controls to mitigate risks. Moreover, the rule reduced staff workload in testing a lot of transactions. In addition, the researchers proposed some future research opportunities. For example, to enhance the development of the detection rules in other business processes and industries, develop other modules of the expert system, and involve internal auditors in the interview process.

After discussing with the subject matter experts, the methodology of Singh et al. (2017) and Changchit & Holsapple (2004) are appropriate to use as framework to develop and improve the anomaly detection rules in this project. Although drawing and analysing the transaction flows are only mentioned by Changchit & Holsapple, this technique assists risks and controls identification. So, this step will be implemented in this project. Moreover, this project will close the gaps in their studies. That is, there will be interviews with a data analytics expert and an internal auditor who specialises in business processes and manufacturing business. Additionally, after testing the effectiveness of detection rules, the experts are invited to the exit meetings to examine the results and finalise the detection rules for effective spotting the anomalies. The following sections discuss the identification of risks, adequate internal control, and detection rules over the P2P and inbound inventory processes.

2.3.1 Risk identification

Risk is defined as the possibility of undesirable situations happening which affect the achievement of a company's goals (CIPS, 2012; COSO, 2017). Deloitte (2019) claims that P2P has a high risk of fraud and money leakage due to the involvement of third parties and large cash flows. Its challenges dramatically increase when the procurement system is customised without permission. Because the abnormal data entries will be processed in the centralised system and multiple departments use it. For the inventory process, Berg et al. (2013) highlight that goods availability with accurate and complete quantity, quality, and time is critical for operation. The overstock and extra inventory holding cost possibly happen when the company orders materials too early, while missing the sales order for shortage key items. Another core objective is reaching the specific service level with optimal cost. In the level of enterprise risk, ECIIA (2021), an international organisation of internal auditing presents cybersecurity risk as a top priority for the year 2021. The following ranks are regulatory change, digitalisation, liquidity, and talent risks.

Seeing that risks are diversely identified and impact businesses in varying degrees. Like cybersecurity risk is significant for firms heavily investing in the technology system than labor-intensive manufacturers. Therefore, this project determines risks from the COSO ERM framework which considers four business objectives below (COSO, 2012).

1. Strategic: to accomplish the high-level company goals and align with the missions
2. Operational: to consume the resources effectively and efficiently
3. Financial: to have the reliable reporting
4. Compliance: to comply with both internal and external laws and regulations

The above risks can be grouped into four categories. For example, fraud (compliance risk), money leakage (financial risk), unauthorised procurement system customisation (operational risk), goods availability both overstock and shortage item (operational risk), and inventory cost (financial risk). These risks are taken into consideration in Section 4.2.

2.3.2 Internal control identification

COSO (2013) defines internal control as actions designed from the tone at the top to accomplish the objectives of the operation, reporting, and compliance. Types of internal control are preventive and detective controls. The preventive control is to block undesirable event before it occurs. While detective control is to uncover errors that have taken place already. In addition to both types of controls, Chartered IIA (2021a) proposes a directive control as the third type. It is a control that encourage the preferable consequences to happen. Because of inclusive aspects, the internal controls are identified by considering all three types of controls. The following table compares and contrasts each type.

Table 8: Three types of internal control

Sources: Chartered IIA (2021a)

Type of internal control	Example of internal control
Preventive – to obstruct the unwanted event	Segregation of duties, system configuration, supervisor review
Detective – to discover faults that occurred in the process	Reconciliation against different information sources
Directive – to lead the operation to the desired outcome	Policy and procedures, communicating to staff

The readers do not confuse the detective control with the detection rule. Because detective control is an activity that is designed to find errors in day-to-day operations by the front-line officers. For illustration, the AP staff is assigned to reconcile information in invoice, PO, and Goods Receipt Notes (GRN) before posting invoice batches to the ERP. For detection rules, they are tools that the internal auditor uses to test the transactions to ensure that the front-line staff perform their duties

effectively. Not only detective control, but the detection rule will also test preventive and directive controls. For example, the rule examines whether there is any conflict in the segregation of duties. If it is appropriate, then the staff follow it or not.

The results from applying detection rules in the company's transaction can be classified as no exception, finding, areas for improvement, and suspicious transactions for further investigation with audit evidence. This data analytics approach enables the internal auditors to indicate internal control failures for providing recommendations in terms of:

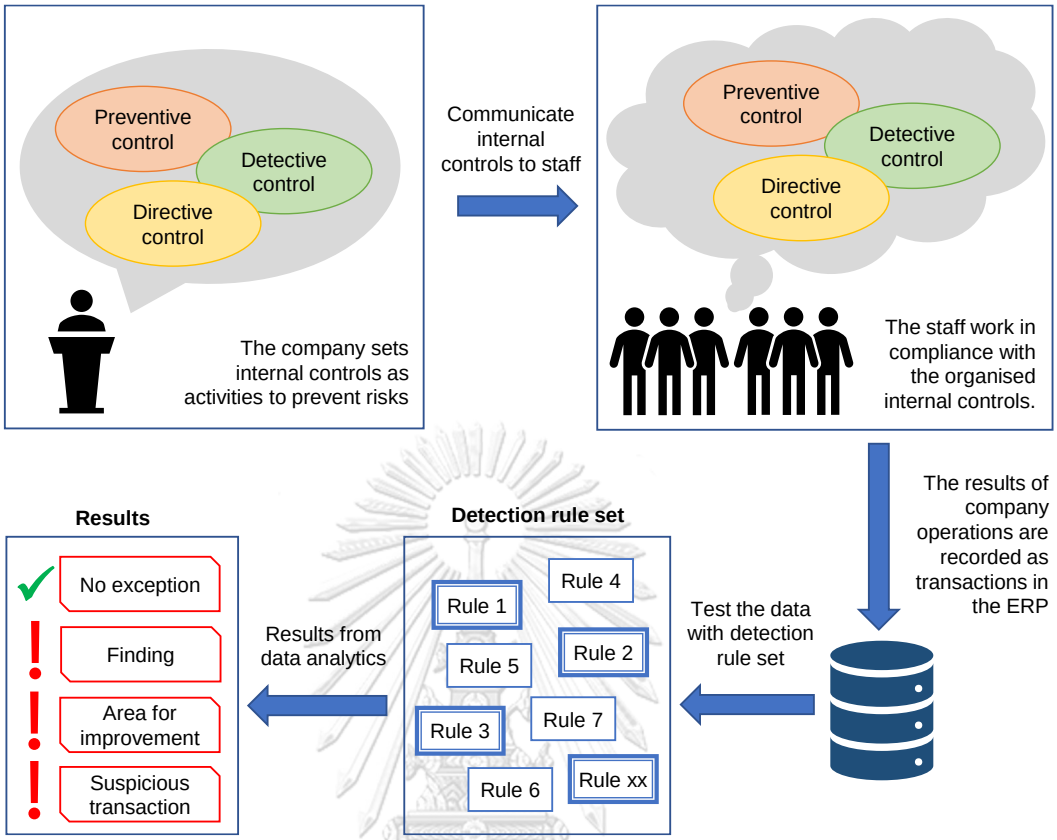
1. Design weakness: the company plans an inadequate internal control. Whether the control is implemented or not, it is ineffective to mitigate risks. So, the company should redesign a new internal control scheme to replace the old one.
2. Operating weakness: the company has already designed adequate internal control, but the staff does not follow. So, enforcement or any encouragement plans should be established.

(Lambrechts et al., 2011)

Remark: The IIA's standards define adequate controls as activities that the management well-planned to reasonably ensure that organisational risks are effectively and efficiently mitigated to achieve the goals (IIA, 2017).

The below diagram summarises how the internal control and detection rule work.

Figure 1: The roles of internal control and detection rules



2.3.3 Detection rule identification

From the previous section, detection rules are identified from the internal controls to prevent risks. In turn, data analytics through detection rules bring outcomes to improve the internal controls.

The detection rules were identified in three categories: data overview, master data review, and transaction review.

- **Data overview**

  Data overview is an analysis to understand the whole picture of business in terms of trends or proportions (Cascarino, 2017).

- **Master data review**

  Master data files contain data that is related to an organisation's business and likely to be used by many business processes such as vendor master data. It may include the reference data such as vendor number and material group which is used to classify and refer by the

system (Dalimunthe, 2019). As standardisation and accuracy are critical for master data, the detection rules aim to test it on the following aspects (McGilvray, 2009).

- Duplication in particular fields or data sets
- Completeness of data recorded in the master file
- Relationship between data sets
- Outstanding records when compare with some criteria such as the company's policy

- **Transaction review**

  Transactional data is the data generated from the business' operations such as Purchase Requisition (PR) and Purchase Order (PO). This type of data usually includes the master and reference data (Dalimunthe, 2019). To detect suspicious transactions, the rules are mostly in terms of the following (McGilvray, 2009).

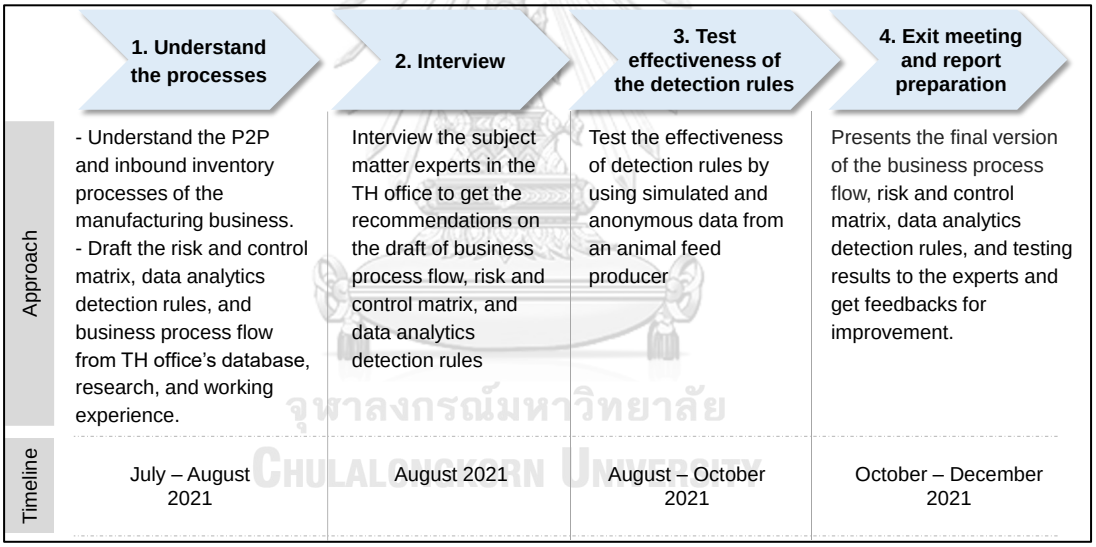
  - Unusual transactions created from unauthorised person, same persons, or created an unusual time.
  - Override controls or regulations; for example, transactions that were approved by unauthorised person, split into multiple transactions, and closely met the approval limit.
  - Unreasonable transactions; for instance, non-sequencing date between prior and following activities, and irregular amount or value compared with nature of transactions.
  - Outstanding transactions such as high or low volume created for some vendors or by some staff

CHAPTER 3
RESEARCH METHODOLOGY

This project improved the current TH office's detection rules and identified new rules in the P2P and inbound inventory processes by analysing the business processes, key risks, and internal controls. The subject matter experts are involved through interviews to provide recommendations towards the effective rules. The rules were tested with generated data set based on the case study company's transactions. The testing results were summarised and reported to the experts to finalise the rules.

Figure 2 illustrates the overall research methodology and project timeline. The details are described below.

Figure 2: Research methodology and timeline



3.1 Understand the processes

Initially, the project started with studying the relationship of activities, related parties, material flows, and information flows in the P2P and inbound inventory processes of the animal feed manufacturing business. Regarding Section 2.2, sub-processes in the P2P and inbound inventory processes are (1) process governance, (2) vendor selection, evaluation, and master data maintenance, (3) ordering, (4) goods receipt, (5) invoice processing, and (6) payment. From these sub-processes, the data was prepared for interviews with the subject matter experts in the TH office as follows.

Business process flows

Because of visualisation and system thinking, the process flow is a tool to understand the relationship between sub-processes from upstream to downstream of the P2P and inbound inventory processes. So, the process flows which comprised the key elements of activities, relevant database, and decision points were drafted. The draft versions were used as an illustration during the interview with the subject matter experts.

Risk and Control Matrix (RCM)

RCM is an audit tool comprising columns of risks, internal control techniques, and other columns assisting in analysis (Anderson et al., 2017). After having the draft of the business process flow, key risks in different activities across the flows were identified. The risks were listed in the groups of strategic risk, operational risk, financial risk, and compliance risk as described in Section 2.3.1. Then, they were confirmed with the subject matter experts during the interview. The internal controls to mitigate the negative consequences were then identified for each risk. A scheme of internal control can mitigate several risks (Thorps, 2019). The risks and internal controls were finally summarised in a matrix. In addition to consider the business process flows, the following resources were determined to prepare the RCM.

- the TH office's knowledge management database
- the international institutes' publications and academic journals
- the author's working experience

Detection rules

After preparing the matrix, the detection rules were developed by linking them to the internal controls. For example, the internal control was that only the approved Purchase Requisition (PR) can be processed to prevent misuse or unnecessary procurement. So, the detection rules should be searching for unapproved PRs and PRs approved by unauthorised person according to the table of authority. According to Section 2.3.3, the detection rules were identified in three categories: data overview, master data review, and transaction review.

Apart from analysing the internal controls, this project developed the rules from the below sources.

- Reviewed the TH office's existing detection rules as shown in Table 9.
- Researched and summarised detection rules from the international institutes' publications and academic journals
- Developed detection rules from the author's working experience

Table 9: The TH office's existing detection rules

Types of detection rules	Detection rules
1. Data overview	1. Profile list of purchasing transactions by period, procurement staff, and material types, etc.
	2. Profile list of major vendors (top 10-20) compared with the AVL and analysis of the nature of transactions
2. Master data review	3. Identify shared information between vendor master data and employee master data such as surname, telephone number, bank account number, and address
	4. Test duplicate information in the vendor master file such as vendor number, vendor name, bank account number, and address
	5. Test the completeness of the vendor master file and identify the missing details
	6. Identify the vendor master data which is inconsistent with the company's policy such as too short company payment term
3. Transaction review	7. Identify vendors in the PO who are not in the AVL
	8. Review the PR approver against the company's table of authority
	9. Identify the PRs that are requested and approved by the same person
	10. Identify the invoices which cannot match with the PO
	11. Identify the POs which are approved after the invoice date
	12. Test the PO approver against the company's table of authority
	13. Analyse the percentage of PO outstanding
	14. Three-way matching by the PO number
	15. Identify duplicate invoice number
	16. Identify payment transactions made for the same invoice numbers

3.2 Interview

The draft of business process flows, RCM, and detection rules together with interview topics were sent to two subject matter experts before the interview. During the interview in August 2021, the author described the business and process overview of the animal feed producer which is the case study company, as details shown in Section 4.1. The interviewees were asked to provide information and recommendations on the draft versions of business process flows, RCM, and detection rules. Each

interview session took approximately an hour. Subsequently, the author revised the flows, RCM, and detection rules per comments and did more research.

The interview topics are:

- Based on your experience, what are the key activities of the P2P and inbound inventory processes?
- What are the key risks of the P2P and inbound inventory processes?
- Focusing on the animal feed manufacturing business, what are the key concerns?
- Regarding the above risks and concerns, what key internal controls should be in place?
- Do you have any other recommendations to improve the business process flow, risk and control matrix, and detection rules?

The subject matter expert's profiles involved in the interview are described below.

The first interviewee is a senior manager in the internal audit team of the TH office. She gets a bachelor's degree in business administration and a master's degree in accounting with first class honors, gold medal. She is a Certified Public Accountant (CPA) and Certificated Internal Auditor (CIA). Over 12 years of working experience, she has a broad range of knowledge and experience in providing internal audit services for clients in the public, state-owned enterprise, and private organisations of manufacturing, banking, insurance, and education sectors. A part of her specialised business processes is procure-to-pay, order-to-cash, production, inventory, financial close, fixed asset, and payroll.

The second interviewee is a senior manager in the internal audit data analytics team of the TH office. He holds a bachelor's degree in computer science and a master's degree in management information systems. With over 20 years of working experience, he provides recommendations to improve business process efficiency for clients in various sectors such as manufacturing, e-commerce, and logistics. He has practical knowledge in multiple business processes covering P2P and inventory processes. In addition to data analytics, his areas of expertise also include system analytics and design, data mining, and business intelligence.

3.3 Test effectiveness of the detection rules

The purchasing and inbound inventory data files of the case study company from 1 July 2020 to 30 June 2021 are listed as follows:

- Approved Vendor List (AVL) and vendor master data
- list of Purchase Requisition (PR)
- list of Purchase Order (PO)
- list of Goods Receipt Notes (GRN)
- list of invoices
- list of Payment Voucher (PV)
- existing and new vendor performance evaluation report
- procurement and inventory policies and procedures
- inventory reports
- PO outstanding reports
- authorisation matrix in the SAP
- table of authority

From the above data files, the new data sets were generated based on the case study company's transactions for testing the effectiveness of the detection rules. That is, the qualitative data such as vendor master data was anonymous by replacing it with another name. For quantitative data such as the list of POs, the author created new data according to the company's transactions by analysing the purchasing frequency of each material, average order quantity, total quantity, minimum and maximum order amount, and anomalies that occurred in the real data files. The author firstly generated data set from the list of POs. Then, a new list of PRs and invoices were created by linking with the PO numbers. The remaining data files were developed subsequently per reference data. Appendix B shows the examples of this step.

After having the new data sets, they are used to test the effectiveness of the detection rules. Appendix C demonstrates some walkthroughs. The results are summarised to discuss with the experts in the following step.

3.4 Exit meeting and report preparation

Originally, this project aimed to arrange the focus group to let the subject matter experts discuss and share views on the results from the effectiveness testing of detection rules. However, because both of them could not attend this activity in the same session. Thus, the focus group was replaced with separate exit meeting. In October 2021, the author presented the results of applying detection rules in the case study company as well as the revised RCM, detection rules, and business process flows to the experts. The purpose is to obtain their perspective on the possible causes of exceptions and whether they

need further investigation from other data sources. The feedbacks were kept for finalising the detection rules. This meeting took approximately an hour each. The project report was prepared.

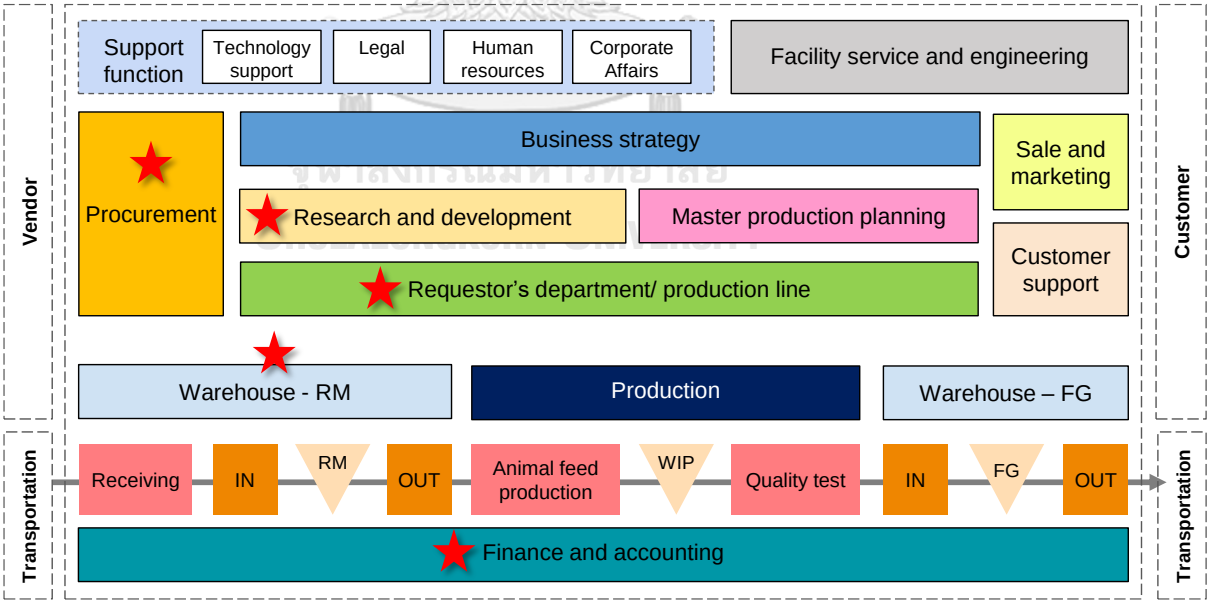
CHAPTER 4
RESULTS AND ANALYSIS

4.1 An overview of case study company

The case study company for this project is named “Company X”, a livestock feed manufacturer in Thailand. The company’s objective is to offer quality, nutritional, and safe animal feed for farming businesses and individual farmers and expand the production capacity for future growth. Its business model is make-to-stock. Now, Company X has five product lines: feed for broiler chicken, layer chicken, chicken breeder, fattening swine, and swine breeder. At the end of 2020, the company revenue is approximately 9,500 million baht. The productions are made only for their brands. Four production factories are located in the strategic provinces: Sukhothai, Nakhon Ratchasima, Nakhon Pathom, and Chumphon to supply material for the North, Northeast, Central, and South of Thailand.

Company X organises itself as a functional structure. Figure 3 illustrates the business control model. The red stars represent the main departments which involve with the P2P and inbound inventory processes.

Figure 3: Company X's business control model



Company X divides purchasing transactions into four material groups:

- **Material group 1: Grain and oil,** e.g., barley, wheat, corn, broken rice, cassava starch, rice bran oil, soybean oil, palm oil, and wheat gluten
- **Material group 2: Protein base,** e.g., pork, fish, and egg

- **Material group 3: Vitamin, enzymes, and additive,** e.g., zinc, calcium, amino acid, and probiotic
- **Material group 4: Office supply and overhead,** e.g., utility, machine maintenance, and stationery

All purchasing transactions are centralised sourcing at the procurement department, Nakhon Pathom office. There are five procurement staff and a department head. More domestic than international vendors supply materials to the company. However, the P2P and inbound inventory processes from both domestic and global supply bases are not different.

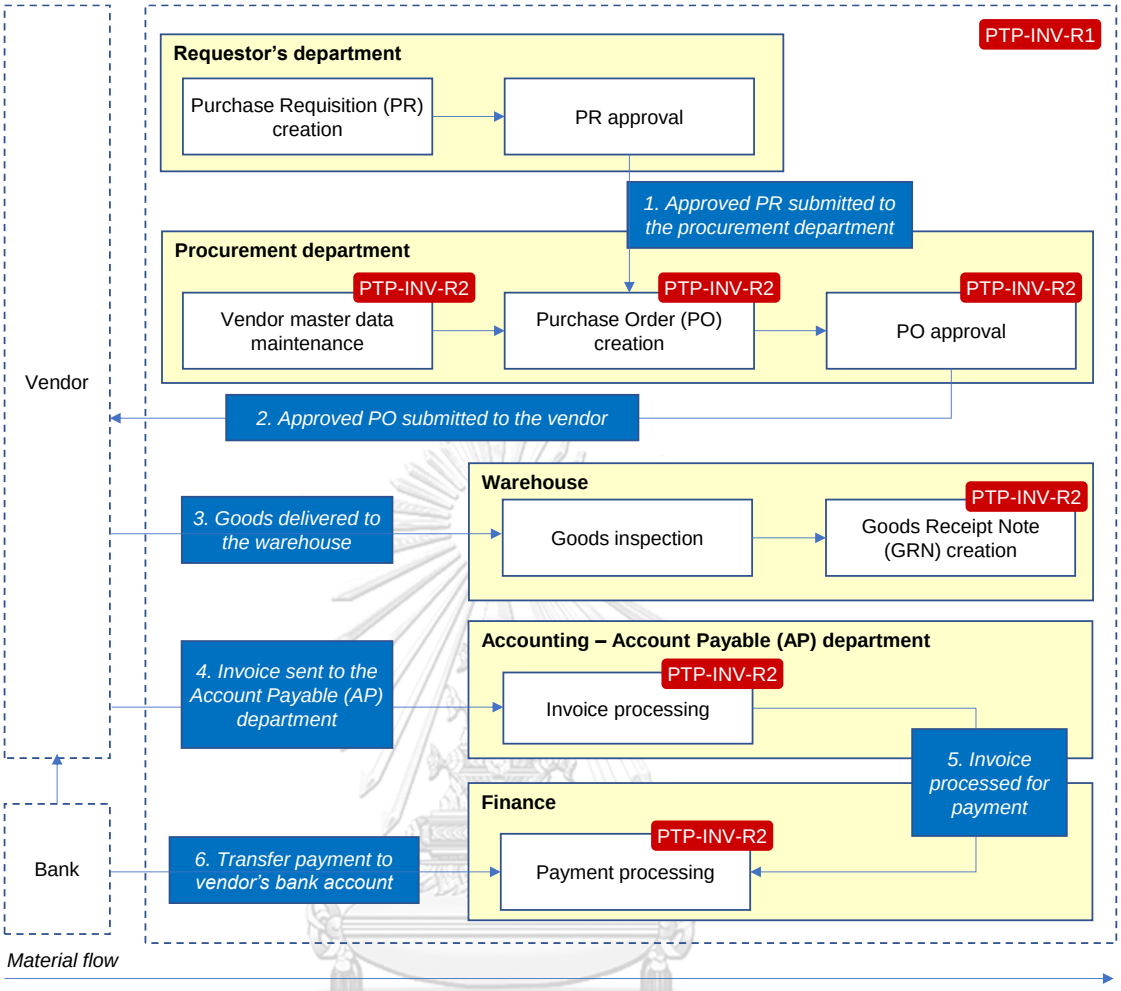
4.2 Detection rules improvement

The following sections are separated by sub-business processes to describe the results of improving detection rules. These are (1) process governance, (2) vendor selection, evaluation, and master data maintenance, (3) ordering, (4) goods receipts, (5) invoice processing, and (6) payment. Each section begins with the process flow of related activities in Company X operations. The RCM is prepared to identify potential negative events in the process and the internal controls that should be in place. Then, the internal controls link to the detection rules as the results.

4.2.1 Process governance

The key functions in the P2P and inbound inventory processes of Company X are the requestor's departments such as research and development department, procurement department, warehouse, accounting department, and finance department. The external stakeholders are 719 vendors and two banks to proceed with the payments. The company utilises the SAP for both procurement and inventory activities. The overview of the processes is shown in the figure below.

Figure 4: The overview of P2P and inbound inventory processes



Remark: The red boxes represent key risks

According to the above figure, the process starts when the user creates the PR. This requirement needs approval before proceeding to the procurement department. The procurement department is responsible for creating PO per requirement details. New vendors are sourced and registered by the procurement staff. After PO is approved, it is sent to the vendor. When the products are delivered, they are inspected and recorded in the GRN. Invoice from the vendor is processed by the accounting department. Then, the finance department makes a payment to the vendor.

Regarding COSO (2013), the process governance is the control environment in the company which broadly impacts the entire internal control system. It is relevant to the establishment of policies, procedures, tone at the top, organisational structure, authorities, and responsibilities as the framework for staff to implement the internal controls over the business processes. From this significance, there are two key risks that can weaken the expected results.

Firstly, staff do not comply with the company's procurement policies (Guile, 2012). This will lead to a lot of adverse impacts. For example, the company purchases unnecessary items if the requirement is not scrutinised by the authorised person. In another example, the company receives incomplete services from unclear or inadequate details. So, the internal control should be the establishment of the written procurement and inventory policies and procedures which are approved by authorised person. These documents are then communicated to staff and related departments such as procurement, warehouse, logistics, and finance. In the internal audit work, the internal auditor will understand the policies and procedures to have an overview of the processes. To ensure that the big picture perceived from the documents is the same as actual operations, the data overview should be implemented. For example, the profile list of purchasing and inventory transactions by period, procurement staff, and material types, etc. Another data overview is the profile list of major vendors and major inventories and analysis of the nature of transactions (Lambrechts et al., 2011). Comparing these rules with the TH office's existing rules, the original rules for the procurement process are adequate. While the data overview rule of the inventory process is newly identified.

The second risk is inappropriate segregation of duties (COSO, 2013; Deloitte, 2019; Louisville Chapter, 2016; Guile, 2012). It weakens the mechanism of checks and balances which eventually causes minor problems such as human error and up to serious issues like fraud (Tan, 2013). So, internal control should be the establishment of clear segregation of duties in the process. Moreover, it should be monitored to ensure that the staff follows the company's policy (Tan, 2013). Table 10 lists the roles that should be separately executed and provides examples of the conflict situations.

Table 10: Example of segregation of duties in the P2P and inbound inventory processes

Adapted from: Lambrechts et al. (2011) and Guile (2012)

Role 1	Role 2	Potential conflict situations
Vendor master data maintenance	PO creation	There is the opportunity of embezzlement. For example, the staff intentionally creates a PO to a vendor whose bank account number is replaced with those of staff. So, the vendor will sue the company for payment after delivering the goods. And the perpetrator may have already resigned.
	Payment processing	Without other persons who proceed with the payment, the staff can change the existing vendor's bank account number to their own. Or the staff creates phantom vendors with their own bank account number.
PO creation	PO approval	Without other persons who recheck the PO, the requirements sent to the vendors may be inaccurate or

Role 1	Role 2	Potential conflict situations
		incomplete. So, the company will receive the wrong or insufficient ingredients for production. Eventually, the company may spend extra time for re-ordering or extra costs for urgent purchases.
PO creation or approval	Goods receipt	In case the vendor delivers unsatisfied raw material as a result of mistakes in PO creation such as high humidity wheat, the staff may uncover their faults by receiving goods in the system. If the production returns them, they record the reason as inappropriate storage. Another example case is that the staff adds a laptop to the company PO for personal purchasing with a better price offering. When the laptops are delivered, the staff record as not fully received in the GRN. There is no problem with the company as only received laptops are eligible to be paid. And there is no issue with the vendor since the additional laptop is paid by that staff and the remaining is paid by the company.
	Payment processing	The staff creates PO to a favorite vendor or vendor who has a close relationship. Without other persons who review the transaction before payment, the staff then proceeds payment to that vendor and gets a kickback in return. Guile (2012) expects that kick-back is one of the most popular risk forms in procurement corruption.
Invoice processing	Payment processing	The staff can add the fictitious invoices and make the payment for that invoice.

As described in the above table, these new detection rules are to discover the transactions in which the same person operates both roles (Lambrechts et al., 2011).

In conclusion, the RCM and detection rules of process governance are summarised on the next pages.

Table 11: RCM and detection rules - Process governance

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-INV-R1	Staff do not comply with the company's procurement policies.	☑				P2P-INV-C1	The company should establish the written procurement and inventory policies and procedures which are approved by authorised person. These documents are communicated to staff and related departments such as procurement, warehouse, logistics, and finance departments.	☑	☑	☑	☑	Data overview	P2P-DA1	To understand the overview of the company's procurement process, the data analytics can be a profile list of purchasing transactions by period, procurement staff, and material types, etc. *(Existing rule)*	• List of POs in last 12 months • Procurement policies and procedures to compare with data analytics results	☑		☑	☑
												Data overview	P2P-DA2	Profile list of major vendors (top 10-20) compared with the AVL and analysis of the nature of transactions. *(Existing rule)*	• List of POs (e.g., in last 12 months) • AVL	☑	☑	☑	☑

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
												Data overview	INV-DA1	To understand the overview of the company's inventory process, the data analytics can be a profile list of inventory transactions by type of inventory, major inventories, locations, and amounts *(New rule)*	• Inventory policies and procedures • Inventory reports in last 12 months			☑	☑
P2P-INV-R2	Inappropriate segregation of duties		☑		☑	P2P-INV-C2	Establishment of the clear segregation of duties in the process. Moreover, it should be monitored to ensure that the staff	☑	☑	☑	☑	Transaction review	P2P-INV-DA1	Identify the transactions in which the same person operates both roles: • Vendor master data maintenance *vs* PO creation	• Authorisation matrix in the SAP • List of PRs, POs, GRNs, invoices, and PVs with		☑	☑	☑

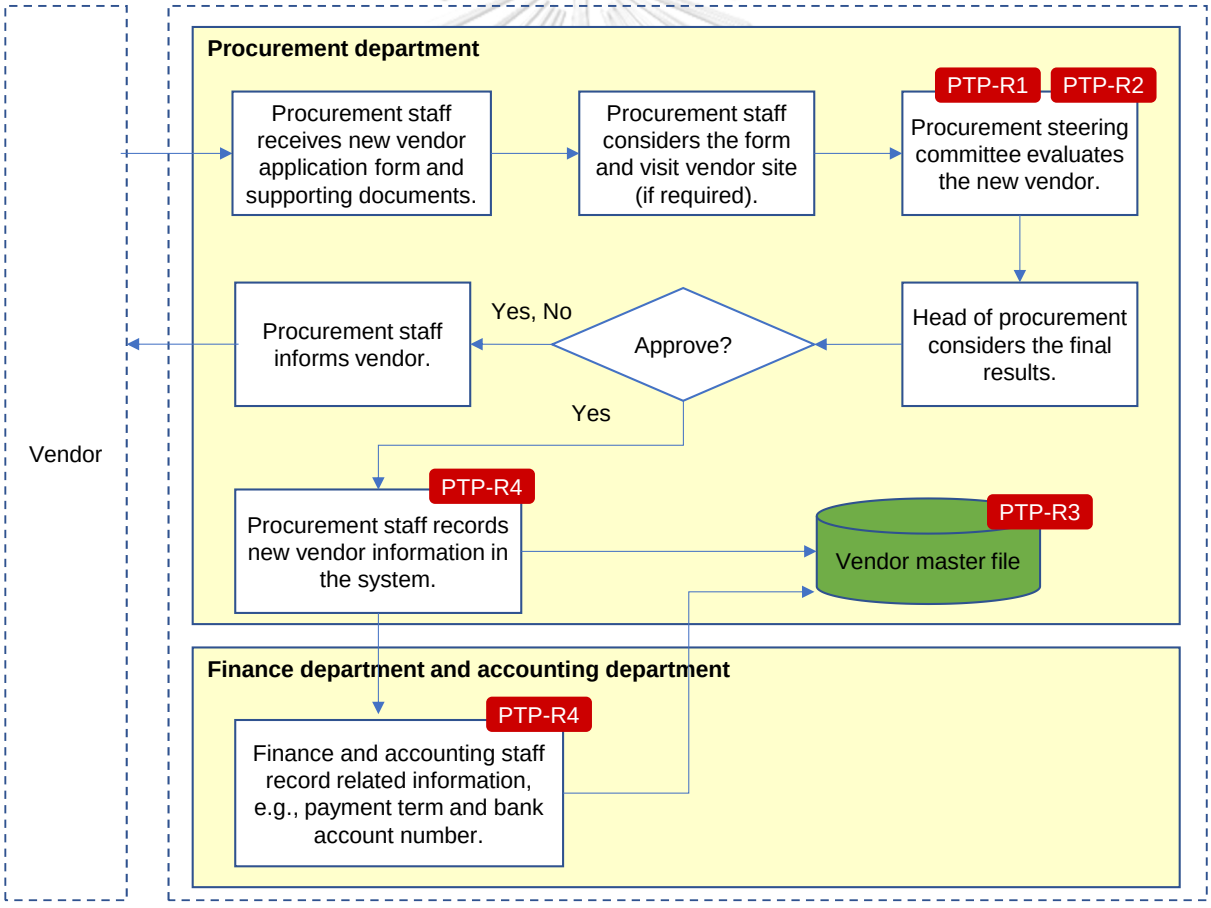
Risk and control matrix													Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification					Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification				
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting						1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting	
							implement align with this company's policy								• Vendor master data maintenance *vs* Payment processing • PO creation *vs* PO approval • PO creation or approval *vs* Goods receipt • PO creation or approval *vs* Payment processing • Invoice processing *vs* Payment processing *(New rule)*	preparer and approver name					

4.2.2 Vendor selection, evaluation, and master data maintenance

As stated in Company X's procurement policy, the objective of this sub-process is to have vendors who can deliver quality products and services to the company on time and in full. The procurement staff is responsible for seeking and maintaining at least two approved vendors for each material item. It is except for specific materials which can have only one approved vendor in the master file.

The key functions in the vendor selection, evaluation, and master data maintenance of Company X are procurement, accounting, finance, and user departments. The external stakeholders are new vendors and 719 vendors in the master file. The following figure illustrates business process flow.

Figure 5: Business process flow - Vendor selection and master data maintenance



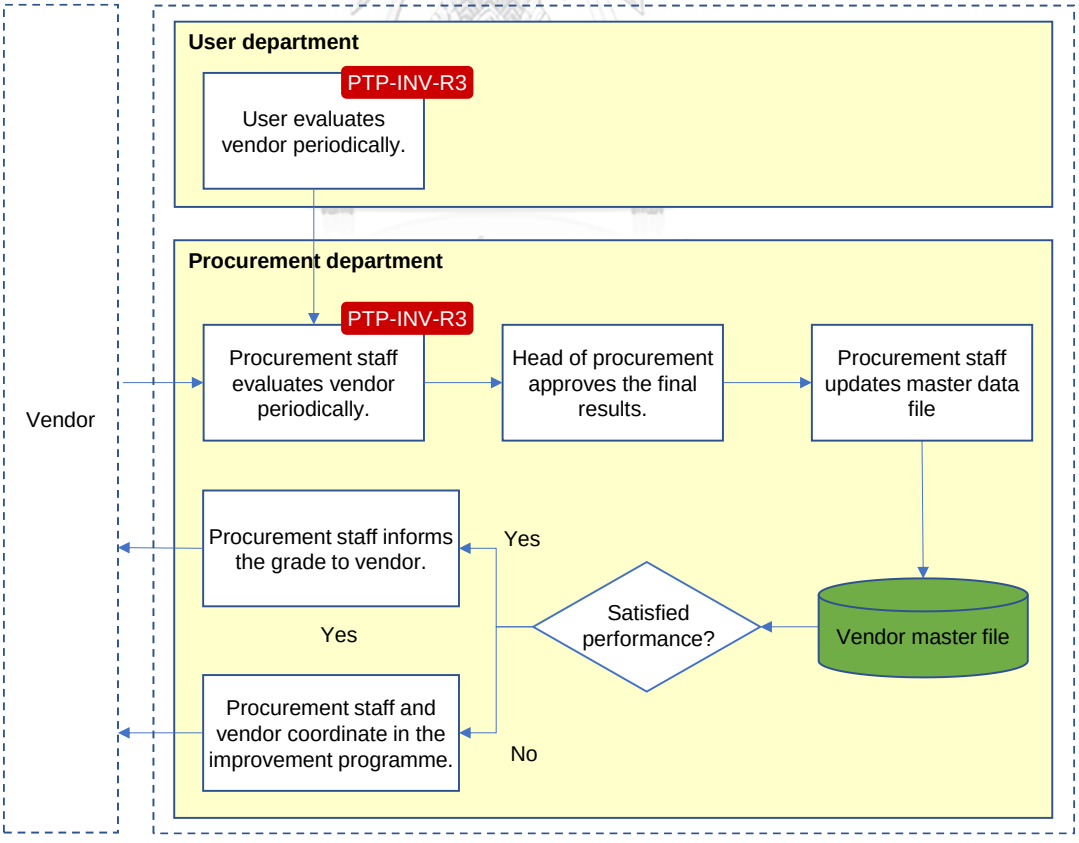
Remark: The red boxes represent key risks

Both individuals and juristic persons can be registered as Company X's vendors. In the beginning, the new vendor submits the application form together with supporting documents to the

procurement staff i.e., the copy of the national ID card, book bank, company profile, and a company certificate. After that, the staff reviews the set of documents and considers visiting the vendor's site. The site visiting is mandatory for a vendor providing the crucial materials to Company X. Alternatively, the selection committee would like to gain more information. The new vendor's information is then discussed and evaluated by the selection committee. The vendor selection criteria are product quality and quality certification, prices, maximum capacity, lead time, offered services, financial status, experience, measures about the environment and social responsibility, minimum order quantity, and expected payment term. The preliminary selection results and document set are submitted to the head of procurement for final approval. This final result is communicated to the vendor via email and letter. For an approved vendor, the procurement staff records its information into the ERP. Finance staff and accounting staff record and review its payment terms and bank account number. When finance staff and accounting staff click approved in the system, the new vendor is activated and ready for ordering products and services.

In addition to new vendor registration and master data maintenance, the following figure shows the vendor evaluation process.

Figure 6: Business process flow - Vendor evaluation



Remark: The red boxes represent key risks

At the first half and year-end, the vendor performances are summarised and evaluated. User and procurement departments are assessors based on three criteria:

- Quality (40%): measured by the percentage of lot reject rate and risk of failure
- Delivery performance (40%): measured by the percentage of delay, percentage of incomplete shipment, and percentage of incomplete commercial documents
- Services (20%): measured by prompt coordination

The scores are calculated and submitted to the head of procurement for approval. The procurement staff updates the vendor grade in the master file and informs each vendor. The AVL consists of vendors with grades A (score 85-100%) and B (score 70-84%). For grade C (score lower than 70%), the vendor is required to attend the improvement programme. However, vendors with fraud cases will be immediately recorded as blacklisted.

From the above objectives and business process, there are five major risks. First of all, the company purchases goods and services with non-approved vendors (Louisville Chapter, 2016). Vendors providing poor-quality products will increase the number of defects. Moreover, Guile (2012) reveals that procurement is a target for fraudsters. So, vendors doing frauds will ruin the company's culture and reputation. This risk can be countered by the establishment of clear vendor selection criteria. The measures include but are not limited to the company profile and historical performance. For vendors supplying key materials, the procurement staff or procurement steering committee should visit the potential vendors' factories. The vendors' reputations should be researched through news and public resources. Asking various companies about their experience from doing business with potential vendors is an alternative way to gain insights. Another internal control to prevent this risk is that ERP blocks PO creation with non-approved vendors. From these internal controls, there are two detection rules to detect irregularities. The new one is that the master data should be reviewed whether any vendors have scores below the selection criteria. The existing one from the TH office's knowledge management database is to discover vendors in the POs who are not in the AVL.

The second risk is conflicts of interest between vendors and the company's employees. Because the procurement staff especially those involved with the vendor selection process may biasedly choose vendors in their family for some procurements (Tan, 2013). In addition, there is the opportunity that vendors are provided company's confidential information (Tan, 2013). Accordingly, for new vendor registration, the head of procurement should carefully review the vendor's application form and supporting documents. The close relationship between the potential vendors and the employees should be identified and investigated before approval. In the part of the detection rule, the TH office's existing rule is still used to detect suspicious transactions for this risk. That is to identify shared information between vendor master data and employee master data such as surname, telephone number, bank account number, and address (Lambrechts et al., 2011; Mishler, 2016).

The next risk is vendor duplication in the master file (Deloitte, 2019). From the author's experience, vendor name duplications are mostly in form of a capital letter, abbreviation, typo, and space typing. Take for example,

Capital letter	Company Limited	Company limited	company limited
Abbreviation	Co., Ltd.	Co. Ltd.	co ltd
Typo	Conpany Limited	Company limtied	Company limitd
Space	Company Limited	Company Limited	CompanyLimited

In addition to name, other vendor information like address or bank account number can be duplicated in the master file. One reason is that some vendors are operated in the same corporate. So, Company X will unconsciously have a high risk of dependency on a vendor. Moreover, duplicated vendors in the master files cause the company to order goods and services over the vendor's capacity which eventually affects the quality of work products, cost, or time. In the worst case, some of them are phantom vendors (Mishler, 2016). So, regularly reviewing the vendor master file is a detective control to reveal duplications. Any revision in the master data needs the supporting documents as evidence. Continuing from the above detective control, the data analytics rules are testing duplicate information in the vendor master file such as vendor number, vendor name, bank account number, and address (Mishler, 2016). In addition, it is testing the completeness of the vendor master file and identifying the missing details. These rules are what the TH office has currently and can be applied in Company X's risk context.

The fourth risk is that the vendor master data is incorrect (Singh et al., 2017). Because vendor master is an essential data used in PO creation and payment. Company X assigns a staff to record vendor information in the SAP. The head of procurement is responsible for reviewing information for accuracy and completeness. However, inaccurate data occurs if the head of procurement does not perform his duties or happens from human error. To certify that all information is correct is to reperform reviewing recorded data in the system against the vendor's supporting documents. Nevertheless, in terms of data analytics, the company can basically identify the inconsistent vendor master data against the company's policy or unusual agreement such as too short company payment term. So, this existing rule from the TH office can be applied in Company X's risk context.

The last risk is that the vendor's performance is inconsistent or unsatisfactory. To encourage the vendor to maintain their performance, the vendor performance criteria should be established and announced to them. Their performances are also monitored and evaluated periodically (Louisville Chapter, 2016; Tan, 2013). Vendors with satisfactory performance are maintained in the AVL. While those with some issues are feedbacked for improvement. The company should establish a clear procedure to manage the non-qualified vendors such as marking them as blacklists or deleting them from the master file (Guile, 2012). To ensure that AVL contains only vendors with acceptable vendor performance, the

data analytics are finding vendors in the AVL who have a score lower than the company's satisfying level. This new rule will help the internal audit has the shortlist of suspicious vendor records and investigate them in the next step.

In brief, the RCM and detection rules of vendor selection, evaluation, and master data maintenance are depicted on the next pages.

Table 12: RCM and detection rules - Vendor selection, evaluation, and master data maintenance

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-R1	**Vendor selection** The company purchases goods and services with non-approved vendors, including vendors with goods quality problems or fraud cases.		☑	☑		P2P-C1	The vendor selection criteria are defined. They include but are not limited to the company profile, historical performance, site visit evaluation, and vendors' reputation.	☑	☑	☑		Master data review	P2P-DA3	Identify new vendors having scores below the selection criteria *(New rule)*	• New vendor evaluation score • New vendor selection and vendor evaluation procedures			☑	
						P2P-C2	The ERP blocks creating the POs with non-approved vendors.	☑		☑	☑	Transaction review	P2P-DA4	Identify vendors in the POs who are not in the AVL *(Existing rule)*	• List of POs • AVL	☑	☑		

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-R2	**Vendor master data maintenance** There are conflicts of interest between vendors and the company's employees.				☑	P2P-C3	The head of procurement carefully reviews the new vendor's application form and supporting documents. The relationship between the potential vendors and employees should be identified and investigated before approval.	☑	☑	☑	☑	Master data review	P2P-DA5	Identify shared information between vendor master data and employee master data such as surname, telephone number, bank account number, and address *(Existing rule)*	• Vendor master data • Employee master data, including relatives' information	☑	☑	☑	☑
P2P-R3	**Vendor master data maintenance** Duplicate vendors in the master file.		☑			P2P-C4	The vendor master file is reviewed regularly. The revision in the vendor master data needs the supporting documents as evidence.	☑	☑	☑	☑	Master data review	P2P-DA6	Test duplicate information in the vendor master file such as vendor number, vendor name,	Vendor master data	☑	☑	☑	☑

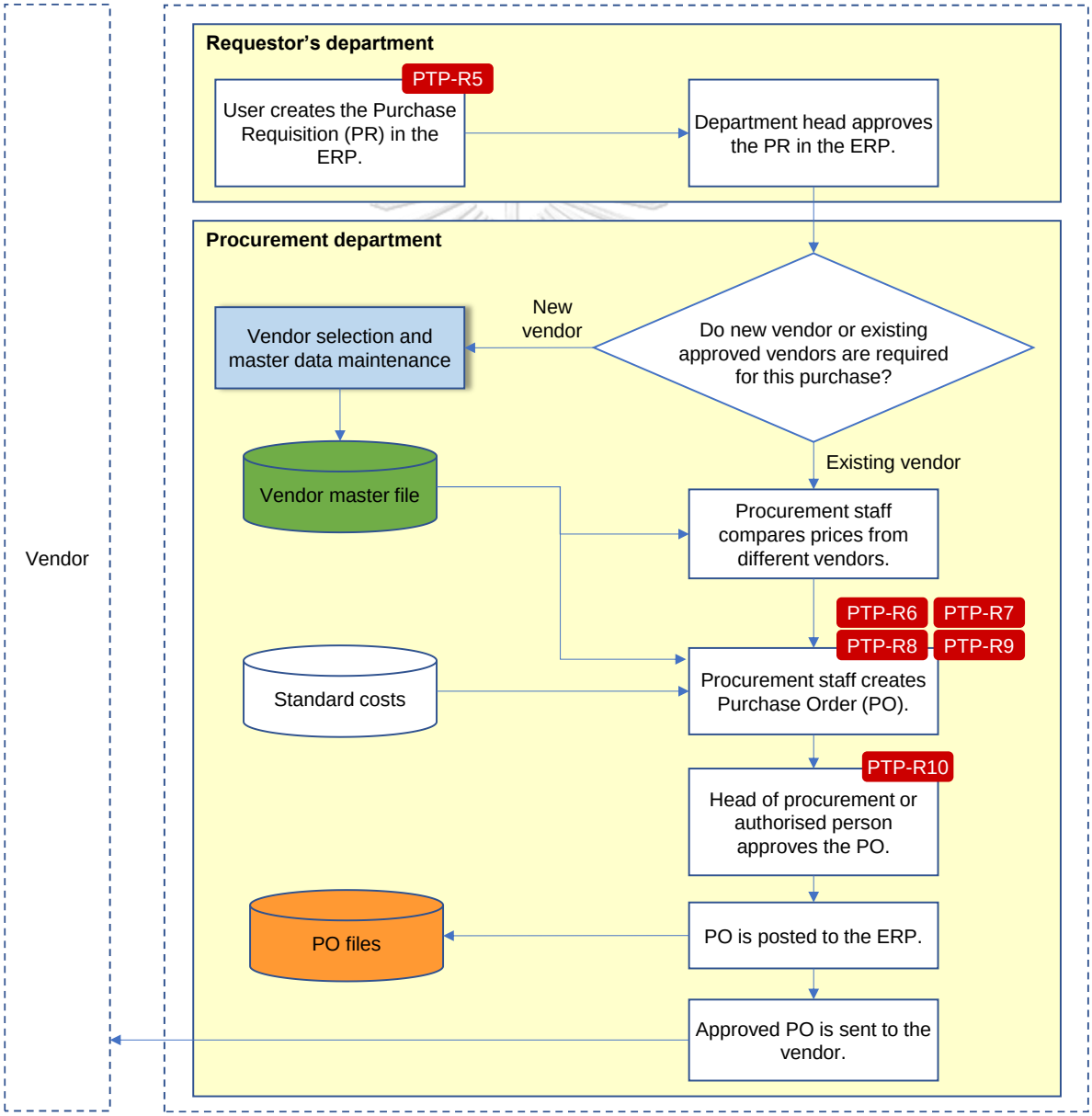
Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
														bank account number, and address *(Existing rule)*					
												Master data review	P2P-DA7	Test the completeness of the vendor master file and identify the missing details *(Existing rule)*	Vendor master data	☑	☑	☑	☑
P2P-R4	**Vendor master data maintenance** The vendor master data is incorrect.		☑			P2P-C5	The duties are segregate between preparer and reviewer. The revision in the vendor master data needs the supporting documents as evidence.	☑		☑		Master data review	P2P-DA8	Identify the vendor master data which is inconsistent with the company's policy such as too short company payment term. *(Existing rule)*	• Vendor master data • Procurement policies and procedures			☑	☑

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-INV-R3	**Vendor evaluation** The vendor performance is inconsistent or dissatisfied.		☑			P2P-INV-C3	The vendor performance criteria should be established and announced to vendors. Their performances are monitored and evaluated periodically. Vendors with satisfied performance are maintained in the AVL. While those with some issues are feedbacked for improvement. Non-qualified vendors are marked as blacklists in the AVL.	☑	☑	☑		Master data review	P2P-INV-DA2	Find vendors in the AVL who have the score lower than the company's satisfying level *(New rule)*	• Vendor performance evaluation report • Vendor master data			☑	☑

4.2.3 Ordering

Purchase ordering is related to the requester and procurement departments. The external stakeholders are 719 approved vendors in the master file. For Company X, the main objective of the ordering process is to prepare the right order per user's requirements and send it to the right vendors accordingly. The business process flow is shown below.

Figure 7: Business process flow - Ordering



Remark: The red boxes represent key risks

In the beginning, a user creates PR in the SAP. The PR form requires information, i.e., request date, requester's name and department, product or service name, details or specification, quantity, and delivery date and location. After the user clicks to submit the PR form, it proceeds to the user's department head or authorised person per the table of authority. Only approved PR is sent to the procurement department. The procurement staff considers whether the new vendor is required or not. The new raw materials are typically requested for research and development of new feed formula. If the new vendor is needed, the procurement staff follows the vendor selection and master data maintenance process as described in Section 4.2.2. In case that there is only a vendor in the AVL for the user's requirement, the procurement staff creates the PO for that vendor. If there are several approved vendors for required items, the procurement staff asks those vendors for quotations to compare prices and special offers. In the step of PO creation, information from PR, vendor master data, and standard costs are linked. The required fields include but are not limited to date, vendor name, item and its specification, quantities, price, total amount, ship-to address, delivery requirements, delivery date, and payment terms. Next, the procurement staff clicks to submit the PO and price comparison (if any) to the head of procurement staff or authorised person for approval. When the PO is approved, it is posted in the PO files. Finally, the procurement staff emails or prints PO and sent it to the vendor.

The standard costs are from the contract and blanket POs that Company X deals with some strategic partners. They are particularly those who supply grain and oil. It is to reduce the process of price comparison for every purchase and gain the low price from high purchasing volume.

Throughout the ordering process, six major risks can obstruct Company X to achieve its objectives. At first, the user creates unnecessary, wrong, or fraudulent PR (Singh et al., 2017). According to the flow, PR is important as it is a starting point of the procurement process. To prevent this risk, Company X has set the table of authority specifying the maximum purchasing amount that staff in each level can approve the PR. Then, this table has been configured in the ERP to automatically define the right person for approval. In addition, the preparer and approver are different persons to cross-check the PR. To ensure the adequacy of these internal controls, the detection rule is to review the PR approver against the company's table of authority. Another rule is to identify the PR that is requested and approved by the same person. These two existing rules from the TH office can be used to discover the suspicious transactions in Company X's PR creation.

The second risk is that the procurement staff creates the PO inaccurately, incompletely, lately, or suspiciously (Louisville Chapter, 2016; Singh et al., 2017). Wrong PO details cause the vendor to deliver what the company does not want. Insufficient order amounts cause the company to lack production resources as committed with clients. And late PO creation and submission to a vendor cause the production to be behind schedule. As mentioned earlier, ERP helps procurement staff by linking the details in PR, vendor master data, and standard costs to PO creation. However, there are opportunities

for mistakes, manual adjustment, ERP customisation which cause irregular data entries (Deloitte, 2019). Carefully document preparation is a control. However, Company X's head of procurement plays a critical role in reviewing the PO especially those with a substantial amount. With the same objectives as his review, the below rules can be used to detect suspicious PO creation.

- Identify the POs which cannot match with the PR (to test the case that PO is created without user' requirements)
- Identify the invoices which cannot match with PO (to test the case that the company receives goods or services without creating the PO) (Mishler, 2016)
- Identify the POs which are created longer than specific target days from PR (to test the case that the POs are not created within the company's target date.
- Identify the POs which are approved after the invoice date (to test the case that the company purchases goods or services from unapproved POs) (Lambrechts et al., 2011)
- Identify POs missing some information
- Identify POs created in weekend (Mishler, 2016)

Apart from manual review by the head of procurement, Company X has implemented the system controls in the ERP. That is the ERP automatically populates the price per item and exchange rate (for imported items) from contract or blanket POs engaged with some strategic partners. The total amount is then calculated for the PO. So, the new detection rule is testing that prices of items listed in the contracts or blanket POs are equal to those recorded in the price master file.

The next risk is that the PO is created for the unapproved or blacklisted vendors (Louisville Chapter, 2016). As a result, the company may face product quality problems or fraud cases. Nevertheless, the ERP blocks creating the POs with non-approved vendors. The data analytics can be identifying vendors in the PO who are not in the AVL to ensure that the system configuration is maintained in good conditions and there is no manual revision later on. The previous detection rule in Section 4.2.2 numbered P2P-DA4 (Identify vendor in the POs who are not in the AVL) can provide results for this risk.

The fourth risk is that POs are duplicated. The duplicate PO means that the company doubles the user's orders. So, Company X counters this risk by giving the PO a unique running number. The revised POs are marked with "R". And re-created POs after the previous cancellation are given the new running number. For analysing the procurement transactions, the new detection rule is to identify POs that have the same running number or have no running number (Singh et al., 2017). Moreover, to detect the case that the procurement staff intentionally repeat the order, the rule is identifying the repetitive requested items in the POs which were created on the same day or in a certain period and sent to the same or different vendors.

Next, the PO is split in order to avoid approval from the authorised person at a higher level (Deloitte, 2019). Because the lower authority level accepts lower risk than the higher level. Thus, when

gathering the amount in split POs, it reveals that this high-value PO is not considered by the appropriate authorised person. To know whether there are split POs, the PO with the total amount near the approval limit should be identified. Besides, same as the rule in the previous risk, the repetitive requested materials in the POs which were created on the same day or in a certain period and sent to the same or different vendors should be highlighted as suspicious transactions. These are new detection rules identified in this project.

Lastly, there is a risk that POs are approved by unauthorised persons or over their approval level (Louisville Chapter, 2016; Mishler, 2016). To prevent the risk, Company X has set the table of authority specifying the maximum purchasing amount that staff in each level can approve. The table has been configured in the ERP to automatically define the right person for approval. For the detection rule, testing the approved POs against the table of authority which is the TH office's current rule can be applied.

In conclusion, the RCM and detection rules of the ordering process are shown on the next pages.

Table 13: RCM and detection rules - Ordering

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-R5	The user creates unnecessary, wrong, or fraudulent PR.			☑	☑	P2P-C6	The company sets the table of authority and configure it in the ERP.	☑		☑	☑	Transaction review	P2P-DA9	Review the PR approver against the company's table of authority *(Existing rule)*	• List of PRs • Table of authority	☑		☑	☑
						P2P-C7	The preparer and approver are different persons to cross-check the PR.	☑			☑	Transaction review	P2P-DA10	Identify the PRs that are requested and approved by the same person. *(Existing rule)*	List of PRs	☑			☑
P2P-R6	The procurement staff creates the PO			☑		P2P-C8	The head of procurement department should carefully review the PO	☑		☑	☑	Transaction review	P2P-DA11	Identify the POs which cannot match with the PR *(New rule)*	• List of PRs • List of POs			☑	☑

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
	inaccurately, incompletely, lately, or suspiciously.						especially those with high amounts.					Transaction review	P2P-DA12	Identify the invoices which cannot match with the PO *(Existing rule)*	• List of POs • List of invoices	☑	☑	☑	☑
												Transaction review	P2P-DA13	Identify the POs which are created longer than specific target days from PR *(New rule)*	• List of PRs • List of POs • Procurement policies and procedures			☑	
												Transaction review	P2P-DA14	Identify the POs which are approved after the invoice date. *(Existing rule)*	• List of POs • List of invoices	☑	☑	☑	☑
												Transaction review	P2P-DA15	Identify POs missing some information *(New rule)*	List of POs			☑	

Risk and control matrix													Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification					Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification				
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting						1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting	
													Transaction review	P2P-DA16	Identify POs created in the weekend *(New rule)*	List of POs		☑	☑	☑	
						P2P-C9	For purchasing by the contract or blanket PO, the ERP automatically populates the price per item and exchange rate (for import items). The total amount is then calculated for the PO.	☑		☑	☑		Transaction review	P2P-DA17	Test that prices of items listed in the contracts or blanket POs are equal to those recorded in the price master file. *(New rule)*	• List of POs • Price master file			☑	☑	
P2P-R7	The PO is created for the unapproved or blacklisted vendors.		☑			P2P-C2	The ERP blocks creating the POs with non-approved vendors.	☑		☑	☑		Transaction review	P2P-DA4	Identify vendors in the POs who are not in the AVL. *(Existing rule)*	• List of POs • AVL	☑	☑			

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-R8	The POs are duplicated.		☑			P2P-C10	The POs are given a unique number. The revised POs are marked with "R". And re-created POs after previously cancellation are given the new running number	☑		☑	☑	Transaction review	P2P-DA18	Identify POs having the same running number. *(New rule)*	List of POs		☑	☑	☑
												Transaction review	P2P-DA19	Identify the repetitive requested materials in the POs which created on the same day or in a certain period and sent to the same or different vendors *(New rule)*	List of POs				☑
P2P-R9	The PO is split in order to avoid approval from		☑			P2P-C11	The purchase transactions are reviewed. The suspicious transactions		☑	☑	☑	Transaction review	P2P-DA20	Identify the POs with a total amount equal	List of POs		☑	☑	☑

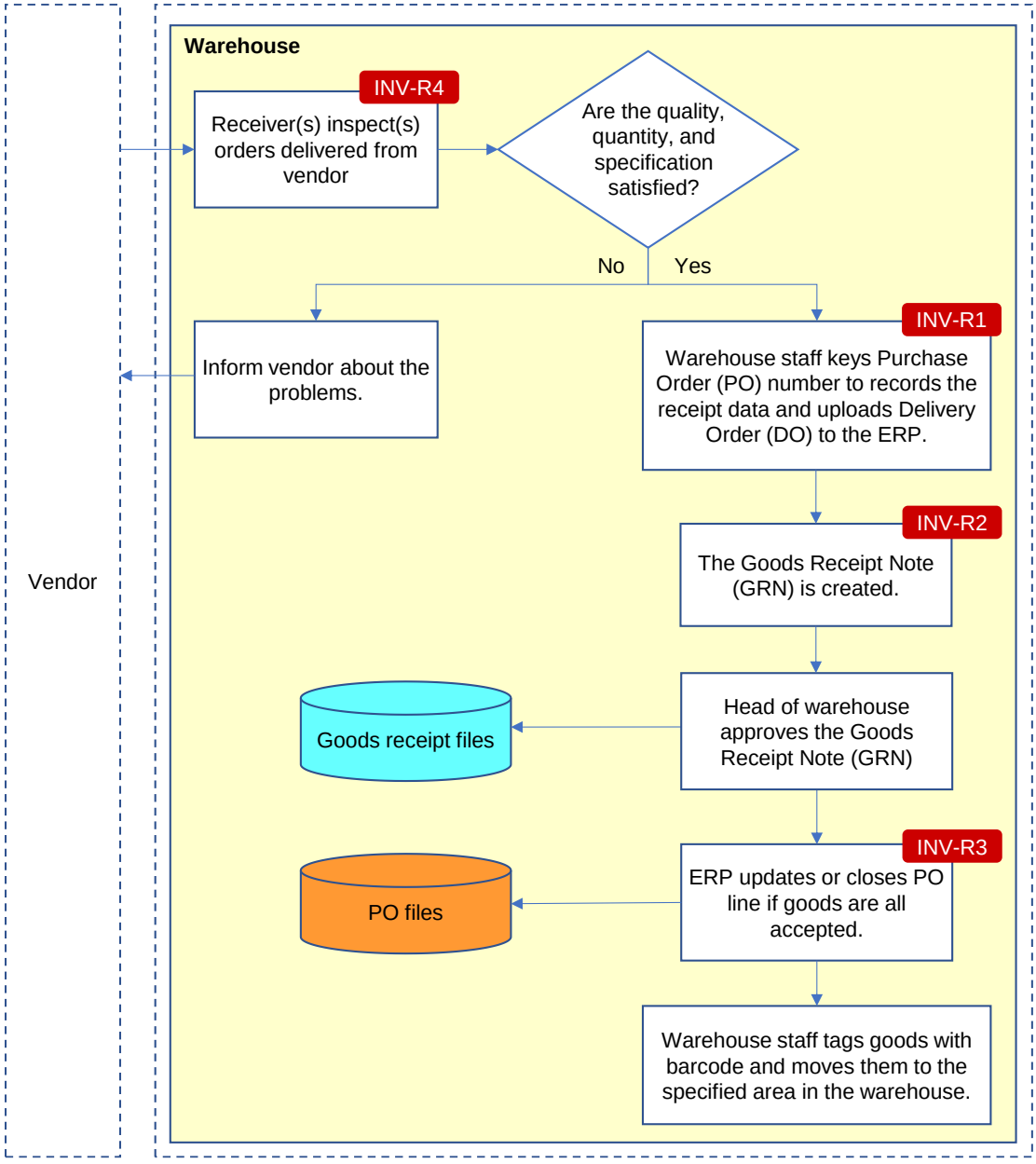
Risk and control matrix													Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification					Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification				
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting						1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting	
	the authorised person at a higher level.						such as PO with a total amount near the approval limit and the same items are purchased on the same day or few days after are identified.								to or near the approved limit. *(New rule)*						
													Transaction review	P2P-DA19	Identify the repetitive requested materials in the POs which created on the same day or in a certain period and sent to the same or different vendors *(New rule)*	List of POs					☑
P2P-R10	Purchase Orders (PO) are approved by unauthorised			☑	☑	P2P-C12	The company sets the table of authority specifying the maximum purchasing amount that	☑	☑	☑	☑		Transaction review	P2P-DA21	Test the PO approver against the company's table of authority *(Existing rule)*	• List of POs • Table of authority	☑		☑	☑	

Risk and control matrix													Data analytics test plan							
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification					Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting						1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
	persons or over their own maximum amount for approval.						staff in each level can approve. This table should be configured in the ERP to automatically define the right person for approval.													

4.2.4 Goods receipts

The key function in the goods receipts of Company X is a warehouse. There are four own warehouses to stock materials for four production factories. The external stakeholders are vendors that the company creates the POs. The business process flow starts from vendors' delivering orders to Company X as follows.

Figure 8: Business process flow - Goods receipts



Remark: The red boxes represent key risks

The company receivers are assigned to different types of goods. That is, the user and laboratory staff are responsible for weighting and sampling test the delivered materials group 1, 2, and 3. For material group 4, the warehouse staff is an inspector of the office supplies, while the machine parts are inspected by engineers. When the vendor delivers materials to Company X warehouses as location specified in the PO, the above receivers follow the check sheet to inspect goods quality, quantity, and specification against details in the PO. If the received order is satisfied, the warehouse staff keys the PO number in the ERP to record the receipt data. The Delivery Order (DO) is scanned and uploaded to the ERP. In the ERP, the Goods Receipt Note (GRN) is created. The GRN will be recorded in the goods receipt files after the head of the warehouse approves it. The ERP also updates or closes the PO line if requested goods are all accepted. Warehouse staff is then responsible for physical goods management. That is, the goods are tagged with a barcode and moved to the specified area in the warehouse. For instance, grain and oil are kept in the specified silo and tank.

Company X expects to receive the correct orders on time and in full amount. Accordingly, there are four key risks that obstruct the company to achieve this purpose. From a subject matter expert's view, the prominent risks in the P2P and inbound inventory processes of the manufacturing business are excess and shortage of stock. Overstock gives rise to obsolescent ingredients and increases inventory holding costs. While understock leads to insufficient raw materials for production. Manpower booked for production is also unutilised as well. Hence, Company X sets the min-max inventory policy for each material item (Louisville Chapter, 2016). The warehouse staff regularly monitors inventory level which is the result of goods receipt and usage against this policy. The PR is created with the reorder quantity when the inventory meets the reorder point. For the transaction review, the new detection rule is to identify the receipt transactions over the maximum inventory level and lower than the minimum inventory level. The variances from these acceptance levels should be then investigated and resolved.

Because of manually inputting data into the ERP, the second risk is that the procurement staff records the GRN inaccurately, incompletely, or lately (Louisville Chapter, 2016). The risk can be prevented by the establishment of appropriate segregation of duty between the receiver and approver of the goods. So, the goods receipt transactions which are received and approved by the same persons could be further investigated (Lambrechts et al., 2011). Another preventive scheme is that the ERP allows staff to record the GRNs for the opened POs. When the receipt quantity is full, the PO is closed. And the closed PO cannot be recorded for further goods receipts. Regarding this control, the GRN should be validated against the PO (Lambrechts et al., 2011). That is, the developed detection rule will identify the closed POs with not fully received to verify the reasons and supporting documents. Additionally, the experts recommended reviewing the transactions having more receipt quantity than the ordered quantity. Because the company will make the payments per quantity received. So, the surplus quantity from requirements will unnecessarily increase the inventory cost.

The third risk is that the company has not received the orders (Louisville Chapter, 2016). To mitigate the risk, Company X has monitored the PO outstanding report periodically. The procurement staff coordinates with the vendors to deliver the goods and services as agreed. However, Guile (2012) argues that there is a corruption risk between vendor and staff from their collaboration for successful delivery. This project has some compensate rules controls to detect fraud such as P2P-DA5 (Identify shared information between vendor master data and employee master data such as surname, telephone number, bank account number, and address) and P2P-DA19 (Identify the repetitive requested materials in the POs which created in the same day or in the certain period and sent to the same or different vendors). In the part of the transaction review, Company X should monitor the percentage of PO outstanding. Moreover, the company should identify goods receipt transactions using duplicate GRNs. Because by doing so, it means that the company has not received the goods for some POs.

The last risk is that suppliers cannot deliver on time, in full amount, and right goods and service per PO which leads to business interruptions (Tan, 2013). To reduce the consequences of this risk, the control coded P2P-INV-C3 can be applied. That is the establishment of vendor performance criteria, periodically monitoring and evaluating vendor performance, and accurately updating the vendors' performance in the master file. Similarly, highlighting vendors in the AVL who have scores in unsatisfied level is the rule to ensure that the AVL comprises only vendors with acceptable performance.

In summary, the TH office does not have the detection rules regarding the goods receipt except monitoring the PO outstanding. So, the remaining rules are new. The RCM and detection rules of the goods receipt process are presented on the next pages.

Table 14: RCM and detection rules - Goods receipts

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for Detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
INV-R1	Over and understock		☑	☑		INV-C1	The company sets the min-max inventory policy. The warehouse staff regularly monitors inventory levels. The PR is created with the re-order quantity when the inventory meets the reorder point.				þ	Transaction review	INV-DA2	Identify the receipt transactions over than the maximum inventory level and lower than the minimum inventory level *(New rule)*	• Inventory report • inventory min-max policy				☑
INV-R2	The procurement staff records the GRN inaccurately,		☑	☑		INV-C2	There is appropriate segregation of duty between goods receiver and approver. .	☑	☑	☑	☑	Transaction review	INV-DA3	Identify goods receipt transactions that are received and approved by the same persons. *(New rule)*	• List of GRNs	☑	☑		☑

Risk and control matrix													Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification					Data analytics type	#DA	Detection rules	Required data for data analytics	References for Detection rules identification				
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting						1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting	
	incompletely, or lately.																				
						INV-C3	The ERP allows staff to record the GRNs for the opened POs. When the receipt quantity is full, the PO is closed. And the closed PO cannot be recorded for further goods receipt.	☑			☑		Transaction review	INV-DA4	Identify the closed POs with not fully receive to verify the reasons and supporting documents. *(New rule)*	• List of GRNs • List of POs	☑	☑		
													Transaction review	INV-DA5	Identify the receipt quantity over than quantity stated in the PO *(New rule)*	• List of GRNs • List of POs				☑	

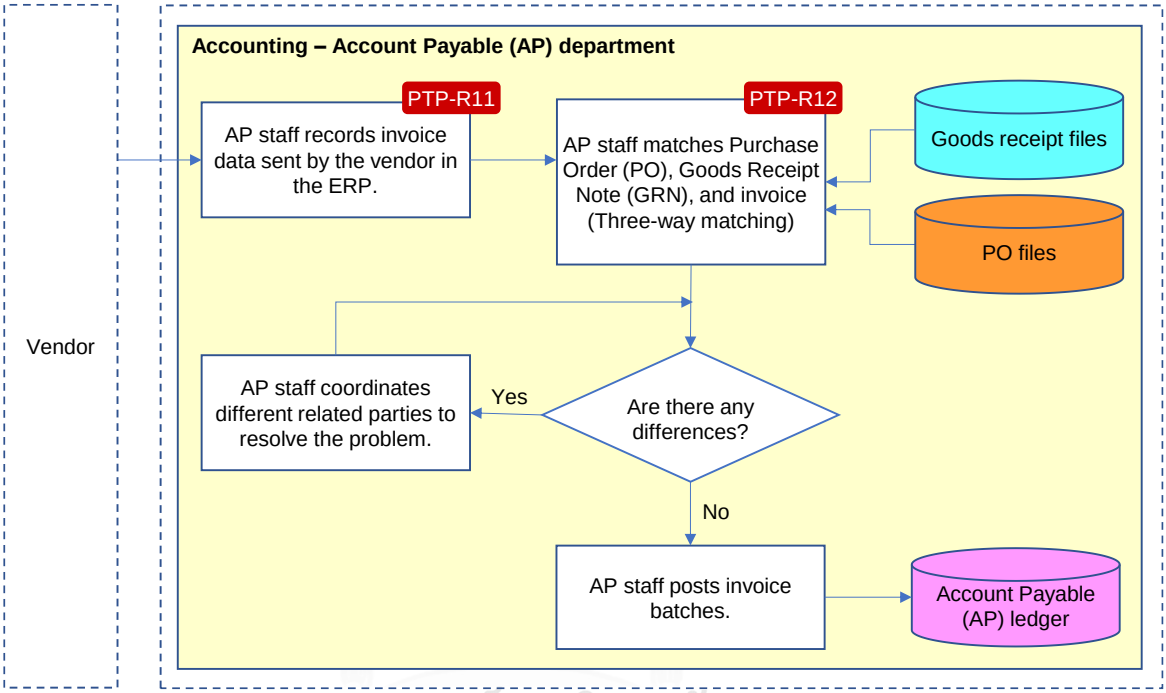
Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for Detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
INV-R3	The company has not received the orders.		☑			INV-C4	The PO outstanding report should be monitored periodically. The procurement staff coordinates with the vendors to deliver the goods and services as agreed.	☑		☑		Transaction review	INV-DA6	Analyse the percentage of PO outstanding *(Existing rule)*	PO outstanding report	☑		☑	☑
												Transaction review	INV-DA7	Identify goods receipt transactions using duplicate GRNs *(New rule)*	List of GRNs			☑	
INV-R4	Suppliers cannot deliver on time, in full amount, and right goods and service per PO which leads to		☑			P2P-INV-C3	The vendor performance criteria should be established and announced to vendors. Their performances are monitored and evaluated periodically. Vendors	☑	☑	☑		Master data review	P2P-INV-DA2	Find vendors in the AVL who have scores lower than the company's satisfied level *(New rule)*	• Vendor performance evaluation report • Vendor master data			☑	☑

Risk and control matrix												Data analytics test plan							
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for Detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
	business interruptions.						with satisfied performance are maintained in the AVL. While those with some issues are feedbacked for improvement. Non-qualified vendors are marked as blacklists in the AVL.												

4.2.5 Invoice processing

The invoices from four warehouses and production factories are centralised proceeded at the Account Payable (AP) department, Nakhon Pathom office. To proceed with the invoices, the AP department is the main function. The external stakeholders are vendors who deliver goods and services to Company X. The business process flow is shown below.

Figure 9: Business process flow - Invoice processing



Remark: The red boxes represent key risks

Company X accepts only approved invoices from the vendor's authorised person. On the goods delivery day or every end of the month, vendors gather the invoices and submit them to the Account Payable (AP) department. The AP staff records details in the invoice to the ERP. Then, the AP staff does the three-way matching for each transaction record by comparing the invoice data (which was input recently) with PO data (recorded in the PO file) and GRN data (recorded in the GRN file). If there is any difference, the AP staff coordinates related parties to resolve the problem. If no difference is found, the AP staff posts the invoice batches to the ERP which are recorded in the AP ledger file.

The objective of invoice processing is to ensure that Company X receives the orders as required and going to pay to the vendors, not more than what is received. To accomplish this goal, there are two crucial risks. Firstly, the AP staff records the invoices inaccurately, incompletely, or later. So, the AP staff of Company X are instructed to carefully record data into the ERP and prepare the evidence of

accuracy checks like tick marks and signature. Not only this manual control, but the ERP also embeds the control of detecting the duplicate invoices number. Thus, the company should identify duplicate invoice numbers (Mishler, 2016). This current detection rule from the TH office is still applicable. The subject matter experts added that if there is any duplication, the supporting documents should be reviewed and investigated.

Secondly, purchase transactions are billed incorrectly. To prevent this risk, Company X's ERP is configured to close the PO after fully matching the amount with invoices. The closed PO cannot be matched with other invoices for payment. In addition, Company X performs the three-way matching manually. The three-way matching is to recheck the purchase transactions that what the company receives (GRN) is right as what the company orders (PO) and what the company is going to pay (invoice). To ensure that both manual and system controls are properly executed, it can be reperforming matching the PO, GRN, and invoice in terms of material name, quantity, and total amounts. The unmatched transactions should be discussed with the company whether they are investigated and resolved promptly (Deloitte, 2019; Lambrechts et al., 2011; Mishler, 2016; Singh et al., 2017). This rule is improved from the TH office's original rule which matches only the document number.

In short, the RCM and detection rules of invoice processing are shown on the next pages.

Table 15: RCM and detection rules - Invoice processing

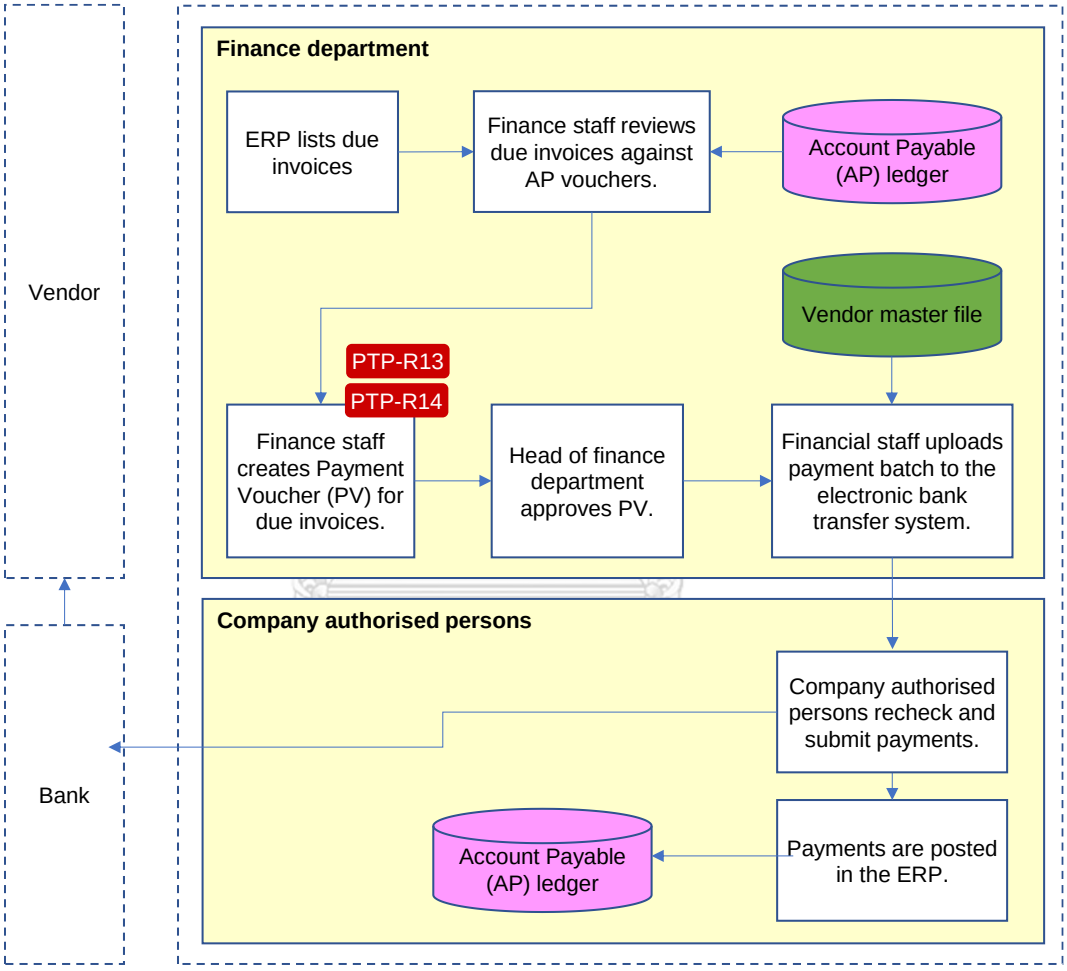
Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
P2P-R11	The AP staff records the invoices inaccurately, incompletely, or lately.			☑		P2P-C13	AP staff carefully records data into the ERP and prepares the evidence of accuracy check.	☑				Transaction review	P2P-DA22	Identify duplicate invoice number *(Existing rule)*	• List of invoices	☑	☑		☑
						P2P-C14	In the ERP, the invoice data is checked to prevent the duplicate invoice recording	☑											
P2P-R12	Purchase transactions are billed incorrectly.			☑		P2P-C15	The three-way matching of the PO, GRN, and invoice. The differences should be investigated and resolved promptly.	☑	☑	☑	☑	Transaction review	P2P-INV-DA3	Match the material name, quantity, and total amount per invoice against those of the PO and GRN	• List of POs • List of invoices • List of GRNs	☑	☑	☑	☑

Risk and control matrix												Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification				Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification			
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting					1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting
						P2P-C16	The PO is closed when matching with an invoice. The closed PO cannot be matched with other invoices for payment.	☑		☑	☑			*(Improved rule from "Three-way matching by the PO number" of the TH office)*					

4.2.6 Payment

Similar to the invoice processing, the payments are centralised proceeded at the headquarter. The finance department is a process owner. The external parties are two banks and vendors who placed invoices to the company. Company X firmly instructs the staff to make the payment for the right vendors which is the objective of this process. The business process flow illustrates below.

Figure 10: Business process flow - Payment



Remark: The red boxes represent key risks

Company X makes payments to the vendors every 15th of each month. The ERP firstly lists due invoices to the finance staff. This list is selected based on terms and conditions agreed with vendors. Then, the finance staff reviews and compares due invoices with the AP voucher prepared by AP staff in the invoice processing step. If no problem is found, the finance staff creates and submits the Payment Voucher (PV) to the head of finance for approval. After receiving the approval, the finance staff uploads the payment to each vendor's bank account number in the electronic bank transfer system. Company X

has nominated two company executives as the authorised persons who can endorse company payments. So, after reviewing amounts in the bank transfer system, they click to submit the payments to the bank. Finally, the payments are automatically posted in the ERP.

From described objectives and activities in the payment process, there are three major risks. The first risk is that the payments are duplicated for an invoice. In other words, the company double payment (Lambrechts et al., 2011; Singh et al., 2017). The ERP has set the control that when the company pays for an invoice, its status is closed. The closed invoice cannot make further payments. Hence, to test the effectiveness of this system control, Company X should identify payment transactions made for the same invoice numbers (Lambrechts et al., 2011; Mishler, 2016). This TH office's current rule is applicable for Company X's control.

Secondly, there is a risk that payments are made to the wrong vendors. Regarding the internal control, the key fields in the ERP are populated to the vendor payment such as the vendor's name, bank account, payment amount, payment term. Therefore, identifying payment transactions made for wrong vendors should be performed to ensure the effectiveness of the control (Mishler, 2016). This is a new rule developed in this project.

An additional risk is that the payments are not approved by authorised person. This control is embedded in the bank's transfer system to allow only the authorised person(s) to approve the money transfer. The transactions without approval cannot proceed with the payment. Because this is the bank's internal control, there are no detection rules for this point.

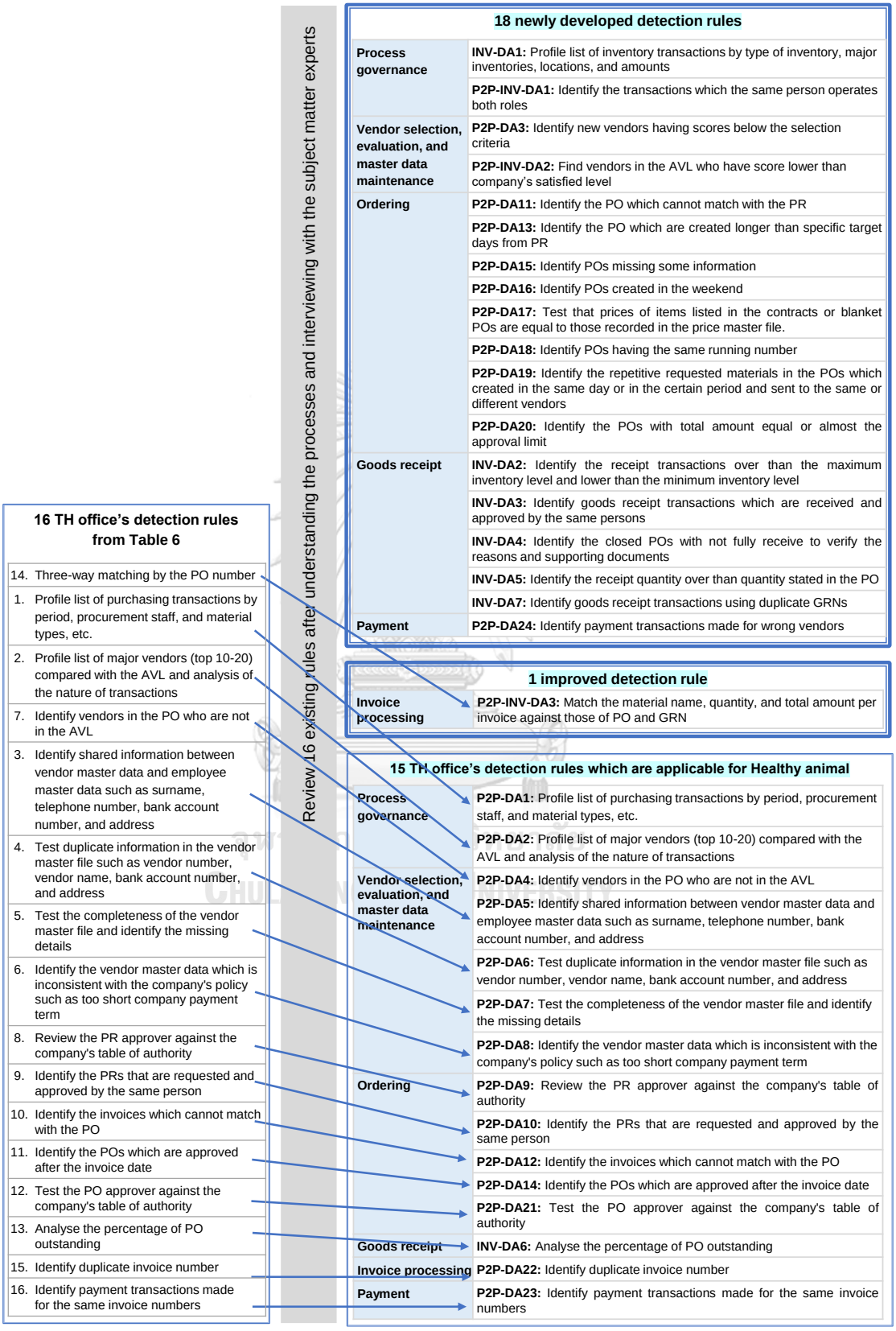
The above three risks directly impact the company's finance. In conclusion, the RCM and detection rules of the payment process are shown on the next page.

Table 16: RCM and detection rules - Payment

Risk and control matrix													Data analytics test plan								
#R	Risk	Type of Risk				#C	Control Activity	References for risk and control identification					Data analytics type	#DA	Detection rules	Required data for data analytics	References for detection rules identification				
		Strategic risk	Operational risk	Financial risk	Compliance risk			1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting						1. Company database	2. Research	3. Researcher's work experience	4. Interview/ exit meeting	
P2P-R13	The payments are duplicated for an invoice.			☑		P2P-C17	When the company pays for an invoice, its status is closed. The closed invoice cannot make further payment.	☑	☑	☑	☑		Transaction review	P2P-DA23	Identify payment transactions made for the same invoice numbers *(Existing rule)*	List of PVs	☑	☑		☑	
P2P-R14	Payments are made to the wrong vendors.			☑		P2P-C18	The key fields in the ERP are populated to the vendor payment such as the vendor's name, bank account, payment amount, payment term.	☑		☑			Transaction review	P2P-DA24	Identify payment transactions made for wrong vendors *(New rule)*	• List of PVs • List of invoices		☑	☑		

From Section 4.2.1 to 4.2.6, there are 34 detection rules from understanding the processes and interviewing with the subject matter experts for finding the anomalies in the case study company. That is, 15 out of 16 detection rules of TH office are applicable to the Company X context. So, they can be used without any adjustment. A remaining rule, three-way matching by the PO number is insufficient to work on Company X's transactions. So, this rule is improved to match with other aspects, namely material name and quantity in addition to the PO number. Furthermore, by reviewing the processes and discussing with the experts, it was found that some detection rules should be identified to complete key points in the chain. Accordingly, 18 detection rules are developed for the project. The results of detection rules improvement are summarised in the figure below.

Figure 11: The results of detection rules improvement



4.3 Effectiveness testing of detection rules

This section explains the results from the effectiveness testing of detection rules in identifying anomalies in Company X's P2P and inbound inventory processes. Overall, the exceptions found from data analytics can be summarised as findings, areas for improvement, or suspicious transactions. That is, if the internal auditor has sufficient information and the data analytics provides clear evidence, the exceptions could be raised as **findings** to confirm with Company X's responsible person. If there are observations to improve the process efficiency and effectiveness, they can be presented as **areas for improvement**. Lastly, if the internal auditor considers that many possible reasons contribute to the **suspicious transactions**, they should be investigated before concluding the results again. The investigation can be performed through inquiry, analytical procedures, observation, inspection, recalculation and reperformance, and external confirmation. In case that there is no exception, no investigation is required (Dilla & Raschke, 2015; IAASB, 2016).

Chopra & Sodhi (2004) disclose that individual risks are usually interrelated and one risk mitigation plan may worsen another. For example, lean inventory to reduce the impact of over-demand estimation will increase the likelihood of supply chain disruption. Therefore, as mentioned earlier, all findings, areas for improvement, or suspicious transactions together with recommendations are required to be confirmed with the company's responsible person, management, and audit committee respectively. In other words, the internal audit's work product is not decision making for Company X but the company will choose the solutions per their risk appetite.

Regarding the detection rules, the linkages of data in the P2P and inbound inventory processes are understood and demonstrated below. The orange dashed lines link reference data between data sets. The blue solid lines match the data which is expected not to be different.

Table 17: The linkage of transactional data in the P2P and inbound inventory processes

PR	PO	GRN	Invoice	PV
PR number	Ref. PR number	GRN number	Invoice number	PV number
PR date	PO number	GRN date	Invoice date	PV date
PR type	PO date	Ref. PO number	Ref. PO number	Ref. invoice number
Material group	PO type	Material code	Ref. vendor code	Ref. vendor code
Material code	Vendor code	Material name	Material name	Total order amount
Material name	Vendor name	Received quantity	Quantity	
Order quantity	Material group	Received unit	Unit	
Order unit	Material code		Price per unit	
Delivery date	Material name		Total PO amount	
Delivery location	Order quantity		Currency	
PR preparer	Order unit		Exchange rate	
PR approver	Price per unit		Posting date	
	Tax code			
	Total PO amount			
	Currency			
	Delivery date			
	Delivery location			
	PO preparer			
	PO approver			

The company establishes three policies and work instructions as a guideline for staff: (1) procurement and inventory policy, (2) new vendor selection and vendor evaluation procedures, and (3) table of authorities. The latest version is revised on 30 April 2017 and approved by the managing director. So, the processes and transactions understood in this project are under the above company's frameworks.

On the following pages, the detection rules are indicated in three groups: existing, improved, and new rules. The **existing rules** are the detection rules which the TH office has currently and are applicable for Company X. An **improved rule** is the rule enhancing the scope of detecting anomalies compared with the original one. Lastly, the **new rules** are the rules that are newly identified to fulfill some detection aspects that do not cover the existing ones.

4.3.1 Process governance

For the process governance, after applying the detection rules identified in Section 4.2.1 with Company X's transactional data, the results are shown as follows.

P2P-DA1: Profile list of purchasing transactions by period, procurement staff, and material types, etc.	**Existing**

The following graphs are generated from Company X's purchasing transactions between 1 July 2020 and 30 June 2021. There is an upward trend in purchasing amount. In addition, the trend is expected to steadily rise in the future which aligns with the company's direction to expand the business. As the transactions will increase, the internal auditor should focus on the manual activities which easily produce mistakes. In addition, Chopra & Sodhi (2004) discloses that the company utilising more automated technology will transfer the risk of manual processing to system failure risk. Accordingly, the internal auditor should coordinate with the IT auditor to review the Information Technology General Control (ITGC) for systems that Company X currently uses as well as its plans.

Remark: ITGC is internal controls embedded in the systems and processes to assure data integrity and appropriate application development and implementation (Anderson et al., 2017).

Figure 12: Company X's purchasing trends

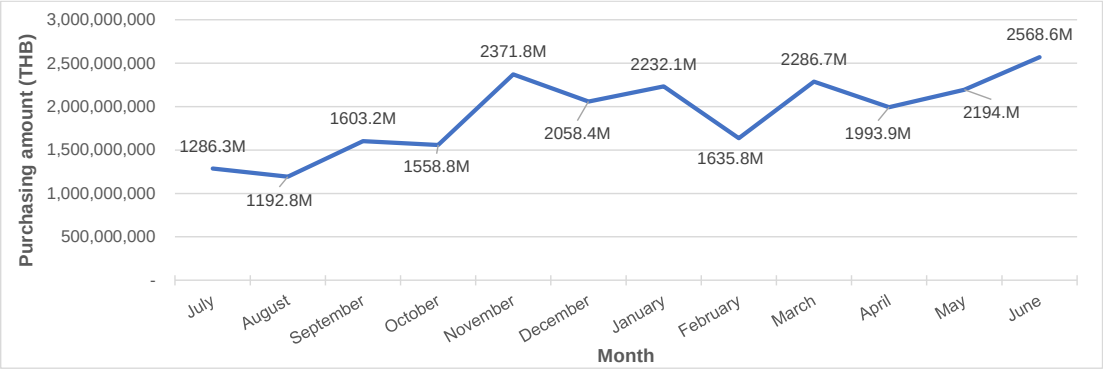
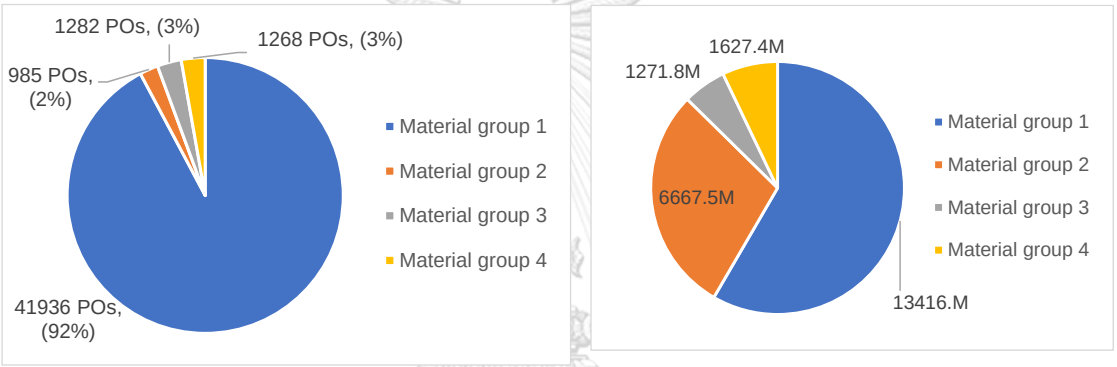
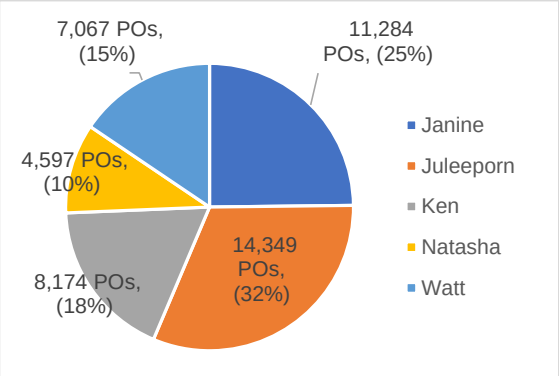


Figure 13: The proportion of purchasing transactions by material group



The most purchasing amount in Company X belongs to material group 1 which is grain and oil used as base ingredients for animal feed production. The remaining proportions are material groups 2, 3, and 4 which are protein base, vitamins, enzymes, additives, office supply, and overhead. Regarding this information, the internal auditor can expect that most purchasing transactions are grain and oil. The inventory spaces are also mainly reserved for them. Although Company X orders material group 2 infrequently when compared with the first group, the amount per PO is high. So, PO approval is a critical step for this material. Another small proportion is material group 4 with 1,268 POs for office supplies. Despite a tiny number of POs, the internal auditors may recommend e-catalogue to reduce Company X's administrative work (Monczka et al., 2014). So, apart from the current 9 strategies vendors, Company X needs to engage in a long-term agreement with more vendors supplying this material group.

Figure 14: The proportion of purchasing transactions by procurement staff



Five procurement staff are responsible for creating POs from users' requirements. It can be expected that Janine and Juleeporn are senior procurement staff who creates over half of company POs. While the remaining three staff create POs in similar proportion.

P2P-DA2: Profile list of major vendors (top 10-20) compared with the AVL and analysis of the nature of transactions	**Existing**

Table 18 lists Company X's top 20 vendors supplying 47% of the total company's spending in the last 12 months. Starred vendors are the strategic partners with who Company X maintains a long-term collaborative relationship. It is reasonable that JT inter-trading is a major vendor as it gathers feed ingredients and delivers to Company X. However, JT inter-trading's contribution proportion is much higher than the following ranks, over twice the second rank and fourfold of the third rank. So, the internal auditor can discuss with the process owner about mitigation plans for the risk of dependency on a major vendor. The internal auditor should expect that Company X has already traded off the benefit from high order volume and the impact of business interruption if JT inter-trading encounters the problems. In addition, Company X has established and implemented a robust Supplier Relationship Management (SRM) programme with JT inter-trading (Monczka et al., 2014). If Company X has not done so, it should be raised as areas for improvement.

It highly appears that the following ranks are major vendors. Because almost all top 20 supply raw materials for animal feed production which is the biggest proportion of the company cost structure. Nevertheless, Total transportation company limited is only a transportation provider in the top 20 vendors as well as in the AVL. Similar to JT inter-trading, the internal auditor can discuss the single-sourcing policy, SRM programme, and mitigation plans for disruptions together with dominant pricing by a sole vendor.

Table 18: List of Company X's top 20 vendors

	Vendor number	Vendor name	Total PO amount	Percentage
1	2000909	JT inter trading company limited ★	2,770,547,200.00	12%
2	2000534	Tanakrit oilseed company limited ★	1,131,309,798.64	5%
3	2000277	Bangkok vegetable oil company limited ★	696,960,616.40	3%
4	1000471	Kirati Suksripaiboon	639,276,511.54	3%
5	1000859	Nipath Panichthumrong ★	525,783,552.72	2%
6	2000189	Total transportation company limited ★	512,156,256.06	2%
7	2000438	Inter ingredient company limited ★	500,772,505.60	2%
8	1000941	Pawares nawasamrith	477,544,715.29	2%
9	1000047	Kittipong Thummanoonkul	439,103,224.32	2%
10	1000105	Puritra Wutdecha ★	410,802,172.00	2%
11	2000854	Charoenkaset company limited	391,160,988.94	2%
12	1000593	Somsamai Tanasinkul ★	340,164,938.26	1%
13	1000151	Narong Damneunsawang	334,725,845.20	1%
14	2000669	Thai rice grain company limited ★	265,488,000.00	1%
15	2000894	A.K. food supply company limited	259,057,942.32	1%
16	1000938	Yuttapong Chaimana	238,424,253.02	1%
17	2000299	Siam corn group company limited	234,930,844.40	1%
18	1000550	Anusak Intrachep	228,191,660.87	1%
19	2000460	Intermed farm Thailand company limited	212,193,200.00	1%
20	1000771	Tanawat Jarubanjong	197,965,622.49	1%
		Total	**10,806,559,848.07**	**47%**

In addition to 9 strategic vendors, the internal auditor may discuss with Company X about making the long-term relationship with the above major vendors without a star. The long-term relationship provides the benefits of supply commitment from vendors, as well as sharing knowledge, technology, and cost information. Although engaging with single suppliers increases risks of supply chain disruption, robust vendor selection and management during the contract period can prevent this risk. An example of an appropriate type of contract is a fixed-price contract with escalation. Because vendors are required to supply material over a year and there is a potential for price volatility (Monczka et al., 2014).

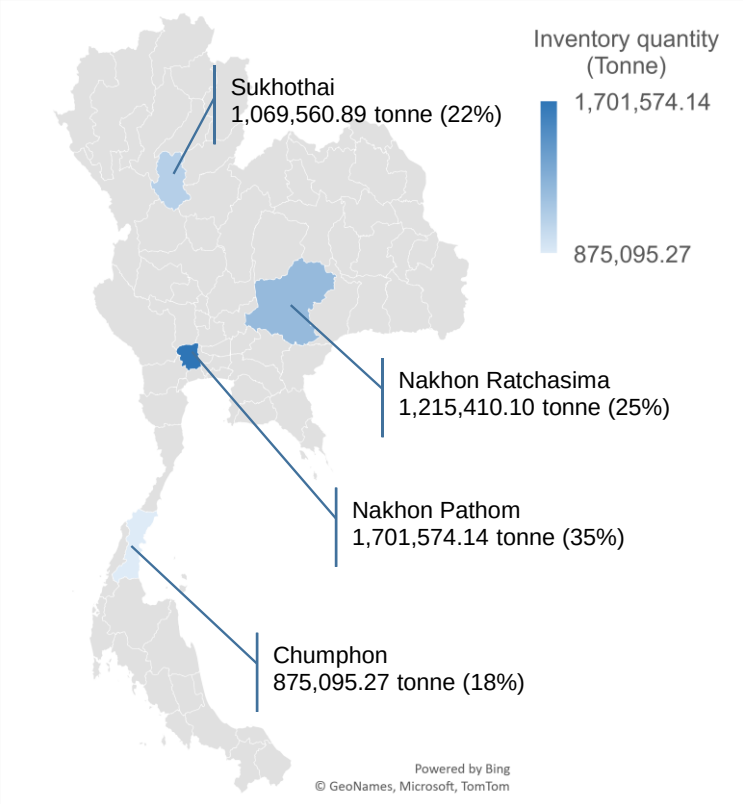
In terms of the nature of transactions, over the last 12 months, Company X has purchased transactions with 554 vendors. As 719 approved vendors are in the AVL, there are 165 vendors (23% of

total approved vendors) that the company has not made the transactions. Because the company evaluates vendor's performances every 6 months, 165 vendors who have no performance in the last 12 months are not evaluated. For this reason, their performances may be unsatisfied and the company is not aware of it before ordering their products or services. Regarding this observation, the TH office's internal auditor should investigate how Company X manages the dormant vendors. Guile (2012) recommends that the company should have clear procedures. For instance, vendors with whom the companies have not interacted more than a year are marked as inactive. Before making an order with them, they are re-qualified and update the quotation for consideration.

INV-DA1:	Profile list of inventory transactions by type of inventory, major inventories, locations, and amounts	**New**

The inventory policies, procedures, and inventory reports in the last 12 months are analysed. The results of these data analytics rules allow the internal auditor to have an overview of Company X's inventory process.

Figure 15: Company X's inventory locations



Company X produces animal feed in Thailand. There are four warehouses located in each factory. From the left figure, it seems that Company X geographically establishes production bases. The largest warehouse is in Nakhon Pathom where stocks 35% of the total company's inventory. The second-largest warehouse is in Nakhon Ratchasima with an inventory proportion of 25%. Sukhothai warehouse accounts for 22% of total inventory quantity. Lastly, Chumphon stocks 18% of company inventories. Each warehouse keeps four material groups used for production and management.

Similar to the rule numbered P2P-DA1 (Profile list of purchasing transactions by period, procurement staff, and material types, etc.), major inventories analysed from the last 12 months inventory reports are grain and oil. The below table shows that the most three inventory amounts belong to local feed corn, soybean oil, and rice bran. Their cumulative inventory quantities are 55% of the total of Company X's inventory. Other materials in the top 10 Company X's major inventories are also shown in the table below.

Table 19: Company X's top 10 inventories

	Material name	**Material group**	**Inventory quantity (Tonne)**	**%**
1	Local feed corn	1	1,151,583.04	24%
2	Soybean oil	1	945,875.60	19%
3	Rice bran	1	588,990.92	12%
4	Soybean meal	1	393,623.18	8%
5	Cassava starch	1	273,478.12	6%
6	Wheat	1	230,849.06	5%
7	Barley	1	197,379.43	4%
8	Palm oil	1	186,550.74	4%
9	Pork	2	122,627.41	3%
10	Amino acid	3	120,831.31	2%
		Total	**4,211,788.81**	**87%**

P2P-INV-DA1: Identify the transactions which the same person operates both roles	**New**

The segregation of duties is analysed to ensure that procurement and inventory activities are performed properly to strengthen the mechanism of checks and balances in Company X. The table below lists responsible persons or positions for each activity. And the results of detection rules are explained as follows.

Table 20: Responsible persons or positions in the procurement and inventory processes

Vendor master data maintenance	**PO creation**	**PO approval**	**Goods receipt**	**Invoice processing**	**Payment processing**
• Janine • Juleeporn • Ken • Natasha • Watt *(All are procurement staff)*	• Janine • Juleeporn • Ken • Natasha • Watt *(All are procurement staff)*	• Jamie *(Head of procurement)* • Samart *(Managing director)* • Executive committee	• User • Laboratory staff • Warehouse staff • Engineer	• AP staff	• Finance staff • Head of finance • Company authorised persons

For the first criterion of comparing responsible persons in vendor master data maintenance and PO creation, it is found that both activities are responsible by the same group of procurement staff. So, this finding should be raised and confirmed with the process owner.

For the criterion of comparing responsible persons in PO approval and payment processing, it is suspected whether the company authorised persons are members of the executive committee. If this expectation is correct, it should be raised as the finding of inappropriate segregation of duties as well. So, the internal auditor should investigate this concern for more details.

There is no finding in the remaining criteria. These are (1) reviewing the duties of vendor master data maintenance and payment processing, (2) PO creation and PO approval, (3) PO creation or approval and goods receipt, and (4) invoice processing and payment processing. Because those activities are executed by different persons.

Nevertheless, these detection rules focus on the control design of segregation of duties. For operating effectiveness or ensuring the designed controls are implemented, the detection rules numbered P2P-DA9 (Review the PR approver against the company's table of authority) and P2P-DA21 (Test the PO approver against the company's table of authority) in the following sub-sections will analyse and describe the results.

4.3.2 Vendor selection, evaluation, and master data maintenance

The results of seven detection rules identified in Section 4.2.2 are explained as follows.

P2P-DA3: Identify new vendors having scores below the selection criteria	**New**

Company X has registered 15 new vendors in the last 12 months. After comparing the new vendor evaluation scores against the acceptance criteria (more than 70%), all of the new vendors have scored higher than 70%. So, this rule can ensure that the new vendors are qualified to provide products and services to the company.

P2P-DA4: Identify vendors in the PO who are not in the AVL	**Existing**

Company X has 719 approved vendors recorded in the AVL. According to 45,471 purchasing transactions from 1 July 2020 to 30 June 2021, there is 147 POs (0.32%) created by 3 non-approved vendors as listed below.

Table 21: List of non-approved vendors whom Company X creates PO

	Vendor number	Vendor name	Total PO amount	Number of purchases
1	2000998	Agri workgroup company limited	186,565,421.00	111
2	2000577	Poultry innotech company limited	174,720.00	17
3	2000845	Siam cooperative	225,160.00	19
		Total	**186,965,301.00**	**147**
		Percentage	**0.81%**	**0.32%**

In terms of impact, above 147 POs created to non-approved vendors values 0.81% of the total purchasing transactions. As the percentage is below 5%, it is insignificant from the view of the TH office's internal auditor. Nevertheless, the internal auditor should investigate the causes. Experts and the author expect that there are three potential responses from Company X.

1. Company X may claim that they are one-time vendors who supply what the company rarely requests. So, the company just gives them the temporary vendor code to create the PO in the ERP. One-time vendors are not involved in the process of vendor performance evaluation and master data maintenance. Because of infrequent ordering, it is costly to do so. For this potential response, however, the number of purchases in the rightest column shows that three vendors have transactions with Company X more than one time. So, Company X should revisit the one-time vendor policy and regularly monitor vendors' transactions. If the company frequently creates orders for these vendors, they should be listed in the vendor master file and follow the company's vendor management processes.
2. Company X may claim that these vendors are in the process of new vendor registration. However, the number of purchases shows that the company creates orders to vendors for a while. So, Company X should shorten the new vendor registration process or resolve the problems for these three vendors.
3. Company X may claim that it is a different period of information. That is, AVL is as of 30 June 2021 while the PO list covers from 1 July 2020 to 30 June 2021. So, these vendors have just been blacklisted. For this case, the evidence should be obtained for auditing.

P2P-DA5:	Identify shared information between vendor master data and employee master data such as surname, telephone number, bank account number, and address	**Existing**

Employee master data is confidential information that Company X does not share with the internal audit team. However, the author takes executives' names and the Board committee's names available on the company's website for testing this detection rule. After searching for the duplicate names and/or surnames between the vendor master data and those on the website, no duplication is found.

P2P-DA6: Test duplicate information in the vendor master file such as vendor number, vendor name, bank account number, and address	**Existing**

The testing begins with finding duplicate vendor numbers in the AVL. From this rule, 719 vendor numbers are unique. Then, the author looks up the repetitive name, bank account number, and address of all 719 vendors. The results are shown below.

Table 22: List of vendors with duplicate names and bank account number

	Vendor number	**Name**	**Address**	**Telephone**	**Bank Country**	**Bank account number**	**Name of bank**	**Bank Branch**
1	2000472	Pro ingredient company limited	101 Charoen Road, Wat prapa sub-district, Bang Kho Laem District, Bangkok 10120	02 656 1002-5	TH	1091893027	Siam Commercial Bank	Wat prapa branch
2	2000893	Pro ingredient company limited	101 Charoen Road, Bang Kho Laem District, Bangkok 10120	02 656 1002-9	TH	1091893027	Siam Commercial Bank	Wat prapa branch
3	1000508	Mr. Prasith Boonpairat	367/3 Thongsak Road, Maikaew District, Phuket 83100	076 668 2200	TH	6818241853	Bangkok Bank	Maikaew branch
4	1000965	Mr. Prasith Boonpairat	367/3 Thongsak Road, Maikaew District, Phuket 83100	076 668 220	TH	6818241853	Bangkok bank	Maikaew branch

As can be seen from the table, there are 4-line items from 2 vendors who have duplicate vendor names and bank account numbers. Having considered the address, their locations are the same. That is, the second vendor is not recorded the sub-district compared with the first vendor. Its telephone extension number is also updated from the first

one. For the third and fourth vendors, there is a space typing for the vendor's address in the last row. As the telephone number in the upcountry of Thailand has 9 digits, the telephone number of the third vendor is doubled "0".

From the author's experience, there are three possible reasons for the duplication.

1. The duplication may result from data migration to the ERP. The clients formerly have different vendor master files separate by material groups. Once they migrate the files to the ERP, vendors who supply products in different material groups are duplicated in the system.
2. As mentioned in Section 4.2.2, different staff record vendor data differently such as using uppercase or lowercase and abbreviation or full name. In addition, some staff makes typos and add more space between words. Although some ERPs or data analytics tools cannot flag this duplication, these types of records are the same vendors.
3. The staff intends to make the duplicated records to increase purchasing quota for those who have benefits.

Consequently, Company X should reconsider these 4-line items. Vendor records should be revised with the updated information and deleted or inactive the unused records.

Table 23: List of vendors with duplicate addresses

	r number	**Name**	**Address**	**ephone**	**ountry**	**ccount number**	**e of bank**	**k Branch**
		sak Veerarak and Mr. Krungtanee	ana road, Mueng District, Phetchabun 67900		H	37036285	Bank	oad branch
		vod Krungtanee	ana road, Mueng District, Phetchabun 67900		H	41891403	ai Bank	oad branch
		ditive public company	khumvit 34 Alley, Sukhumvit Road, Klong Bua angkok 10670	49	H	30352268	Bank	a branch
		ical company limited	khumvit 34 Alley, Sukhumvit Road, Klong Bua angkok 10670	90	H	26570361	Bank	a branch
		harmaceutical public limited	on building Phongsangthai Road, Dindaeng angkok 10400	94	H	06257522	mmercial Bank	branch

	r number	Name	Address	ephone	ountry	ccount number	e of bank	k Branch
		company limited	on building Phongsangthai Road, Dindaeng angkok 10400	94	H	47531711	mercial Bank	branch
		ealth laboratory company	on building Phongsangthai Road, Dindaeng angkok 10400	94	H	69197290	mercial Bank	branch
		company limited	on building Phongsangthai Road, Dindaeng angkok 10400	94	H	84520254	mercial Bank	branch
		food company limited	on building Phongsangthai Road, Dindaend angkok 10400	94	H	93104602	mercial Bank	branch
		wan Chutrakul	2 Chaengwattana Road, Ban Bua Thong, ri 11130	594	H	79832645	Bank	gna
		imited partnership	2 Chaengwattana Road, Ban Bua Thong, ri 11130	865	H	76056722	Bank	gna
		ttra Auraiporn	Road, Ban Ta Num sub-district, Mueng district ri 34000		H	35405220	Bank	chinburi
		Auraiporn	Road, Ban Ta Num sub-district, Mueng district ri 34000	743	H	26321072	Bank	us ri

According to Table 23, there are 13-line items from 13 vendors who have duplicate vendor addresses. These data analytics results cannot be immediately summarised as finding because of four potential reasons from the author's experience.

1. For juristic persons, it is possible that the duplicate addresses are the rent office. So, the vendors are different companies.
2. Alternatively, those juristic persons are affiliate companies. So, if Company X places a lot of orders on this group of vendors, the company will have more risks of dependency on a major vendor.

3. There may be a cartel in this group of vendors. A cartel is a kind of corruption in which a group of vendors makes collusion for fraudulent commitment. They typically fix the quotation prices, share information about the purchaser (Company X), or make a market rigging by allocating the production capacity in the vendor groups (UNGC, 2013).

4. For individuals, two or more family members may register as Company X's vendor for the purpose of sharing income tax.

For the next step, the internal auditor should review information in the ERP against the vendor's application document sets whether they are accurately recorded. Additionally, the internal auditor may verify existing of the above 5 duplicate locations and find out whether vendors are affiliate companies.

Table 24: List of vendors with duplicate bank account numbers

	r number	Name	Address	lephone	Country	account number	Name of bank	Branch
		V	Baras Road, Thiaumont, Hainaut 2130	9930	BE	00 AAAA 000000 00000000	k	
		S.A.	anta Teresa degli Scalzi Street, Tamarite de esca 23880	08	ES	00 AAAA 000000 00000000	ntander	
		on S.A.	Blanca Street, Les Franqueses del Vallès City, 09350	34	ES	00 AAAA 000000 00000000	ntander	
		imal feed	l building, Via Giberti Road, Giacosa, Torino 10020	5748	SI	00 AAAA 000000 00000000	nte Dei Paschi Di	
		completion	ionstrasse, Rassach, Styria 8943	07712	AT	00 AAAA 000000 00000000	tria	

From the above table, there are 5-line items from 5 vendors who have duplicate bank account numbers. As all of them are foreign vendors, the duplicate bank account number is possibly the format of International Bank Account Number (IBAN) which is used to proceed the cross-border transactions (ISO, 2021). So, for the next step, the internal auditors should inquire process owners for more information and review the supporting documents.

mpleteness of the vendor master file and identify the missing details	isting

The author and experts agree that the bank account number is the key information in the vendor master file as it will be used for payment. Thus, this detection rule focuses on searching for missing vendor bank account numbers. The results are illustrated below.

Table 25: List of vendors with missing bank account numbers

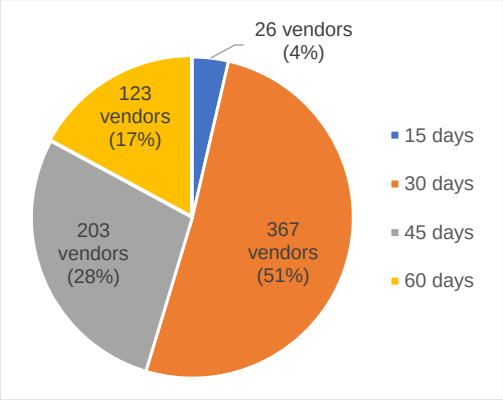
	r number	Name	Address	elephone	Country	unt number	of bank	Branch	PO amount
		dient PTE.	Hong Leong Ha Building, Raffles Quay		G				40,346,055.54
		ong Corporation	yeongju street, Gyeongsangbuk-do, Seoul	275	R				183,866.80
		nate PTE.	rth tower, Siang Kuang Avenue, 138500		G				1,383,502.48
		Agri tech company	loor The Sun Building, Kowloon City ongkong		K				2,917,640.00
		ience & Technology	Road, Tianjin 300066	309	N				349,018.60
		ding PTE.	ridge road, Singapore 100822		G				5,064,108.00
		n Chanakitsongkram	ng Rayong Road, Rayong 21500	12	H				391,567.28
		orporation	Min centre, XiCheng District, Beijing	722	N				17,784.00

	r number	Name	Address	elephone	Country	unt number	of bank	Branch	PO amount
								Total	**50,653,542.70**

It is found that 8 vendors do not have bank account numbers recorded in the vendor master data. Surprisingly, Company X makes payments to them 50,653,542.70 THB or 0.22% of the total purchasing amounts in the last 12 months. So, this finding should be discussed with the head of procurement and the head of finance to find out more information.

P2P-DA8: Identify the vendor master data which is inconsistent with the company's policy such as too short company payment term	**Existing**

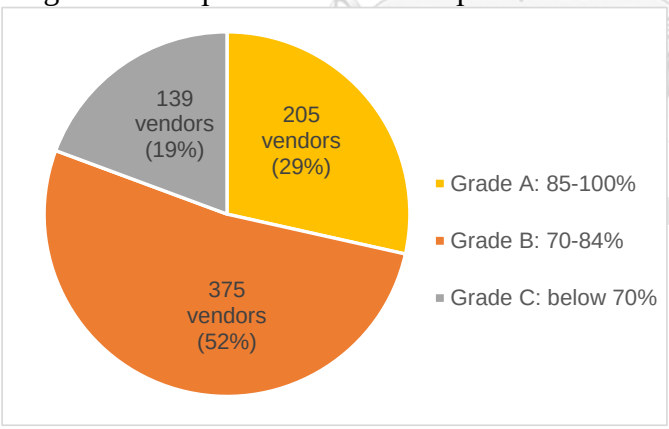
Figure 16: Proportion of vendor's payment term



Company X payment terms are varied and different for each vendor. They are ranged from 15 days to 60 days. New vendors will have at least a 30-day payment term. Some strategic partners get a short payment term of 15 days. From this information, the data analytics results reveal that all 719 approved vendors have payments ranging between 15 and 60 days under the company policy. Over half of vendors gain a 30-day payment term. The second most are 45-day payment term as over a quarter of vendors get. Followed by 60 days and 15 days offered to 17% and 4% of vendors respectively.

P2P-INV-DA2: Find vendors in the AVL who have score lower than company's satisfied level	**New**

Figure 17: Proportion of vendor's performance score



This detection rule is similar to P2P-DA3 (Identify new vendors having scores below the selection criteria) but extends the scope to all vendors in the AVL. As mentioned in Section 4.2.2, the AVL will comprise vendors with scores higher than 70%. The results from data analytics are in line with the company's criteria as 81% of approved vendors have a score over 70%. For future auditing, internal auditors can focus on the remaining 19% of vendors and verify whether they are in the improvement programme.

4.3.3 Ordering

This section illustrates the results of 13 detection rules identified in Section 4.2.3. For the rule numbered P2P-DA4 (Identify vendors in the POs who are not in the AVL), the testing results are already shown in Section 4.3.2.

P2P-DA9: Review the PR approver against the company's table of authority	**Existing**

There are 43,205 PRs created between 1 July 2020 and 30 June 2021. Company X establishes the table of authority for PR approval as shown in Table 26. Table 27 lists a part of unauthorised PR approvers as the results of this detection rule.

Table 26: Company X's table of authority - PR approver

Material group	PR < 1 million THB (Department head)	PR 1 – 5 million THB (Managing Director)	PR > 5 million THB
1: Grain and oil	Pakorn	Samart	Executive committee
2: Protein base	Arisa		
3: Vitamin, enzymes, and additive	Samantha		
4: Office supply and overhead	Orawan		

Table 27: Example of unauthorised PR approvers

PR number	Mat. group	Material name	PR amount	Preparer	Approver	Request date	Approval date
A03925	3	Active probiotic	1,403,000.00	Paiboon	Samantha	24-07-20	24-07-20
A03473	3	Optimum calcium	2,320,000.00	Paiboon	Samantha	30-10-20	30-10-20
A03474	3	A-Amino acid + 3 DC	1,446,720.00	Paiboon	Samantha	30-10-20	30-10-20
A03475	3	A-Amino acid + 2 DC	3,312,000.00	Paiboon	Samantha	30-10-20	30-10-20
A03008	3	Pro amino acid	6,200,800.00	Paiboon	Samart	16-11-20	16-11-20
A02447	2	Local pork grade B	1,296,000.00	Paiboon	Arisa	01-12-20	01-12-20
A02448	2	Local pork grade B	1,382,400.00	Paiboon	Arisa	01-12-20	01-12-20
A02449	2	Local pork grade B	2,552,000.00	Paiboon	Arisa	01-12-20	01-12-20
A02713	2	Local chicken top part	10,432,000.00	Paiboon	Samart	16-12-20	16-12-20
A02405	2	Egg A22 size M	1,288,000.00	Sawas	Arisa	11-01-21	11-01-21
A01732	1	Local jasmine rice	1,068,000.00	Sawas	Pakorn	23-03-21	23-03-21

PR number	Mat. group	Material name	PR amount	Preparer	Approver	Request date	Approval date
A01933	1	Soybean grade B	6,460,000.00	Onetaya	Samart	07-04-21	07-04-21
A01987	1	Soybean grade B	6,560,000.00	Onetaya	Samart	09-04-21	09-04-21

Regarding the above examples, the full list comprises 1,013 PRs approved by unauthorised persons as specified in the table of authority. For example, the first four PRs which value over one million need Mr. Samart as an approver. But Ms. Samantha who is a department head approved them instead. However, the internal auditor cannot conclude these 1,013 PRs as findings immediately because of the following possibilities.

1. For PRs value over than one million baht, Mr. Samart may delegate the decision to the department head. Thus, the internal auditor can ask for evidence of delegation of authority from Mr. Samart such as a letter or emails to ensure that those PRs are reviewed and approved by authorised person.
2. For PRs value over five million baht, Mr. Samart may approve PRs in the ERP before submitting them to the executive committee later. If this anticipation is correct, the internal auditor should request for minutes of the meeting or the evidence that PRs are approved by the committee according to the table of authority.

P2P-DA10: Identify the PRs that are requested and approved by the same person	**Existing**

It is not found that PR preparer and approver are the same persons. However, the following table lists 10 PRs that do not have the PR preparer's name. From discussion with the experts, it is expected that PR approvers (department head and managing director) have the right to create PR in the ERP as well. Therefore, the internal auditor should investigate users' rights in the ERP by reviewing the ERP authorisation matrix. Moreover, the internal auditor should understand the procedures of PR creation for these 10 transactions before summarising whether they are finding.

Table 28: List of missing PR preparer

PR number	Mat. group	Material name	PR value	Preparer	Approver	Request date	Approval date
A02922	2	Egg B35 size L	1,342,000.00		Samart	03-07-20	03-07-20
A02012	2	Mix bone high grade	265,440.00		Arisa	13-07-20	13-07-20
A01113	1	Cassava chip 87	2,016,000.00		Samart	08-10-20	08-10-20
A01502	1	Cassava chip 87	2,272,000.00		Samart	27-10-20	27-10-20
A02094	2	Local pork grade B	432,000.00		Arisa	12-11-20	12-11-20
A02488	2	Local fish part – feed grade	730,800.00		Arisa	01-12-20	01-12-20

PR number	Mat. group	Material name	PR value	Preparer	Approver	Request date	Approval date
A01405	1	Local feed corn	1,512,640.00		Samart	04-01-21	04-01-21
A02406	2	Local chicken top part	270,000.00		Arisa	04-01-21	04-01-21
A02515	2	Local chicken top part	247,760.00		Arisa	15-03-21	15-03-21
A02319	2	Local pork grade B	199,640.00		Arisa	17-03-21	17-03-21

P2P-DA11: Identify the PO which cannot match with the PR	**New**

As Company X's POs are generated from the approved PRs, this detection rule will find out suspicious POs which do not have PR as the reference to ensure that all POs are created from user requirements. It is found that 2,890 from the total 45,471 POs (6.4%) cannot match with the list of PRs. From 2,890 suspicious line items, it is found that 1,901-line items are the POs with zero amount, 660-line items are the POs with a negative amount, and the remaining 329-line items are POs with positive amounts. The following tables show an example of suspicious line items.

Table 29: The example of zero PO amount

PO number	Mat. group	Vendor name	Material name	PO amount
B03534	3	Hai Hua laboratory	Glucanase and amylase blend 60-40	-
B03665	3	Argo-chem feed company limited	Metabolisable activator XT	-
B03363	3	Miyear pro-chem company limited	Beta-mannanas 2w	-
B03851	3	Bio science services company limited	Probiotics lead 3/4	-
B03685	3	One chemical specialties company limited	Bio-digestive 23 PD	-

There are 1,901 POs created for 5 vendors with zero amount. These five vendors are chemical manufacturers and science laboratory service providers. So, the author and experts anticipate that these POs are created for Company X's research and development (R&D) purposes. It means the vendors are requested for new material free of charge. The laboratory services may be offered as complimentary. If the materials are satisfied, Company X will purchase them for manufacturing. So, instead of creating PR in the ERP, the new material requisition may be in form of a Bill of Material (BoM) endorsed by the

head of R&D. The BoM is sent to the procurement department for creating a PO in the system. For this reason, these kinds of POs have no PR to match with.

Table 30: The example of negative PO amounts and vendor performance score

PO number	Mat. group	Vendor name	Material name	PO amount	Vendor performance score
B03596	3	SB supply company limited	S Protect solution	-1,920.00	99 (Grade A)
B03971	3	SB supply company limited	Feed additive 334-8z	-122,960.00	
B03871	3	SB supply company limited	Lucta N 0H764	-122,976.00	
B03554	3	Total feed company limited	Optimum vit mix	-224,000.00	72 (Grade B)
B03545	3	Animal health laboratory company limited	Zinc integrate 100	-214,192.00	64 (Grade C)
B03882	3	Animal Pharmaceutical public company limited	Exterweight VKL	-493,200.00	93 (Grade A)
B03182	3	Animal Pharmaceutical public company limited	Exterweight VKL	-548,000.00	
B03189	3	Animal Pharmaceutical public company limited	Exterweight VKL	-548,000.00	
B03348	3	Animal Pharmaceutical public company limited	Pro enzymes PV1	-4,000.00	

Continuing from the above prediction, POs unmatched with PRs are POs for R&D purposes. In this case, from the author's experience, the POs with negative amounts are created for rejected products. If Company X uses this practice to return unsatisfied goods, there may be a finding in the vendor performance management process. Because grade A vendors should not have material issues several times. In addition, regarding Section 4.2.2 above four vendors need more clarification why their offices are located at the same place. The likely reasons are that they are different companies but located in the rental office. Or in the worst case, they are companies in the same groups which operates a cartel on feed ingredient.

Table 31: The example of positive PO amounts

PO number	Mat. group	Vendor name	Material name	PO amount
B01151	1	Sun agriculture company limited	Rice bran oil – feed grade	568,000.00
B01153	1	Kittipong Thummanonkul	Local feed corn	202,640.00
B01154	1	Pawares nawasamrith	Local feed corn	219,016.80
B01158	1	Somsamai Tanasinkul	Local feed corn	200,138.40
B01162	1	Pornlada Damneunsawang	Local feed corn	203,968.80

The remaining 329-line items are POs with positive amounts. Although Company X's POs will be created from PRs, these 329 questionable POs cannot suddenly judge as findings. For example, regarding the results of P2P-DA13 (Identify the PO which are created longer than specific target days from PR), some POs are late created. In addition, the list of POs and PRs are in the same periods. So, it is reasonable that POs at the beginning of July cannot find the PR to match with.

From the above three potential causes of unmatching between PO and PR, internal auditors should inquire the responsible persons of Company X for more information and request supporting documents before concluding the reasons and deciding whether the company orders goods without requirements from users.

P2P-DA12: Identify the invoices which cannot match with the PO	**Existing**

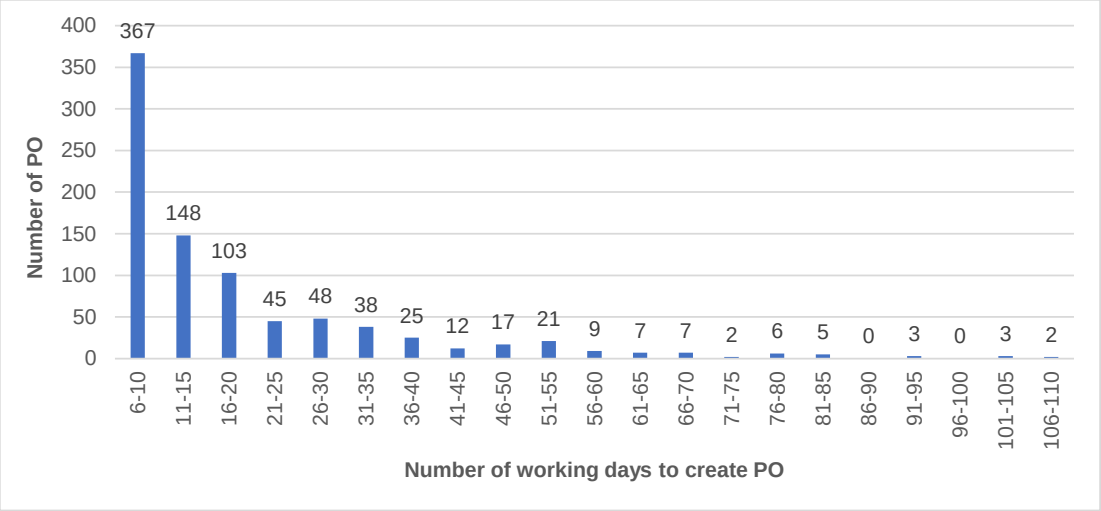
The PO number is reference data between PO and invoice files. This rule can detect 301 POs from 45,471 POs (0.66%) which do not have an invoice to match with. However, before deciding whether the company receives goods or services without creating the PO, the following possible rationales should be discussed with Company X.

1. Because Company X offers different payment term ranging from 15 to 60 days. So, vendors send the invoice to the company on the due date. It is reasonable that POs in May and June 2021 have no invoices from vendors.
2. Vendors gather several bills and send them to the company. Hence, some POs are waiting for the vendor's invoices.
3. Some transactions are expenses which do not require PO creation. For instance, machine maintenance, fuel and gas, and product write-off. So, the internal auditor should confirm with the process owner.

P2P-DA13: Identify the PO which are created longer than specific target days from PR	**New**

According to Company X's target, the procurement staff must create a PO within 5 working days after receiving the PR. This target is set to prevent late PO creation which will lead to delayed production plan. From 15,623 POs created after the company has launched this target, it is found that 868 POs (5.6%) are created longer than 5 working days as shown in Figure 18. From the view of the TH office's internal auditor, the exceptions are significant since their proportions exceed 5%. So, the internal auditor should investigate the reasons for this problem and provide a recommendation to shorten the PO creation process. On this, the results from this data analytics are classified as finding because of breaking the company's target.

Figure 18: Frequency of PO creation longer than five days



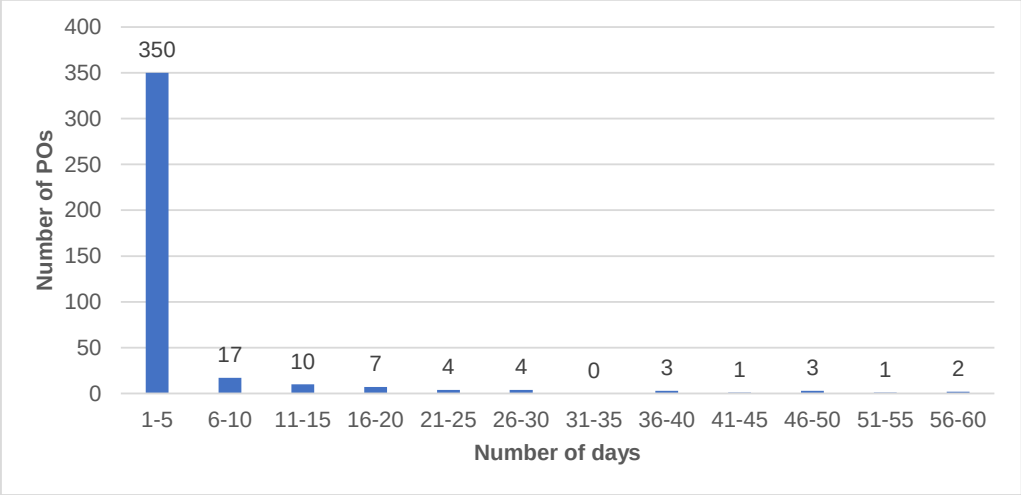
P2P-DA14: Identify the POs which are approved after the invoice date	**Existing**

The PO date and invoice date are compared in this detection rule. The results are that 402 POs are approved after receiving products or services from vendors. In other words, there is a possibility that Company X purchases goods or services from unapproved POs. Figure 19 shows the frequency of PO approved after the invoice date. Most of them are in the range of 1-5 days while the maximum delay is 56 days.

The subject matter expert shares two possible reasons. Firstly, it is an urgent purchase that the company received goods for production and prepared the PO and GRN in the ERP later. Moreover, when vendors delivered goods to Company X, it was noticed that the specification or quantity was wrong. So, the procurement staff revised and sent it to the approver which is completed in the next few days.

Although there are some potential causes of the exception, these cases still don't comply with the company policy. So, this exception should be raised as a finding to confirm and discuss with clients.

Figure 19: Frequency of PO approved after invoice date



P2P-DA15: Identify POs missing some information	**New**

The author firstly identifies key fields that need to include in the PO, otherwise, the vendor cannot deliver products and services accurately and completely. They are PO number, PO date, vendor name, material name, order quantity, order unit, price per unit, total PO amount, currency, delivery date, and delivery location. The results reveal that all 45,471 POs have the necessary information as identified.

P2P-DA16: Identify POs created in the weekend	**New**

Company X's working days are Monday to Saturday. In the peak period of demand, some staff in the factory, warehouse, and procurement department will work on Sunday with approval from the managing director. Regarding the PO files, it is found that 118 POs are created on Sunday as illustrated in Table 32.

To investigate, the internal auditor should obtain the announcement to open the operation lines on these 10 days. If there is no written notice, it should be raised as a finding. For further examination, the internal auditor may start reviewing POs and supporting documents on days with a few POs created. Because, over the last 12 months, Company X creates 148 POs per day on average. The preliminary results are that Watt who is a procurement staff creates the most suspicious POs with 81 from 118 POs.

The top three vendors in these POs are Ms. Praew, Mr, Thanwa, and Mr. Pongsak who are not Company X's top vendors. Interestingly, all POs created for them are from Watt. Regarding this information, the internal auditor should discuss and confirm with the responsible person whether it is fraud or not.

Table 32: Summary of POs created on weekend

	Date	Number of POs
1	05-Jul-20	1
2	08-Nov-20	2
3	20-Dec-20	6
4	10-Jan-21	25
5	17-Jan-21	13
6	24-Jan-21	49
7	31-Jan-21	13
8	07-Feb-21	6
9	11-Apr-21	1
10	25-Apr-21	2
Total		**118**

Procurement staff	Number of POs	Percentage
Janine	30	25%
Ken	7	6%
Watt	81	69%

Vendor	Number of POs	Percentage
Praew Parama	16	14%
Thanwa Buapai	9	8%
Pongsak Fairuengkao	7	6%

P2P-DA17: Test that prices of items listed in the contracts or blanket POs are equal to those recorded in the price master file.	**New**

The author does not obtain the purchasing contracts and blanket POs which is the confidential information to test this detection rule. However, Company X signs contract or creates blanket POs with vendors annually, effective from 1 January to 31 December 2020. By this information, the results from testing this detection rule with the top vendor are shown as follows.

Table 33: Different price per unit of JT inter trading company limited

PO number	PO approved date	Mat. group	Material name	Price per kg
B01484	08-07-20	1	Local feed corn	17.00
B02437	15-07-20	1	Local feed corn	17.00
B02881	21-08-20	1	Local feed corn	17.25
B03100	29-11-20	1	Local feed corn	16.75
B03773	14-08-20	1	Soybean oil	9.50

PO number	PO approved date	Mat. group	Material name	Price per kg
B04100	30-08-20	1	Soybean oil	10.00
B04104	31-08-20	1	Soybean oil	10.00
B04421	18-09-20	1	Soybean oil	9.75
B04549	19-10-20	1	Soybean oil	9.50
B04779	09-11-20	1	Soybean oil	10.50
B04985	27-01-21	1	Soybean oil	11.00
B05143	12-02-21	1	Soybean oil	11.75
B05216	11-04-21	1	Soybean oil	13.25
B05670	29-02-21	1	Rice bran oil – feed grade	5.25
B06009	01-02-21	1	Rice bran oil – feed grade	5.25

As JT inter trading has a contract with Company X, the material prices should be fixed throughout the year. However, as can be seen from the table, local feed corn and soybean oil prices are varied. So, the internal auditor may take this shortlist to discuss with the responsible person for more details. If there are price adjustments, the contract amendments should be obtained to review.

P2P-DA18: Identify POs having the same running number	**New**

From 45,471 POs in the last 12 months, 247 PO line items have repetitive 90 running numbers. However, it is found that a PO line item represents an order in the PO. Take for illustration, if a PO contains five orders, there will be five PO line items for the same running number. So, after re-considering 90 POs, there is no duplicate line-item number. As a result, there is no suspicious PO found from this rule.

P2P-DA19: Identify the repetitive requested materials in the POs which created on the same day or in a certain period and sent to the same or different vendors	**New**

Because animal feed ingredients are a commodity which the prices are vary every day. Therefore, Company X purchases raw materials for production on a daily basis, particularly when the prices are tended to cheaper. Accordingly, to detect the split POs in this detection rule, the author scopes the criteria to find the group of POs created on the same date to purchase the same material for the same factories on the same delivery date. From these criteria, there are suspicious 235 line-items from 30 cases as following examples.

Table 34: The examples of suspicious split POs

Case	PO number	PO date	Vendor name	Material name	Company X factory	PO amount	Delivery date	Total PO amount
A	B02115	02-09-20	Phuket fishery company limited	Pro fish mix	Chumphon	662,400.00	04-09-20	910,800.00
	B02118	02-09-20	Phuket fishery company limited	Pro fish mix	Chumphon	248,400.00	04-09-20	
B	B02099	05-10-20	Central farming company limited	Local pork grade B	Sukhothai	454,720.00	10-10-20	985,840.00
	B02108	05-10-20	Central farming company limited	Local pork grade B	Sukhothai	271,920.00	10-10-20	
	B02135	05-10-20	Central farming company limited	Local pork grade B	Sukhothai	259,200.00	10-10-20	
C	B01188	18-11-20	Sawang Budtrang	Concentrated soybean oil	Nakhon Pathom	145,200.00	21-11-20	290,400.00
	B01233	18-11-20	Sawang Budtrang	Concentrated soybean oil	Nakhon Pathom	145,200.00	21-11-20	
D	B02313	19-03-21	JQ Argo sourcing company limited	Wheat feed grade 68	Nakhon Ratchasima	407,040.00	23-03-21	814,080.00
	B02366	19-03-21	JQ Argo sourcing company limited	Wheat feed grade 68	Nakhon Ratchasima	407,040.00	23-03-21	

The above table lists the example of suspicious split POs. Because these POs are created on the same day sent to the same vendor to purchase the same material used for the same location and date. In addition, POs in cases A and B are potentially split to avoid approval from authorised persons at a higher level. For cases C and D, it is obvious that PO amounts are equal. So, there are likely to be duplicate POs. So, the internal auditor should take these results to discuss and confirm with Company X's responsible person whether they are split POs.

P2P-DA20: Identify the POs with a total amount equal to or near the approval limit	**New**

Table 35 is Company X's table of PO approval. One million baht is the first step in dividing the approver between the head of procurement and the managing director. From data analytics, there are 33 POs created with an amount less than 1% from the first ceiling, one million baht. The next approval limit is 5 million baht. However, the maximum gap between the PO amount and the second ceiling is 3%. Table 36 present the examples.

Table 35: Company X's table of authority - PO approver

Material group	**PO < 1 million THB (Head of procurement)**	**PO 1 – 5 million THB (Managing Director)**	**PO > 5 million THB**
1: Grain and oil	Jamie	Samart	Executive committee
2: Protein base			
3: Vitamin, enzymes, and additive			
4: Office supply and overhead			

Table 36: Example of POs with amount near approval limits

PO number	**Mat. group**	**Material name**	**PO amount**	**Preparer**	**Approver**	**Document date**
B01298	1	Soybean grade B	999,200.00	Jira	Jamie	04-02-21
B01740	1	Palm oil	998,000.00	Nithi	Jamie	22-03-21
B01196	1	Wheat mix	997,500.00	Nithi	Jamie	17-07-20
B01175	1	Cassava chip 87	996,000.00	Nithi	Jamie	26-05-21
B01203	1	Rice bran oil – feed grade	995,000.00	Nithi	Jamie	15-07-20
B01661	1	Rice bran oil – feed grade	995,000.00	Nithi	Jamie	25-07-20
B01737	1	Rice bran oil – feed grade	995,000.00	Nithi	Jamie	01-08-20
B01198	1	Rice bran oil – feed grade	995,000.00	Nithi	Jamie	10-08-20
B01477	1	Rice bran oil – feed grade	995,000.00	Nithi	Jamie	20-08-20
B01483	1	Rice bran oil – feed grade	995,000.00	Nithi	Jamie	30-08-20
B01320	1	Soybean oil	4,850,000.00	Nithi	Samart	08-05-20
B01295	1	Local Jasmin rice	4,820,000.00	Nithi	Samart	08-05-20
B01373	1	Cassava starch	4,700,000.00	Nithi	Samart	07-05-20
B01533	1	Local feed corn	4,650,000.00	Nithi	Samart	05-05-20

As can be seen from the table, there are the observations that the above PO amounts are created close to one million baht and five million baht. It can be foreseen that the procurement staff intends to avoid sending the POs to the managing director due to taking a longer time or a problem in reporting line, for instance. However, some PO creations seem usual. Looking at rice bran oil – feed grade, those quantities may result from the maximum quantity of containers per trip, or maximum vendors' production capacity, or just according to the Company X material requirement plan. So, the internal auditor can take the shortlist from data analytics to discuss with Company X's responsible person for clarification. Because these POs may not intend to split according to the approval level.

P2P-DA21: Test the PO approver against the company's table of authority	**Existing**

The author compares 45,471 POs created between 1 July 2020 and 30 June 2021 with the company's table of authority for PO approval. The results of this detection are shown in the following table.

Table 37: Example of unauthorised PO approvers

PO number	Mat. group	Material name	PO amount	Preparer	Approver	Request date	Approval date
B02575	3	Molasses 7Cv	4,600,000.00	Nithi	Jamie	04-01-21	04-01-21
B02577	2	Protein hydrolysates	4,600,000.00	Nithi	Jamie	04-01-21	04-01-21
B03608	3	Optimum vit mix	6,400,000.00	Nithi	Jamie	04-01-21	04-01-21
B03833	3	Zinc integrate 100	4,140,000.00	Nithi	Jamie	04-01-21	04-01-21
B03839	3	Pro enzymes PV1	4,140,000.00	Nithi	Jamie	04-01-21	04-01-21
B01296	1	Local barley 70/30	4,480,000.00	Nithi	Jamie	05-01-21	05-01-21
B01595	1	Local feed corn	7,160,000.00	Nithi	Jamie	05-01-21	05-01-21
B02195	2	Local pork grade B	5,161,267.14	Jira	Jamie	06-01-21	06-01-21
B01292	1	Palm oil	7,200,000.00	Nithi	Samart	20-07-21	20-07-21
B01293	1	Palm oil	5,040,000.00	Nithi	Samart	20-07-21	20-07-21

There are 652 POs approved by unauthorised persons as specified in the table of authority. Similar to P2P-DA9 (Test the PR approver against the company's table of authority), the internal auditor cannot immediately conclude them as findings because of the following potential reasons.

1. For POs value over than one million baht, Mr. Samart may delegate the decision to the head of procurement, Mr. Jamie. Especially in the new year's holiday, the first eight POs show that Jamie is an approver. Therefore, the internal auditor should ask for evidence of delegation of authority from Mr. Samart to make sure that POs are reviewed and approved by authorised person.

2. For POs value over five million baht, they may be approved by Mr. Samart in the ERP before sending the document set for the executive committee's consideration and approval later. If this reason is accurate, the internal auditor should request evidence that PO is approved by the committee as stated in the table of authority.

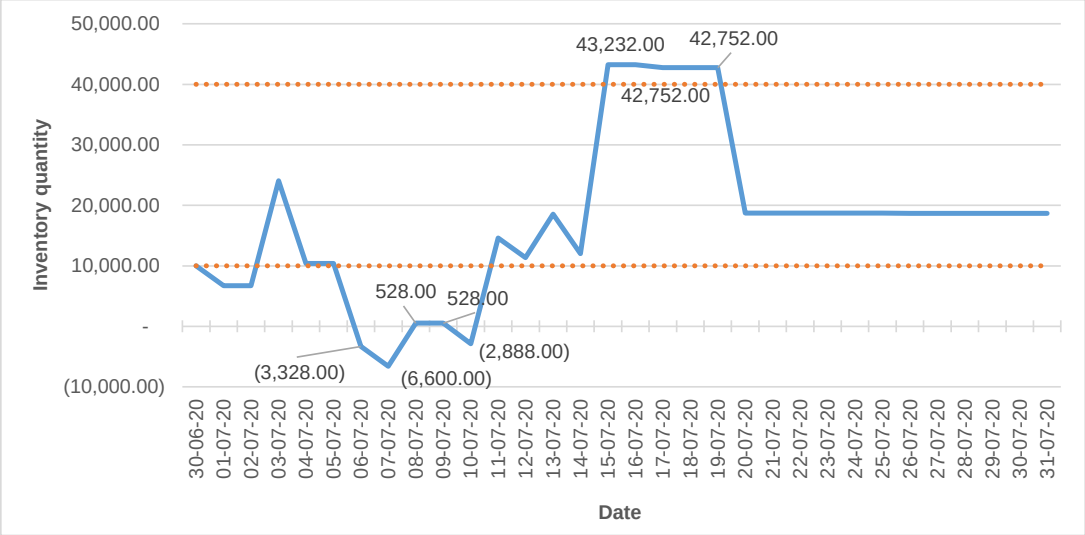
4.3.4 Goods receipts

This section described the effectiveness of six detection rules identified in Section 4.2.4 in detecting the suspicious transactions of Company X's goods receipts process. For the rule numbered P2P-INV-DA2 (Find vendors in the AVL who have scores lower than the company's satisfied level), the testing results are already shown in Section 4.3.2.

INV-DA2: Identify the receipt transactions over than the maximum inventory level and lower than the minimum inventory level	**New**

Company X prepares a min-max report to control inventory levels for each material item. Regarding these detection rules, the inventory levels of the top 3 materials in July 2020 are analysed as follows.

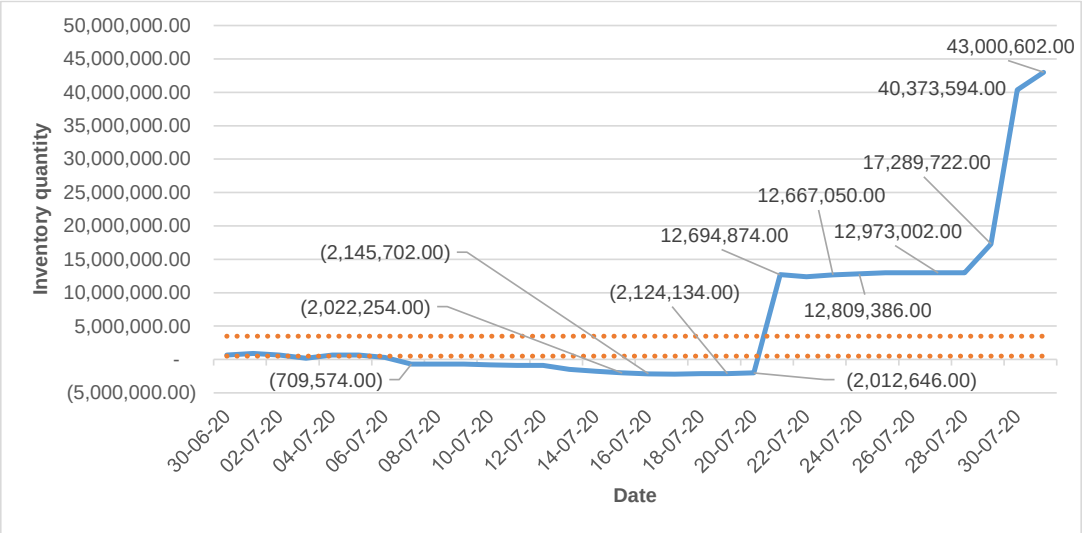
Figure 20: Inventory level of local feed corn in July 2020



According to the above figure, the internal auditor will understand that there are many consecutive days that the feed corns are not enough for production and they are overstock in some periods. The auditor should investigate whether the company performs appropriate action plans to control the inventory level. On 15 July 2020, it should be reviewed whether there is any approval for purchasing

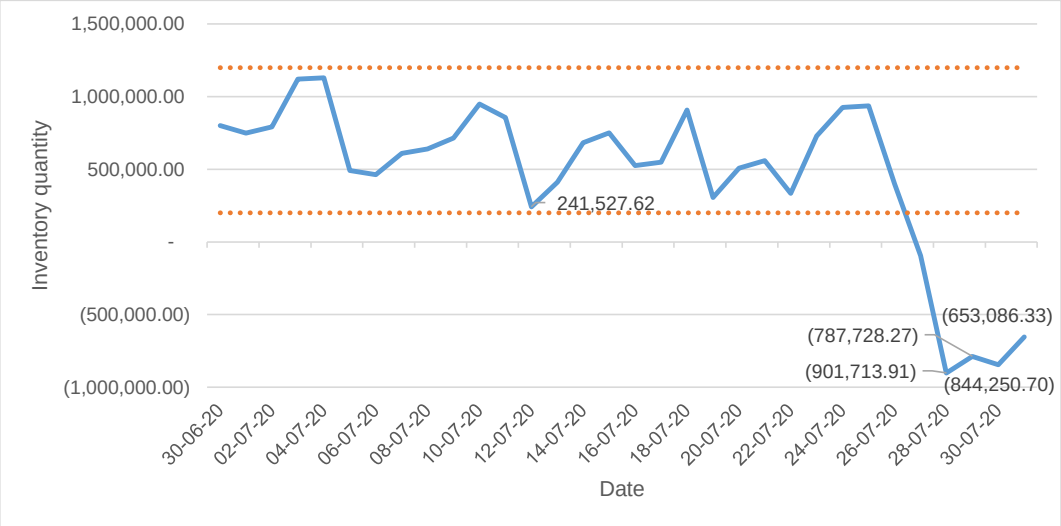
amount greater than the upper limit per the inventory management policy. In addition, since 20 July 2020, it seems that there is no usage from the production. As feed corn is a perishable material, the auditor should review whether the feed corn is appropriately kept in the silo and its quality is monitored.

Figure 21: Inventory level of soybean oil in July 2020



For soybean oil, it can be seen from the graph that Company X normally purchases it in a big lot, on 21 and 30 July 2020 respectively. By doing so, the internal auditor should review the PO and approval from authorised person to purchase over the silos' capacity. The information for PO approval is expected to include management considerations such as seasonal effect, economic of scale benefit from high purchasing amount, or agricultural future exchange transactions. The rancidity is an additional concern for soybean oil. So, an enormous inventory level since 21 July is a big question to ask the responsible person for material management and usage rate per its shelf life.

Figure 22: Inventory level of rice bran in July 2020



For the rice bran, the inventory level is in the control until the last week of July. The insufficient stock for production is a crucial problem that Company X has already set in the inventory management policy. If the out-of-stock is caused by delayed delivery, the incident should be recorded and reflected in the vendor performance evaluation. Or, the out-of-stock is resulted by lacking inventory monitoring or late PO creation, the action plans for this case are expected to be obtained for the internal auditor's investigation.

INV-DA3: Identify goods receipt transactions that are received and approved by the same persons	**New**

The goods receipt approvers are assigned only to the head of the warehouse, Tanawat. From analysing GRNs between 1 July 2020 and 30 June 2021, it is found that all 52,353 receiving transactions are approved by the head of the warehouse. However, it can doubt that does he not take leave throughout the last 12 months? If Tanawat confirms that he has not left during the last 12 months, the internal auditor may recheck his absent report with the human resources department. Or, the warehouse department shares his username and password for goods receiving approvals to his team. Therefore, the internal auditor may observe the operation at the warehouse to obtain more details.

INV-DA4: Identify the closed POs with not fully receive to verify the reasons and supporting documents	**New**

There are 8,145 POs that are closed while the company has not received all goods per ordered quantity as examples in Table 38.

Table 38: The example of GRN quantity less than PO quantity

	PO number	GRN quantity	PO quantity	Diff	% Diff
1	B04167	2,238,302.67	148,800,000.00	(146,561,697.33)	-98%
2	B05842	1,360,000.00	80,240,000.00	(78,880,000.00)	-98%
3	B09279	400,000.00	7,600,000.00	(7,200,000.00)	-95%
4	B06507	44,824.00	96,000.00	(51,176.00)	-53%
5	B66757	45,336.00	96,000.00	(50,664.00)	-53%
6	B08367	47,312.00	83,052.80	(35,740.80)	-43%
7	B08484	49,178.10	80,000.00	(30,821.90)	-39%
8	B04008	172,800.00	241,920.00	(69,120.00)	-29%
9	B04009	16,152.00	20,000.00	(3,848.00)	-19%
10	B00092	22,792.00	24,000.00	(1,208.00)	-5%
11	B08848	23,616.00	24,000.00	(384.00)	-2%
12	B01094	23,648.00	24,000.00	(352.00)	-1%
	…	…	…	…	…
8144	B08400	27,263.19	27,263.20	(0.01)	0%
8145	B07709	27,761.59	27,761.60	(0.01)	0%
	Total	**176,555,709.32**	**423,901,256.00**	**(247,345,546.68)**	**-58%**

It is reasonable that the vendors deliver ordered materials per their Stock Keeping Unit (SKU) which may be a little less than the company's order amount. Or actually, vendors deliver materials per ordered quantity but the goods inspector deducts some weight for dirties and contaminants. Another possible reason is that the user requests to terminate or cancel PO. Hence, for these potential three reasons, the internal auditor should discuss with Company X and review the supporting documents particularly the POs with high different percentages.

INV-DA5: Identify the receipt quantity over than quantity stated in the PO	**New**

There are 241 from 52,353 transactions (0.46%) that Company X receives goods more than the order quantity requested in the PO. These excess receipt transactions need the inventory space which is the limitation of Company X. The example of exceptions from this detection rule is shown below.

Table 39: The example of GRN quantity more that PO quantity

	PO number	GRN quantity	PO quantity	Diff	% Diff
1	B00559	48,000	16,000	32,000	200%
2	B04794	14,400	4,800	9,600	200%
3	B04529	256,000	96,000	160,000	167%
4	B04141	8,800	4,000	4,800	120%
5	B04723	31,077	15,451	15,626	101%
6	B04693	31,034	16,402	14,631	89%
7	B04477	109,174	65,610	43,565	66%
8	B00075	25,744	16,768	8,976	54%
9	B08429	30,456	20,000	10,456	52%
10	B09804	18,068	12,000	6,068	51%
11	B04886	4,800	3,200	1,600	50%
12	B05101	14,400	9,600	4,800	50%
…	…	…	…	…	…
272	B09429	12,008	12,000	8	0.1%
273	B54799	20,013	20,000	13	0.1%
274	B35162	15,208	15,200	8	0.1%
275	B84393	1,800,480	1,800,000	480	0.0%
	Total	**39,794,305**	**38,971,766**	**822,539**	**2.1%**

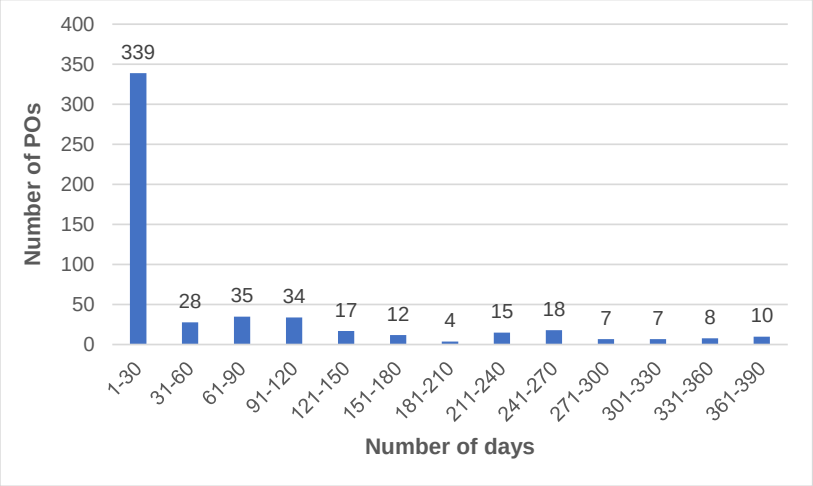
The internal auditor can take the above list especially the line items with a high difference percentage to discuss with the process owner the reasons why the company receives extra material from the user's requirement. Similar to the above detection rules, it is acceptable that the vendors have to deliver materials per their SKU. So that Company X receives the orders greater than the request. If the company responds to the audit team for this reason, the unit conversion for each material item should be obtained to recalculate and recheck whether the procurement staff makes the quantity order appropriately. However, from the above table, the total surplus amount of 2.1% is insignificant from the internal auditor's point of view.

INV-DA6: Analyse the percentage of PO outstanding	**Existing**

As of 30 June 2021, there are 534 POs that the company has not received orders. The deliveries delay from 1 to 374 days. Most delay occurs within 30 days (63% of the total outstanding POs). The internal auditor can highlight POs with a delay of over 6 months to discuss more details. If Company X does not need those orders, the POs should be cancelled in the ERP. If the company still requires that order, the auditor should investigate the cause of the delay and discuss the mitigation plan to reduce recurrent late delivery. Additionally, from the exit meeting with the subject matter expert, it is anticipated that Company X may not establish a guideline to monitor and manage the long outstanding POs. Thus, the internal auditor should confirm with process owners in this issue as well.

Chopra & Sodhi (2004) proposes solutions to avoid the delay; for example, maintaining excess inventory but still balancing with the capacity. This stockpiling inventory is appropriate for commodity products having low inventory holding costs and being able to store for a long time. So, it is practical that Company X increases some of the inventory levels for future uncertainties. Although the graph below shows that PO is outstanding mainly within a month, Figure 12 shows that the company business is expanding. Therefore, building more own warehouses is another recommendation to discuss with Company X's management team. In contrast, similar to the suggestion in P2P-DA2 (Profile list of major vendors (top 10-20) compared with the AVL and analysis of the nature of transactions), SRM is an alternative. Because high inventory increases high cost. SRM encourages both parties to close and frequent communication. So, it improves supply chain visibility resulting in inventory level reduction but decreasing variation in the production plan (CIPS, 2020). Accordingly, the internal auditor should take both different views to discuss with the process owners and management for the company's direction.

Figure 23: Frequency of PO outstanding



INV-DA7:	Identify goods receipt transactions using duplicate GRNs	**New**

From 52,353 GRNs created from 1 July 2020 to 30 June 2021, there is no duplicate GRN number. So, the internal auditor can reasonably ensure that the GRNs are unique.

4.3.5 Invoice processing

There are two detection rules identified for detecting suspicious transactions in invoice processing. The results are shown as follows.

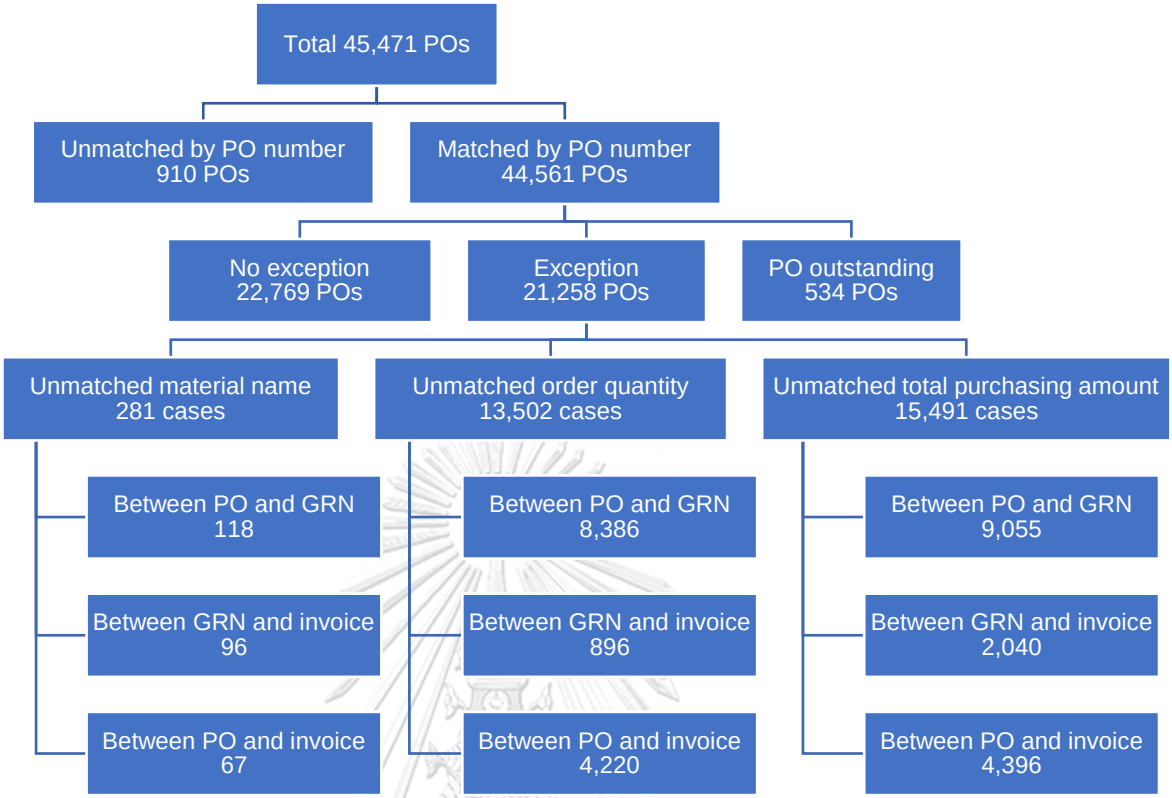
P2P-DA22:	Identify duplicate invoice number	**Existing**

Regarding the list of invoices from 1 July 2020 to 30 June 2021, there is no duplicate invoice number recorded in the ERP. So, the internal auditor ensures that the system control to prevent the repetitive invoice recording is adequately performed.

P2P-INV-DA3:	Match the material name, quantity, and total amount per invoice against those of PO and GRN	**Improved**

The PO, GRN, and invoice files containing transactions from 1 July 2020 to 30 June 2021 are used to test this detection rule. At first, all 45,471 POs are based to match with GRNs and invoices through the PO numbers. It is found that 44,561 POs can link to GRNs and invoices, while 910 POs cannot find GRNs and invoices to match with. Next, for 44,561 POs, they are analysed whether each set of PO, GRN, and invoice has the same material name, order quantity, and total purchasing amount. Data analytics reveal that 22,769 POs have no irregularity, 534 POs are outstanding, and the remaining 21,258 POs have different unmatched cases. That is 281 cases of unmatched material name, 13,502 cases of unmatched order quantity, and 15,491 cases of unmatched total purchasing amount. As some transactions have many exception cases, the total of anomalous cases is higher than 21,258. The summary of the three-way matching scenario is shown below.

Figure 24: The summary of three-way matching scenario



The details of unmatched cases are described in the next pages.

Table 40: The details of exception cases from three-way matching

Exceptions	Number of exceptions	Details and potential causes
Material name		
- PO vs GRN	118	There are 118 POs from 10 material names that are different between PO and GRN. The potential causes are: • The material master data is not up to date for the new material name. • Vendor sends substitute material with similar specifications to the company. • Vendor sends wrong items to the company but the staff agrees to receive them. • The staff crates incorrect GRN.
- GRN vs invoice	96	There are 96 GRNs from 10 material names that are different between GRN and invoices. The potential causes are:

Exceptions	Number of exceptions	Details and potential causes
		• The material master data is not up to date for the new material name. • The staff or vendor crates incorrect documents.
- PO vs invoice	67	There are 67 POs from 10 material names that are different between PO and invoice. The potential causes are: • Vendor sends substitute material with similar specifications to the company. • The material master data is not up to date for the new material name. • Vendor crates wrong invoices.
Order quantity		
- PO vs GRN	8,386	Regarding the detection rule numbered INV-DA4 (Identify the closed POs with not fully received to verify the reasons and supporting documents), 8,145 POs are found. Additionally, according to the rule numbered INV-DA5 (Identify the receipt quantity over than quantity stated in the PO), there are 241 POs detected in this criterion. The different quantity between what Company X orders and what the company receives could result from the following reasons. • PO status, closed or open, is not updated. • For open POs, they are partially received. The remaining items will be delivered next time. • For closed POs: o vendor may deliver materials per their SKU quantity. o the goods inspector may deduct some weight for dirties and contaminants that the vendor delivers to the company. o the user requests to terminate or cancel PO. Therefore, the internal auditor should discuss with the process owners and obtain the relevant documents for review.
- GRN vs invoice	896	There are 95 POs that the company receives goods more than the vendor asks to pay for. In Company X's view, this is low risk. The possible reason is that it is not the due date when the vendor can submit invoices to the company.

Exceptions	Number of exceptions	Details and potential causes
		In contrast, there are 801 POs that the company receives goods less than the amount stated in the invoice. It may result from the following causes: • vendor create wrong invoice quantity • vendor submit invoice before fully delivering goods to the company
- PO vs invoice	4,220	There are 2,836 POs that the ordered quantity is more than the quantity due for payment. The feasible ground is similar to previous causes. For example, they are blanket POs that the company has partially received. On the other hand, there are 1,384 POs that are requested for payment over than quantity that Company X received. Alike per prior case, the vendor may create the wrong invoice quantity or vendor submits invoice before fully delivering goods to the company.
Total purchasing amount		
- PO vs GRN	9,055	As the quantity between PO and GRN is different, the purchasing amount is consequently different. So, the earlier 8,386 items having diverse quantities between PO and GRN should be investigated. That will be the rationale of this case as well. However, the remaining 669 POs are questions to Company X. The subject matter experts anticipate that they are resulted from different prices. For example, the price is set on the delivery date or adjusted later. From experts' experience, many companies negotiate with the vendors to accept the agricultural products with high a percentage of humanity if the vendors agree to have some price reduction. In conclusion, the internal auditor should investigate and discuss with the responsible persons for above possibilities.
- GRN vs invoice	2,040	Similarly, 896 POs that GRN and invoice quantity are different should be investigated as the supporting information

Exceptions	Number of exceptions	Details and potential causes
		for these exceptions. However, there are 1,144 POs that have quantity in GRN equal to the invoice but the purchasing amount is different. So, the price adjustment should be the question to discuss with the process owner.
- PO vs invoice	4,396	After investigating different quantities between PO and invoice, 4,220 out of 4,396 will be known as the cause too. Nevertheless, the remaining 176 POs need to be further investigated. Another possible suggestion by the subject matter experts is that PO contains only material price while vendors include transportation and handling cost in the invoice.
Outstanding PO	534	The details are described in the detection rule numbered INV-DA6 (Analyse the percentage of PO outstanding)

From the above exceptions, the internal auditor should discuss with the responsible person. If Company X responds with expected reasons, the internal auditor should review the supporting documents before deciding whether they are findings. If there is no proper evidence, it should be raised as findings to the management and audit committee.

Because this detection rule is improved from the current one of TH office, Three-way matching by the PO number. So, regarding Figure 24, it is obvious that this ordinary rule discloses only suspicious 910 unmatched POs for investigating. While 44,561 POs having no suspicious transactions are not considered in detail whether their material, order quantity, and purchasing amount are different or not. Therefore, this improved rule enhances audit dimensions.

4.3.6 Payment

In the payment process, there are two detection rules identified in Section 4.2.6. The results of the rules to detect anomalies in the Company X business are explained as follows

P2P-DA23: Identify payment transactions made for the same invoice numbers	**Existing**

In the case that Company X receives an invoice for due payments, the finance staff will create PV with the amount equal to that invoice. In some situations, the company creates many PVs to pay for vendors per payment period as agreed. So, for this case, the total amount of PVs is less than an invoice amount. However, as of a specific date, the total amount of PVs must not be greater than the invoice amount. In other words, the company will not pay more than the amount of due invoices. Regarding these criteria, the below table lists suspicious PVs created for individual invoices for further investigation as follows.

Table 41: Duplicate payment voucher creation for an invoice

	PV number	Entry date	PV amount	Invoice number	Invoice amount	Different
1	202000518	16-08-20	5,204.80	0005467	5,204.80	5,204.80
2	202000520	16-08-20	5,204.80			
3	202100841	24-01-21	7,500.00	2021A942	75,000.00	7,500.00
4	202101065	31-01-21	75,000.00			
5	202103989	12-05-20	116,680.20	008997333	116,680.20	233,360.40
6	202103998	12-05-20	116,680.20			
7	202104298	29-05-20	116,680.20			

From this detection rule, there are seven PVs that the internal auditor should discuss with Company X's process owner for more information. The first two PVs were created on the same day and the same amount for the same invoice. So, it is potential that the finance staff creates duplicate PV. For the third PV, it is anticipated that the PV amount is incorrect. But it has not been cancelled after creating the correct one. For the last three PVs, there are excess PV creation for an invoice.

P2P-DA24: Identify payment transactions made for wrong vendors	**New**

The invoice number is the key reference between the list of PVs and invoices to detect the transactions paid to the wrong vendors.

Table 42: Suspicious PVs creating to wrong vendors

	Invoice number	**PV number**	**Reference from PV**		**Reference from invoice**	
			Vendor number	**Vendor name**	**Vendor number**	**Vendor name**
1	00853984	202000677	2000981	Not in AVL	2000987	Pro plant company limited
2	01/UR-SE/21	202000993	2000664	Not in AVL	2000305	Smart cattle and poultry corporation
3	NOE2020-233	202000342	2000222	Not in AVL	2000625	Oliver ingredient PTE
4	86600909	202100343	2000298	Not in AVL	2000011	Lacta industry supply company limited
5	IS40833320	202100345	2000842	Gold feed elementary company limited	2000998	Agri workgroup company limited
6	GE-556w-4708	202100346	2000980	Better agricultural company limited	2000577	Poultry innotech company limited
7	989839033	202100347	2000073	Not in AVL	2000845	Siam cooperative

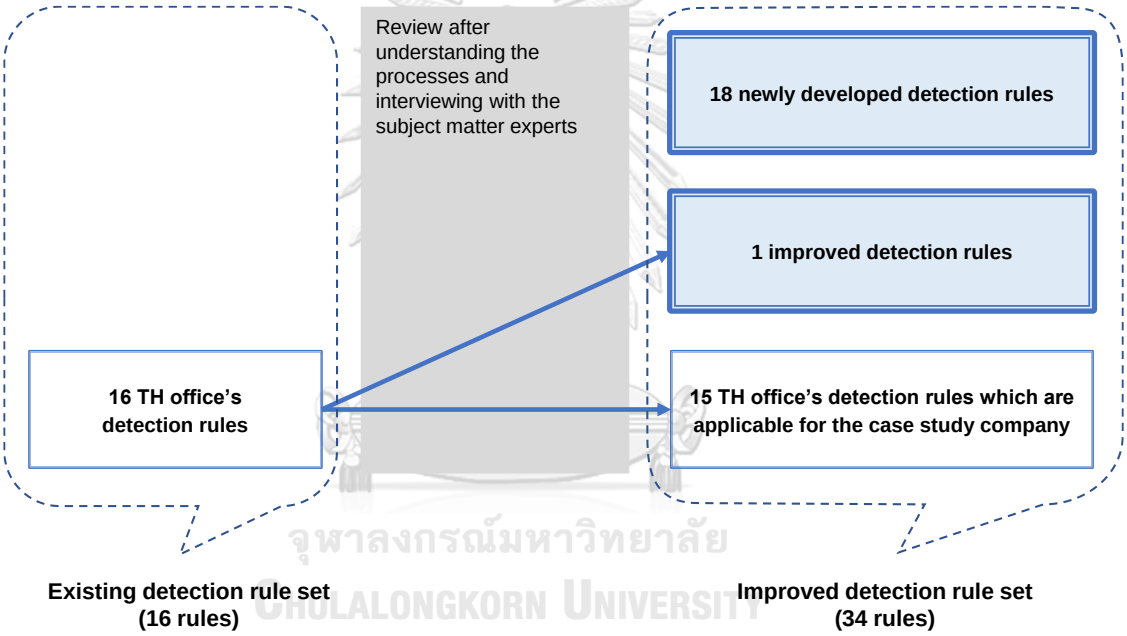
According to the above table, seven PVs are suspected that they are created to the wrong vendors. For first to fourth PVs, vendors indicated in the PVs are not listed in the AVL and they are also different from those specified in the invoices. For the last three PVs, it is known from the detection rules numbered P2P-DA4 (Identify vendors in the PO who are not in the AVL) that those vendors in the invoices are not in the AVL. Moreover, the PVs are not created for them. From these results, the internal auditor should raise them as findings to confirm with the responsible person and find out the root causes.

CHAPTER 5
DISCUSSION AND CONCLUSION

5.1 The discussion of detection rules results

Having reviewed the 16 existing rules of the TH office, an improved rule and additional 18 rules were identified to complete reviewing the P2P and inbound inventory processes. All of the 34 detection rules called "**Improved detection rule set**" were tested their effectiveness with the case study company. Figure 25 shows the overview of detection rules improvement

Figure 25: The summary of detection rules improvement

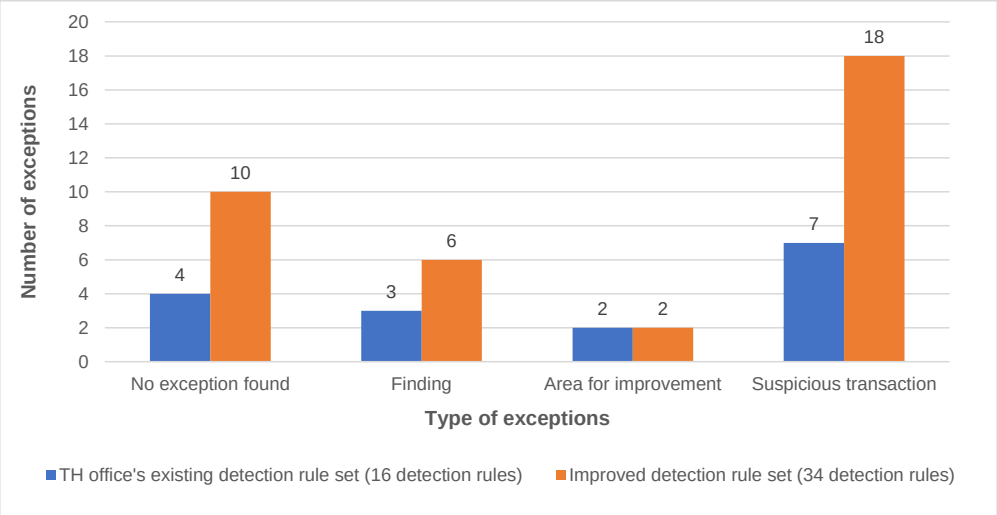


Because developed rules are identified to complete auditing key risks and controls in the P2P and inbound inventory processes. In other words, they are additionally defined to spot irregularities over the processes that the current rules miss. Therefore, the effectiveness testing results of the existing detection rule set (16 rules) are compared with those of the improved detection rule set (34 rules).

The results indicate that the improved detection rule set can discover more findings and suspicious transactions than the 15 primary TH office's rules. That is, the number of findings significantly adds up by 100% while 157% for suspicious transactions. No additional areas for improvement are found by the new rule set. Lastly, no exception is increasingly found by the developed rule set, 150% from the original rules. Although no exception is raised, these improved rules enhance the assurance level for the internal auditor. Figure 26 illustrates the results. However, from Section 4.3.1 and

4.3.2, the rule numbered P2P-INV-DA1 (Identify the transactions which the same person operates both roles) and P2P-DA6 (Test duplicate information in the vendor master file such as vendor number, vendor name, bank account number, and address) can discover both finding and suspicious transactions in Company X. So, the total of exceptions shown in Figure 26 is higher than 16 and 34 rules for blue and orange bars.

Figure 26: Comparison of effectiveness of existing and new improved detection rules



Regarding the results, there are two main rationales why the improved detection rules can increase the effectiveness of detecting irregularities in the case study company. Firstly, the new rules are identified from different points of view across the P2P and inbound inventory processes. Regarding the process governance, the data overview from a new rule numbered INV-DA1 enhances the view of the inbound inventory process which continues from the procurement of the current rules. The rule numbered P2P-INV-DA1 examines the segregation of duties throughout the processes that support several present rules in the remaining sub-processes. P2P-DA3 and P2P-INV-DA2 are added to ensure vendor qualification which is another aspect of vendor selection, evaluation, and master data maintenance processes. The updated rule numbered P2P-DA11 discovers differences between PR and PO which is a missing joint in the ordering processes. Lastly, the rule numbered P2P-INV-DA3 extends the ordinally 3-way matching from only matching the document numbers to compare the material name, quantity, and price which is the purpose of these processes.

Secondly, the new rules support the existing rules in achieving the TH office's auditing objectives. For instance, many developed rules in the ordering process are specified from various scenarios to ensure that the company makes the **right order**. For example, long PO creation (P2P-DA13), missing details in the POs (P2P-DA15), PO created in non-business days (P2P-DA16), different PO prices referring to the contract (P2P-DA17), duplicate POs (P2P-DA18), and split POs (P2P-DA19 and

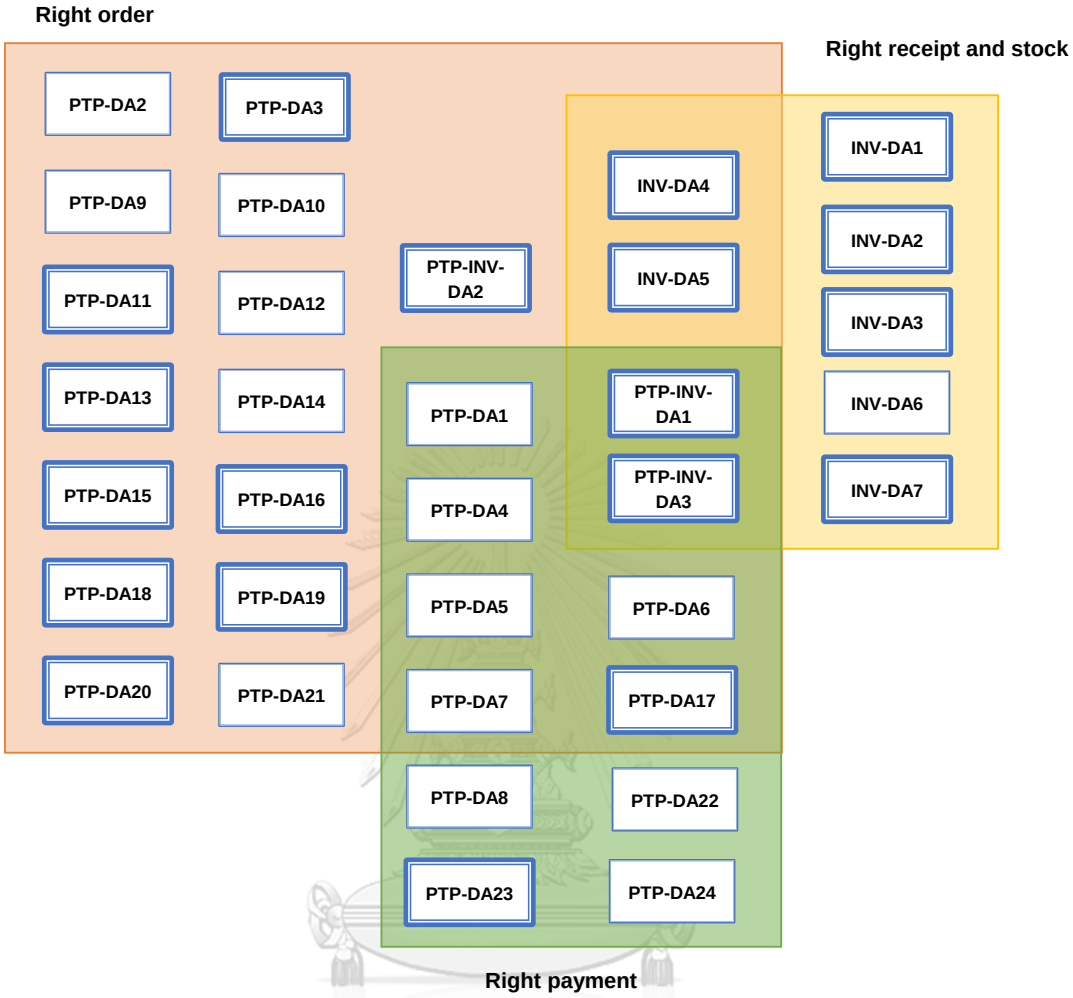
20). Compared with those of the TH office, the rules are focused on the appropriate authorised person, sending unapproved POs to the vendors, or not creating PO for ordering.

The additional detection rules are established for the goods receipt process to complete the purpose of **right receipts and stock**. That is, the original rule is to monitor and follow up on the outstanding POs. The five new rules are completing the dimension of goods receipt against the inventory levels (INV-DA2), receipt authority (INV-DA3), different quantity of receiving and ordering (INV-DA4 and 5), and duplicate receipts (INV-DA7).

For **right payment**, the rule numbered P2P-DA24 increases the assurance level. That is, in addition to the correct payment amount from the current rule, the new rule ensures that the payments are made for the right vendors.

The group of detection rules divided by the process objectives are shown in the figure below. A detection rule can serve many purposes which are marked in the interception areas. The double frame boxes represent the newly identified rules. The existing rule numbers are input in the single frame boxes.

Figure 27: The group of detection rules divided by the process objectives



The list of 34 detection rules together with its objectives and effectiveness testing results are summarised in the following table.

Table 43: List of detection rules tested effectiveness in anomaly detection

Detection rules		Status of rules	Objectives			Effectiveness testing results			
						No exception found	Exception found		
			Right order	Right receipt and stock	Right payment		Finding	Areas for improvement	Suspicious transaction
Process governance									
P2P-DA1:	Profile list of purchasing transactions by period, procurement staff, and material types, etc.	**Existing**	☑		☑	☑			
P2P-DA2:	Profile list of major vendors (top 10-20) compared with the AVL and analysis of the nature of transactions	**Existing**	☑					☑	
INV-DA1:	Profile list of inventory transactions by type of inventory, major inventories, locations, and amounts	**New**		☑		☑			
P2P-INV-DA1:	Identify the transactions which the same person operates both roles	**New**	☑	☑	☑		☑		☑
Vendor selection, evaluation, and master data maintenance									
P2P-DA3:	Identify new vendors having scores below the selection criteria	**New**	☑			☑			
P2P-DA4:	Identify vendors in the PO who are not in the AVL	**Existing**	☑		☑				☑
P2P-DA5:	Identify shared information between vendor master data and employee master data such as surname,	**Existing**	☑		☑	☑			

Detection rules		Status of rules	Objectives			Effectiveness testing results			
						No exception found	Exception found		
			Right order	Right receipt and stock	Right payment		Finding	Areas for improvement	Suspicious transaction
	telephone number, bank account number, and address								
P2P-DA6:	Test duplicate information in the vendor master file such as vendor number, vendor name, bank account number, and address	**Existing**	☑		☑		☑		☑
P2P-DA7:	Test the completeness of the vendor master file and identify the missing details	**Existing**	☑		☑		☑		
P2P-DA8:	Identify the vendor master data which is inconsistent with the company's policy such as too short company payment term	**Existing**			☑	☑			
P2P-INV-DA2:	Find vendors in the AVL who have score lower than company's satisfied level	**New**	☑			☑			
Ordering									
P2P-DA9:	Review the PR approver against the company's table of authority	**Existing**	☑						☑
P2P-DA10:	Identify the PRs that are requested and approved by the same person	**Existing**	☑						☑
P2P-DA11:	Identify the PO which cannot match with the PR	**New**	☑						☑

Detection rules		Status of rules	Objectives			Effectiveness testing results			
						No exception found	Exception found		
			Right order	Right receipt and stock	Right payment		Finding	Areas for improvement	Suspicious transaction
P2P-DA12:	Identify the invoices which cannot match with the PO	**Existing**	☑						☑
P2P-DA13:	Identify the PO which are created longer than specific target days from PR	**New**	☑				☑		
P2P-DA14:	Identify the POs which are approved after the invoice date	**Existing**	☑				☑		
P2P-DA15:	Identify POs missing some information	**New**	☑			☑			
P2P-DA16:	Identify POs created in the weekend	**New**	☑						☑
P2P-DA17:	Test that prices of items listed in the contracts or blanket POs are equal to those recorded in the price master file.	**New**	☑		☑				☑
P2P-DA18:	Identify POs having the same running number	**New**	☑			☑			
P2P-DA19:	Identify the repetitive requested materials in the POs which created in the same day or in the certain period and sent to the same or different vendors	**New**	☑						☑
P2P-DA20:	Identify the POs with total amount equal or almost the approval limit	**New**	☑						☑

Detection rules		Status of rules	Objectives			Effectiveness testing results			
						No exception found	Exception found		
			Right order	Right receipt and stock	Right payment		Finding	Areas for improvement	Suspicious transaction
P2P-DA21:	Test the PO approver against the company's table of authority	**Existing**	☑						☑
Goods receipt									
INV-DA2:	Identify the receipt transactions over than the maximum inventory level and lower than the minimum inventory level	**New**		☑					☑
INV-DA3:	Identify goods receipt transactions which are received and approved by the same persons	**New**		☑					☑
INV-DA4:	Identify the closed POs with not fully receive to verify the reasons and supporting documents	**New**	☑	☑					☑
INV-DA5:	Identify the receipt quantity over than quantity stated in the PO	**New**	☑	☑					☑
INV-DA6:	Analyse the percentage of PO outstanding	**Existing**		☑				☑	
INV-DA7:	Identify goods receipt transactions using duplicate GRNs	**New**		☑		☑			
Invoice processing									
P2P-DA22:	Identify duplicate invoice number	**Existing**			☑	☑			
-	Three-way matching by the PO number	**Original**	☑						☑

Detection rules		Status of rules	Objectives			Effectiveness testing results			
						No exception found	Exception found		
			Right order	Right receipt and stock	Right payment		Finding	Areas for improvement	Suspicious transaction
	(The original rule of TH office which is not applicable for Company X)								
P2P-INV-DA3:	Match the material name, quantity, and total amount per invoice against those of PO and GRN *(Improved rule from "Three-way matching by the PO number" of the TH office)*	**Improved**	☑	☑	☑				☑
Payment									
P2P-DA23:	Identify payment transactions made for the same invoice numbers	**Existing**			☑				☑
P2P-DA24:	Identify payment transactions made for wrong vendors	**New**			☑		☑		

5.2 Limitation of data analytics

Even though data analytics provides benefits to internal audit activities, it cannot be applied in all audit testing. Particularly, data is written on the documents and other kinds of hard copy formats. If there are lots of transactions recorded in the set of papers, the sampling test approach is still proper. The poor quality of data is also inadequate for analysed. In other words, data availability is a vital element for data analytics (Deloitte, 2019; Tachasinkul & Panyasakorn, 2021). Furthermore, as large data sets are requested for effective data analytics, the challenges are sufficient data storage and speed of data processing. If the company needs third parties' resources to do so, there may be data privacy and data security issues instead (IAASB, 2016).

Regarding Chartered IIA (2017), the whole population testing cannot give 100% assurance. Because after the anomalies are identified from using the data analytics tools, the internal auditors need to examine whether they are findings or not. So, as data analytics is still needed judgement from humans, mistakes can be taken place. Wang & Cuthbertson (2015) states that the most significant stage in applying data analytics in internal auditing is to interpret the results from the rule bases. This step consumes a lot of time. Nevertheless, different results formats or visualisation affect the auditor's interpretation. Dilla & Raschke (2015) exemplify that interactive data visualisation allows the investigator to detect frauds effectively and efficiently. On the one hand, Dilla & Raschke (2015) state that the traditional sampling test method cannot detect fraudulent transactions which are deliberately prepared. While those irregularities are discovered by data analytics technique. On the other hand, the subject matter experts argue that if fraudulent schemes are completely executed throughout the supply chain, it is difficult that detection rules can spotlight these wrongdoings.

Internal auditor competency is another concern. Complex data files require skilled staff or data science to work on. Insufficient ERP knowledge and training curriculums provided for staff result in inaccurate transaction processing. So, the company needs to improve the training curriculum focusing on data and technology for staff (Deloitte, 2019; IAASB, 2016).

5.3 Conclusion

As today's businesses generate big data, the traditional sampling test is not an effective approach to discover anomalies in the business processes. Therefore, data analytics in the internal audit utilises the capability of technology to reveal the irregularities and provide recommendations for control weaknesses. Having reviewed 16 existing rules of the TH office through interviews and research, 15 out of 16 detection rules needed no adjustment as they applied to Company X as a case study company. A remaining rule was improved by extending the dimensions to detect anomalies. Furthermore, additional 18 rules are identified to complete some key risks and controls in the P2P and inbound inventory

processes. The results of effectiveness testing demonstrate that all of 34 improved detection rules discovered more findings and suspicious transactions for further investigation than the original 16 rules, with a 100% and 157% increase respectively. However, the improved rules found no additional area for improvement. They also found no exception by a 150% increase from the original ones. Because the improved rules were identified from different points of view across the processes with the purpose to achieve the TH office's auditing objectives, they effectively discovered irregularities in the case study company.

Similar to Singh et al. (2017) and Changchit & Holsapple (2004), the results of this project also evidently demonstrate that data analytics with the detection rules is an effective and efficient approach compared with the sample testing method. Because it reduces auditing time as the internal auditors spend time to further investigate only flagged transactions. Moreover, it increases the confidentiality level for both internal auditors and clients through testing all or larger transactions than the small sample size. In other words, working on large data increases the opportunity to detect more issues.

However, the results of detection rules are still needed judgement from experienced internal auditors which is a cause of the mistake. Data availability is the main obstruction of this method. In addition, there are issues of data privacy, data security, required skills, and technical problems that the internal auditors should consider. Lastly, although working on the population data, the data analytics cannot reveal all of the anomalies if they are deliberately prepared. These detection rules need to review and improve according to the more dynamic and complex operations also developed schemes from the perpetrators.

These 34 detection rules will be presented to the TH office as improved detection rules to provide internal audit services in the P2P and inbound inventory processes, especially for manufacturing sectors. These rules will help the TH office detect more problems in the client's operations. Besides, it saves audit fieldwork periods which leads to lower professional fee costs to clients. It is expected that this project methodology will be the guideline for the TH office to develop detection rules in other business processes and industries in the future. Because of the anonymous data set generated in this project, the results of the effectiveness test can be presented to potential clients in the proposal process. Eventually, the TH office will deliver value-added work products and strengthen the market positioning.

5.4 Future work

This project focuses on improving the detection rules in the P2P and inbound inventory processes. So, across the supply chain, the future development is to enhance the scope of other business processes. For instance, sales, production, outbound inventory, logistics, human resource management, fixed asset, and financial reporting. In addition, this project concentrates on the manufacturing business. Therefore, there are opportunities to improve the detection rules for other industries. For example,

healthcare, telecommunication, transportation, public services, financial services, and energy. Even in the manufacturing business, there are other kinds of products to work in the future such as automotive and consumer products which have different contexts from animal feed production.

In addition to excel spreadsheets, the various data management and visualisation tools which are capable to proceed with big data can be used to improve and test the detection rules in more complex areas. Examples of the tools are Microsoft Access, Microsoft Power BI, ACL, IDEA, Tableau, and Alteryx. However, the spreadsheet is widely used as a data analytics tool (Lambrechts et al., 2011). So, the future work can be developing the worksheet for the user to input the data. Then the exceptions are automatically identified according to the rules formulated in that sheet. This will encourage the users to monitor suspicious transactions in responsible areas themselves. Alternatively, it lets the internal auditors work on the data to increase the value of the internal audit report.

Lastly, because this project uses historical data to test the effectiveness of improved detection rules. The exceptions found from the rules are what occurs in the past. So, to detect the anomalies for taking action promptly, there is the opportunity to embed the rules in the programme linking to the ERP. These real-time analytics enable the company to make better decisions and be proactive to respond the situations (Gartner, 2021).

REFERENCES

Alessa. (2020). Rules-based Vs. Advanced Analytics – Do You Have to Choose? Available from: https://tier1fin.com/alessa/blog/rules-based-vs-advanced-analytics/ [Accessed 11 December 2021].

Anderson, U., Head, M., Ramamoorti, S., Riddle, C., Salamasick, M. & Sobel, P. (2017) *Internal Auditing: Assurance & Advisory Services*. 4th ed. Institute of Internal Auditors Research Foundation.

Baumann, M. (2021) Improving a Rule-based Fraud Detection System with Classification Based on Association Rule Mining. [Preprint] Available from: doi: 10.13140/RG.2.2.29906.68808.

Berg, J., Van, D., Roskott, B. & Heck, G. & Davarynejad, M. (2013) Inventory Management, a Decision Support Framework to Improve Operational Perfomance. *Organizational Integration of Enterprise Systems and Resources: Advancements and Applications*. 268-288. Available from: doi: 10.4018/978-1-4666-1764-3.ch015.

Carvel, L. (2021) *SAP Inventory Management Tutorial for First-Timers.* Available from: https://blogs.sap.com/2021/12/02/sap-inventory-management-tutorial-for-first-timers/ [Accessed 4 December 2021].

Cascarino, R. (2017) *Data Analytics for Internal Auditors*. New York, Auerbach Publications.

Changchit, C. & Holsapple, C., W. (2004) The development of an expert system for managerial evaluation of internal controls. *Intelligent Systems in Accounting, Finance and Management*. 12. 103-120. Available from: doi:10.1002/isaf.246.

Chartered Institute of Internal Auditors (Chartered IIA). (2017) *Data analytics - Is it time to take the first step?* Available from: https://chapters.theiia.org/montreal/ChapterDocuments/Data%20Analytics%20Is%20it%20time%20to%20take%20the%20first%20step.pdf [Accessed 10 April 2021].

Chartered Institute of Internal Auditors (Chartered IIA). (2021a) *Control - Information guidance*. Available from: https://www.iia.org.uk/resources/control/ [Accessed 4 December 2021].

Chartered Institute of Internal Auditors (Chartered IIA). (2021b) *What is internal audit?* Available from: https://www.iia.org.uk/about-us/what-is-internal-audit/ [Accessed 30 April 2021].

Chartered Institute of Procurement & Supply (CIPS). (2012) *Supply Chain Risk Management (SCRM) - Key Procurement Topic*. Available from: https://training.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/3-Risk-Mitigation/Risk-Analysis-and-Management/1/Supply_Chain_Risk_Management.pdf [Accessed 16 August 2021].

Chartered Institute of Procurement & Supply (CIPS). (2020) *Supplier Relationship Management - SRM.* Available from: https://training.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/Members-only-content/Supplier%20Relationship%20Management%20-%20SRM.pdf [Accessed 12 December 2021].

Chartered Institute of Procurement & Supply (CIPS). (2021) *Importance of Procurement.* Available from: https://www.cips.org/employers/insights/why-procurement-matters/ [Accessed 7 September 2021].

Chopra, S. & Sodhi, M. S. (2004) Managing Risk to Avoid Supply-Chain Breakdown. *MITSloan Management Review*. 46(1), 53-62.

Committee of Sponsoring Organizations of the Treadway Commission (COSO). (2012) *Risk assessment in practice.* Available from: https://www.coso.org/Documents/COSO-ERM%20Risk%20Assessment%20in%20Practice%20Thought%20Paper%20October%202012.pdf [Accessed 5 December 2021].

Committee of Sponsoring Organizations of the Treadway Commission (COSO). (2013) *Internal Control - Integrated Framework.* Available from: https://www.coso.org/pages/ic.aspx [Accessed 30 August 2021].

Committee of Sponsoring Organizations of the Treadway Commission (COSO). (2017) *Enterprise Risk Management—Integrating with Strategy and Performance*. Available from: https://www.coso.org/pages/erm.aspx [Accessed 30 August 2021].

Dalimunthe, R. (2019) Understanding the types of data in a business/organization. Available from: https://towardsdatascience.com/understanding-the-types-of-data-in-a-business-organization-67d7cb9914bd [Accessed 31 August 2021].

Deloitte. (2019) *Procure to Pay analytics*. Available from: https://www2.deloitte.com/content/dam/Deloitte/in/Documents/risk/in-ra-procure-to-pay-analytics-noexp.pdf [Accessed 29 August 2021].

Deloitte. (2021) *Internal Audit Services – Assure. Advise. Anticipate*. Available from: https://www2.deloitte.com/us/en/pages/risk/solutions/internal-audit-transformation.html [Accessed 12 April 2021].

Dilla, W. N. & Raschke, R. L. (2015) Data visualization for fraud detection: Practice implications and a call for future research. *International Journal of Accounting Information Systems*. 16, 1-16.

European Confederation of Institutes of Internal Auditing (ECIIA). (2021) *Risk in Focus 2021: hot topics for internal auditors.* Available from: https://www.eciia.eu/2020/09/risk-in-focus-2021-hot-topics-for-internal-auditors/ [Accessed 5 December 2021].

EY. (2021) *How internal audit is helping organisations build trust*. Available from: https://www.ey.com/en_gl/consulting/how-internal-audit-is-helping-organizations-build-trust [Accessed 12 April 2021].

Gartner. (2021) *Real-time Analytics*. Available from: https://www.gartner.com/en/information-technology/glossary/real-time-analytics [Accessed 4 September 2021].

Gepp, A., Linnenluecke, M. K., O'Neill, T. & Smith, T. (2018) Big Data Techniques in Auditing Research and Practice: Current Trends and Future Opportunities. *Journal of Accounting Literature*. 40. 102-115.

Gollapinni, O. (2019) *SAP MM – Purchasing Flow in a Nutshell*. Available from: https://blogs.sap.com/2019/04/10/sap-mm-purchasing-flow-in-a-nutshell/ [Accessed 30 August 2021].

Guile, P. (2012) Tightening the chain on fraud. *Finance & Management Magazine*. 202, 14-16.

Harper, M. (2020) *What Are Key Business Processes?* Available from: https://www.apqc.org/blog/what-are-key-business-processes [Accessed 7 September 2021].

International Auditing and Assurance Standards Board (IAASB). (2016) *Exploring the Growing Use of Technology in the Audit, with a Focus on Data Analytics*. Available from: https://www.ifac.org/system/files/publications/files/IAASB-Data-Analytics-WG-Publication-Aug-25-2016-for-comms-9.1.16.pdf [Accessed 16 March 2021].

International Organization for Standardization (ISO). (2021) *IBAN REGISTRY: This registry provides detailed information about all ISO 13616-compliant national IBAN formats*. Available from: https://www.swift.com/resource/iban-registry-pdf [Accessed 19 August 2021].

KPMG. (2018) *Internal Audit, Risk and Compliance - Internal Audit Sourcing*. Available from: https://home.kpmg/ca/en/home/insights/2018/02/internal-audit-risk-and-compliance.html#:~:text=KPMG's%20Internal%20Audit%20Methodology%20(IAM,impediments%20to%20achieving%20those%20objectives. [Accessed 12 April 2021].

Lambrechts, A. J., Lourens, J. E., Millar, P. B. & Sparks, D. E. (2011) *Global Technology Audit Guide - Data Analysis Technologies.* Available from: https://www.iia.nl/SiteFiles/IIA_leden/GTAG%2016%20Data%20Analysis%20Technologies.pdf [Accessed 3 September 2021].

McGilvray, D. (2009) MIT Information Quality Industry Symposium, In: Granite Falls Consulting, Inc. *Ten Steps to Quality Data and Trusted Information,* 15 July 2009, Cambridge, Massachusetts. 1-19.

Mishler, C. (2016) Data Analytics for Internal Auditors - Getting Started and Beyond, In: Experis Finance and The Institute of Internal Auditors Detroit Chapter (eds.) *Data analytics*. 23 February 2021, Detroit. United States. 1-51.

Monczka R. M., Handfield, R. B., Giunipero, L. C. & Patterson J. L. (2014) *Purchasing and Supply Chain Management*. 6th ed. United States of America, Cengage Learning.

PwC. (2016) *Turning the corner Advancing the use of analytics within internal audit*. Available from: https://www.pwc.ru/ru/publications/advancing-in-analytics-eng-2017.pdf [Accessed 14 April 2021].

PwC. (2021) *The PwC Internal Audit – Internal audit. Expect more.* Available from: https://www.pwc.com/gx/en/services/audit-assurance/internal-audit/audit-services.html [Accessed 12 April 2021].

Rendon, R. G. & Garrett, G. A. (2005) Contract management. *Managing Contracts in Turbulent Times: The Contract Management Maturity Model.* 48-57.

Singh, N., Cheng, E. & Lai, K.-H. (2017). A data analytics - based approach to auditing. *Internal Auditing*, (July/August), 1–9.

Tachasinkul, A. & Panyasakorn, T. (2021) Data analytics for internal auditor, In: PwC Thailand and Wolters Kluwer TeamMate Asia Pacific (eds.) *Data analytics for internal audit: Are you underestimating its benefits and overestimating its complexity*? 17 August 2021, Bangkok. Thailand. 6-14.

Tan, L. H. (2013) *An analysis of internal controls and procurement fraud deterrence*. Naval Postgraduate School. Available from: https://core.ac.uk/download/pdf/36731405.pdf [Accessed 14 August 2021].

The Institute of Internal Auditors – Australia (IIA - Australia). (2020) *White paper - A conceptual framework for effective audit analytics*. Available from: https://iia.org.au/sf_docs/default-source/technical-resources/2018-whitepapers/iia-whitepaper_a-conceptual-framework-for-effective-audit-analytics.pdf?sfvrsn=2 [Accessed 14 April 2021].

The Institute of Internal Auditors (IIA). (2011) *About FAQ: Is it mandatory to have an internal audit activity?* Available from: https://global.theiia.org/about/about-internal-auditing/_layouts/mobile/dispform.aspx?List=2775e335%2D7dae%2D41e3%2Dac49%2Dbe4dbe45c804&View=cc3a7887%2D16e8%2D45f6%2D891b%2D8730c4dc771c&ID=5#:~:text=Title%3A%20Is%20it%20mandatory%20to%20have%20an%20internal%20audit%20activity%3F&text=Although%20private%20companies%20%E2%80%94%20those%20not,its%20core%20organizational%20governance%20elements. [Accessed 10 April 2021].

The Institute of Internal Auditors (IIA). (2012) *Developing the Internal Audit Strategic Plan*. Available from: https://www.iia.nl/SiteFiles/IIA_leden/Praktijkgidsen/PG%20Developing%20the%20Internal%20Audit%20Strategic%20Plan%5B1%5D.pdf [Accessed 10 April 2021].

The Institute of Internal Auditors (IIA). (2017) *International standards for the professional practice of internal auditing (standards)*. Available from: https://na.theiia.org/standards-guidance/Public%20Documents/IPPF-Standards-2017.pdf [Accessed 16 March 2021].

The Institute of Internal Auditors (IIA). (2020) *The IIA's three lines model: An update of the three lines of defense*. Available from: https://global.theiia.org/about/about-internal-auditing/Public%20Documents/Three-Lines-Model-Updated.pdf [Accessed 4 April 2021].

The Institute of Internal Auditors (IIA). (2021) *Definition of Internal Auditing.* Available from: https://na.theiia.org/standards-guidance/mandatory-guidance/Pages/Definition-of-Internal-Auditing.aspx [Accessed 4 April 2021].

The Louisville Chapter of the Institute of Internal Auditors (Louisville Chapter). (2016) *Procurement process business risks and controls*. Available from: https://chapters.theiia.org/louisville/News/ChapterDocuments/Forms/AllItems.aspx?Paged=TRUE&p_SortBehavior=0&p_FileLeafRef=Politics%2dof%2dInternal%2dAuditing%2dFlyer%2epdf&p_ID=2&PageFirstRow=31&&View={1F785358-9713-436B-8CD2-8B8EF2AA3A6A} [Accessed 16 August 2021].

The Stock Exchange of Thailand. (2021) *Common Shares Listing Admission – Companies dealing in general business.* Available from: https://www.set.or.th/en/regulations/simplified_regulations/common_shares_p1.html [Accessed 12 April 2021].

Thorps, D. (2019) *5 missteps to avoid when evaluating internal controls*. Available from: https://www.journalofaccountancy.com/issues/2019/jul/evaluating-internal-control.html [Accessed 1 September 2021].

Wild, T. (2017) *Best Practice in Inventory Management*. 3rd ed. London, Routledge. Available from: https://doi.org/10.4324/9781315231532 [Accessed 23 September 2021].

United Nations Global Compact (UNGC). (2013) *A Guide for Anti-Corruption Risk Assessment.* Available from: https://www.unglobalcompact.org/library/411 [Accessed 22 August 2021].

Wang, T. & Cuthbertson, R. (2015) Eight Issues on Audit Data Analytics We Would Like Researched. *Journal of Information Systems.* 29(1), 155-162. Available from: doi:10.2308/isys-50955

APPENDIX

Appendix A Ethical approval confirmation

Ethical Approval Confirmation (Overseas Programmes)

wmg-overseas@warwick.ac.uk <wmg-overseas@warwick.ac.uk>

Thu 8/5/2021 10:13 PM

To: RANGSIPUNYAPORN, PENPAK (PGT) <Penpak.Rangsipunyaporn@warwick.ac.uk>
Cc: cuse.chula@gmail.com <cuse.chula@gmail.com>; chuvej@gmail.com <chuvej@gmail.com>

Ethical Approval Confirmation

Dear Miss Rangsipunyaporn,

Warwick ID Number: 1943429

Thank you for submitting your Supervisor's Delegated Approval form to the WMG Overseas Programmes Course Office for the project: An improvement of data analytics detection rules in the internal audit of the procurement and inbound inventory processes.

Your reference number is REGO-2021-WMGOS-0118.

You now have the appropriate approval in place to begin your data collection. It is advisable to note the actual dates of data collection in the final dissertation methodology or results chapter, to evidence that your data was collected after the date of ethical approval (as stated on this email). You are reminded that you must now adhere to the answers and detail given in the completed WMG SDA ethical approval form (and associated documentation) within your research project. If anything changes in your research such that any of your answers change, then you must contact us to check if you need to reapply for or update your ethical approval before you proceed.

If your data collection strategy, including the detail of any interview/ survey questions that you originally drafted changes substantially prior to or during data collection, then you must reapply for ethical approval before your changes are implemented.

Please ensure you insert a copy of this email into the appendices of your project.

Best Wishes

Mengjiao Han
WMG Overseas Programmes Course Office
wmg-overseas@warwick.ac.uk
warwick.ac.uk/fac/sci/wmg/overseas/

Appendix B Data preparation for effectiveness testing

The project generates new data sets based on purchasing characteristics of the case study company. The following describes the research methodology in Section 3.3 with two examples for qualitative and quantitative data.

The first example is vendor master data which mainly contains qualitative data. The data was initially cleaned by many methods such as removing extra spaces in the vendor name, splitting vendor number and vendor name into different columns, and combining vendor address from different address lines. Next, it was anonymous according to the list of anonymous data as the example below.

Figure 28: Example list of anonymous data

Vendor name	Anonymous vendor name
Marc	Midway sugar 1991 company limited
Integ	Inter sugarcane company limited
Korn	K.M. molasses public company limited
Sutth	Supreme 1994 company limited
N.S.	N enterprise company limited
Nakh	Nature product and supplies company limited
Park	PG Ingredient company limited
TBS	Well molasses company limited
Sinta	Siam corn company limited
Thait	Thai corn company limited
P&K	Parker grain sources company limited
Centı	Center agriculture company limited
Rittha	Rattana agri-industry company limited
Grain	Feed grain international company limited
Jittra	Northen working group company limited
Crop	Crop worldwide company limited
Korai	Korravee feed company limited
Coop	Cooperation agri-group company limited
Corn	Corn farming and trading company limited
Hathı	Haruthai Promwong
Kinar	Mr. Pongsak Veerarak and Mr. Songyod Krungtani
Jutha	Julaluk Rattana-amorn
Bordı	Mr. Prasith Boonpairat

Lastly, the new data sets were re-checked to ensure that they contain irregularities similar to the real data like wrong spelling or missing some information. For illustration, Figure 29 demonstrates that there are two records for a vendor in the real data set. The second record has extra spaces in its address and does not have the last digit in the telephone number. Accordingly, the anonymous records were generated with these anomalies.

Figure 29: Example of adding anomalies in the new data lines

	Vendor number	Name	Address	Telephone	Bank account number
Real	2[redacted]982	Bor[redacted]	[redacted] Thummasonthorn road	[redacted]7700	906[redacted]
	2[redacted]439	Bor[redacted]	[redacted] Thummasonthorn road	[redacted]770	906[redacted]
Anonymous	1000508	Mr. Prasith Boonpairat	367/3 Thongsak Road, Maikaew District, Phuket 83100	076 668 2200	6818241853
	1000965	Mr. Prasith Boonpairat	367/3 Thongsak Road, Maikaew District, Phuket 83100	076 668 220	6818241853

For quantitative data, the author takes creating the new PO list to describe as an example. In the beginning, the author analyses the nature of purchasing transactions of each material type and vendors in terms of total, average, number, minimum, and maximum of PO amount as well as its batch size. Figure 30 shows a part of the PivotTable results.

Figure 30: Understand the nature of purchasing transactions

Row Labels	Sum of PO amount	Average of PO amount	Count of PO amount	Min of PO amount	Max of PO amount
Molasses 7Cv	**133,229,935.88**	**2,422,362.47**	**55**	**56,529.20**	**10,400,000.00**
1991 March	11,984,823.60	1,997,470.60	6	56,529.20	6,432,000.00
1991 Integr	19,213,834.84	2,401,729.36	8	56,685.32	4,989,529.28
1993 Korn r	32,399,362.40	2,699,946.87	12	255,362.40	4,600,000.00
1994 Sutthi	14,515,996.00	2,419,332.67	6	269,784.00	4,960,000.00
1998 N.S. ir	4,375,559.04	625,079.86	7	473,559.04	1,001,600.00
1999 Nakho	10,400,000.00	10,400,000.00	1	10,400,000.00	10,400,000.00
1999 Park &	33,200,360.00	2,766,696.67	12	137,200.00	4,880,000.00
1999 TBS m	7,140,000.00	2,380,000.00	3	2,380,000.00	2,380,000.00
Local feed corn	**7,464,646,512.62**	**215,884.74**	**34,577**	**4,556.80**	**23,040,000.00**
1990 Sintav	2,262,808.80	205,709.89	11	181,956.00	215,868.80
1991 Thaith	10,968,198.24	176,906.42	62	67,790.40	227,500.96
1991 P&K g	24,677,041.92	195,849.54	126	173,732.00	232,793.81
1992 Centra	227,911.20	227,911.20	1	227,911.20	227,911.20
1993 Rittha	4,283,950.08	194,725.00	22	54,841.68	221,616.40
1994 Grain	6,972,150.56	154,936.68	45	71,552.80	212,928.40
1995 Jittra	28,687,791.88	189,985.38	151	29,452.80	221,130.08
1996 Crop v	13,645,798.80	220,093.53	62	205,568.00	243,836.80
1997 Korat	7,627,397.08	195,574.28	39	56,034.40	232,212.00
1997 Coope	12,917,895.69	230,676.71	56	202,464.00	248,261.20
1999 Corn a	70,972,128.00	124,512.51	570	36,037.20	276,163.20
2001 Hatha	4,620,067.20	210,003.05	22	188,578.80	231,104.00
2001 Kinare	1,006,544.80	201,308.96	5	191,314.80	211,914.80
2002 Juthat	6,982,628.80	205,371.44	34	196,217.60	216,801.60
2002 Bordi	47,406,969.18	221,527.89	214	110,239.20	260,985.60
...					
...					

Remark: The above material names were already anonymous.

The new data sets are then generated by the formula of random in Microsoft Excel and re-checked whether their characters are consistent with the real ones. The below figure depicts the data set created for the first vendor of Molasses 7Cv which has 6 orders of 11,984,823.60 THB in total. Finally, the new data sets are adjusted with the anomalies found from the real data set. Take the PO amount cannot match with PR for instance. The PR line that is linked with the PO number is adjusted the amount with the percentage of difference like the real data set.

Figure 31: The example of the new data set of POs

Material group	Vendor name	Material name	PO amount
3	Midway sugar 1991 company limited	Molasses 7Cv	2,450,000.10
3	Midway sugar 1991 company limited	Molasses 7Cv	3,550,000.10
3	Midway sugar 1991 company limited	Molasses 7Cv	3,107,000.10
3	Midway sugar 1991 company limited	Molasses 7Cv	1,998,000.10
3	Midway sugar 1991 company limited	Molasses 7Cv	650,410.10
3	Midway sugar 1991 company limited	Molasses 7Cv	229,413.10
			11,984,823.60

Appendix C Walkthrough the effectiveness test of detection rules

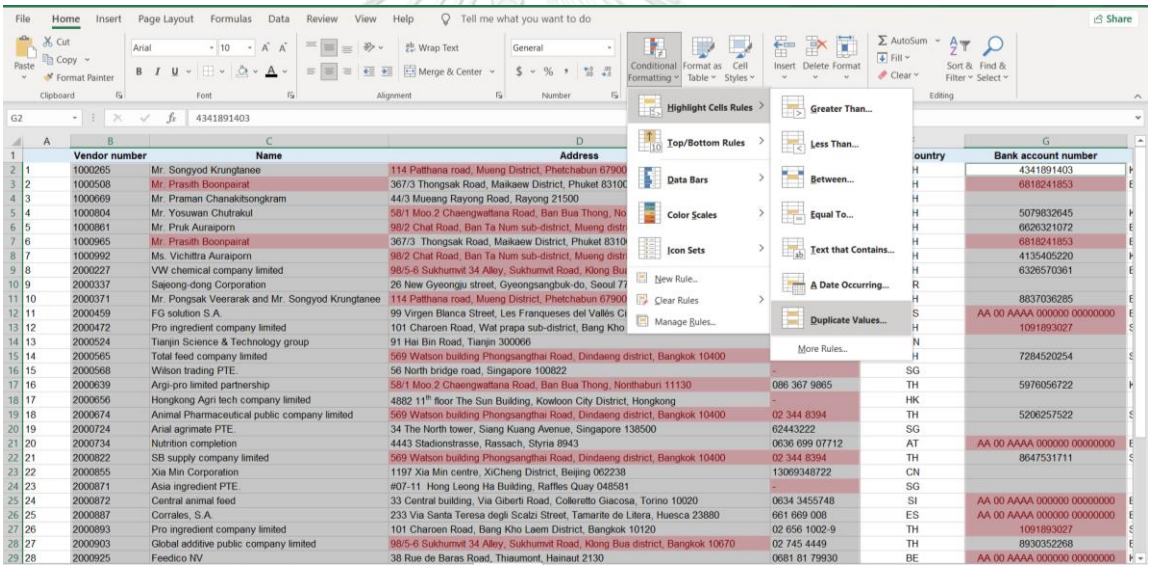
This appendix walkthroughs three examples of using the rules to detect anomalies in the new data sets generated based on Company X's transactions.

Example 1

P2P-DA6: Test duplicate information in the vendor master file such as vendor number, vendor name, bank account number, and address

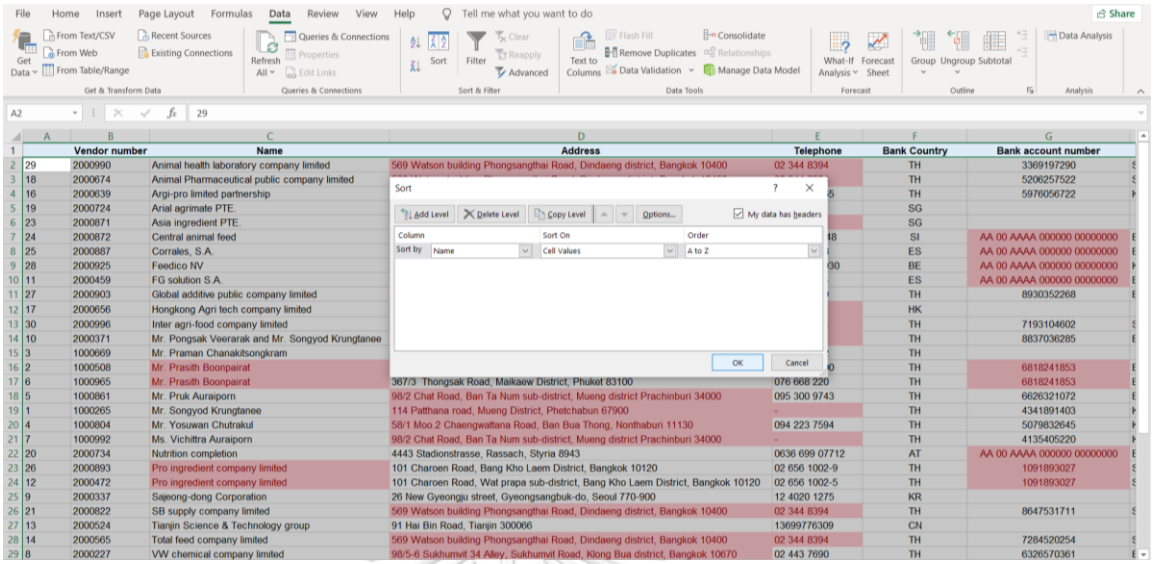
The author applied the function of duplicate value in Microsoft Excel to the AVL file. By clicking *Home*, *Conditional Formatting*, *Highlight Cells Rules*, and *Duplicate Values*, respectively, the repetitive data was highlighted in red cells as the following figure.

Figure 32: Capture screen of duplicate values



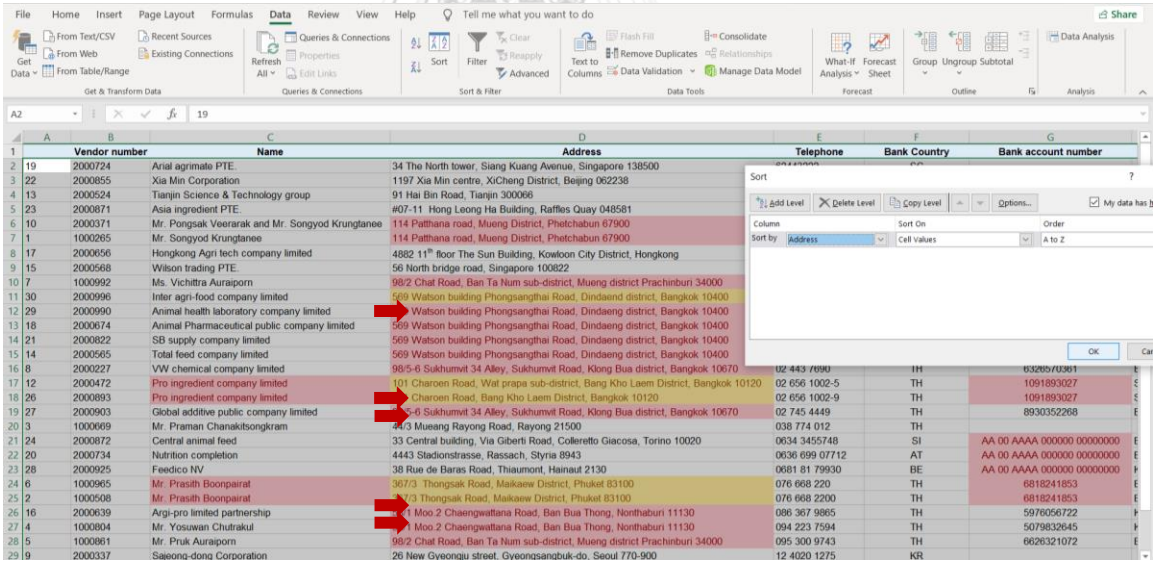
As mentioned in Section 4.2.2, there were some duplicate records that cannot be found from the above method due to differences in uppercase vs lowercase, abbreviation, typo, and space typing. So, vendor name, bank account number, and address were separately ascending sorted as follows.

Figure 33: Capture screen of the ascending sorting of vendor name



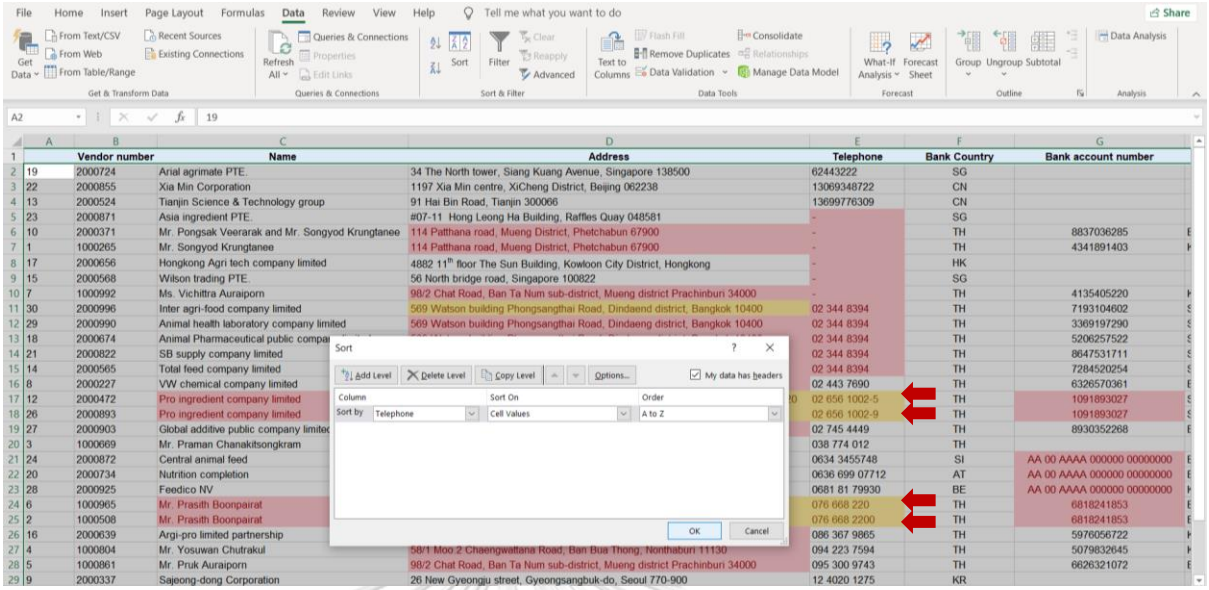
From sorting the vendor name, no additional duplicate value was found.

Figure 34: Capture screen of the ascending sorting of vendor address



After sorting vendor addresses, it was found that the vendor in row 11 had the same address as vendors in rows 12-16. However, because of typo in the district, it was not highlighted. Moreover, due to the missing district name, a vendor in rows 17-18 had the same location. Furthermore, as a result of extra space, a vendor in rows 24-25 had duplicate addresses as well.

Figure 35: Capture screen of the ascending sorting of vendor telephone number



	Vendor number	Name	Address	Telephone	Bank Country	Bank account number
19	2000724	Arial agrimate PTE.	34 The North tower, Siang Kuang Avenue, Singapore 138500	62443222	SG	
22	2000855	Xia Min Corporation	1197 Xia Min centre, XiCheng District, Beijing 062238	13069348722	CN	
13	2000524	Tianjin Science & Technology group	91 Hai Bin Road, Tianjin 300066	13699776309	CN	
23	2000871	Asia ingredient PTE.	#07-11 Hong Leong Ha Building, Raffles Quay 048581	-	SG	
10	2000371	Mr. Pongsak Veerarak and Mr. Songyod Krungtanee	114 Patthana road, Mueng District, Phetchabun 67900	-	TH	8837036285
1	1000265	Mr. Songyod Krungtanee	114 Patthana road, Mueng District, Phetchabun 67900	-	TH	4341891403
17	2000656	Hongkong Agri tech company limited	4882 11th floor The Sun Building, Kowloon City District, Hongkong	-	HK	
15	2000568	Wilson trading PTE.	56 North bridge road, Singapore 100822	-	SG	
7	1000992	Ms. Vichittra Auraiporn	98/2 Chat Road, Ban Ta Num sub-district, Mueng district Prachinburi 34000	-	TH	4135405220
30	2000996	Inter agri-food company limited	569 Watson building Phongsangthai Road, Dindaend district, Bangkok 10400	02 344 8394	TH	7193104602
29	2000990	Animal health laboratory company limited	569 Watson building Phongsangthai Road, Dindaeng district, Bangkok 10400	02 344 8394	TH	3369197290
18	2000674	Animal Pharmaceutical public compa		02 344 8394	TH	5206257522
21	2000822	SB supply company limited		02 344 8394	TH	8647531711
14	2000565	Total feed company limited		02 344 8394	TH	7284520254
8	2000227	VW chemical company limited		02 443 7690	TH	6326570361
12	2000472	Pro ingredient company limited		02 656 1002-5	TH	1091893027
26	2000893	Pro ingredient company limited		02 656 1002-9	TH	1091893027
27	2000903	Global additive public company limite		02 745 4449	TH	8930352268
3	1000669	Mr. Praman Chanakitsongkram		038 774 012	TH	
24	2000872	Central animal feed		0634 3455748	SI	AA 00 AAAA 000000 00000000
20	2000734	Nutrition completion		0636 699 07712	AT	AA 00 AAAA 000000 00000000
28	2000925	Feedico NV		0681 81 79930	BE	AA 00 AAAA 000000 00000000
6	1000965	Mr. Prasith Boonpairat		076 668 220	TH	6818241853
2	1000508	Mr. Prasith Boonpairat		076 668 2200	TH	6818241853
16	2000639	Argi-pro limited partnership		086 367 9865	TH	5976056722
4	1000804	Mr. Yosuwan Chutrakul	58/1 Moo 2 Chaengwattana Road, Ban Bua Thong, Nonthaburi 11130	094 223 7594	TH	5079832645
5	1000861	Mr. Pruk Auraiporn	98/2 Chat Road, Ban Ta Num sub-district, Mueng district Prachinburi 34000	095 300 9743	TH	6626321072
9	2000337	Sajeong-dong Corporation	26 New Gyeongju street, Gyeongsangbuk-do, Seoul 770-900	12 4020 1275	KR	

The ascending sorting of telephone numbers shows that row 17-18 and row 24-25 may have the same telephone number. Because of different extension numbers and extra “0” in the last digit, they were not highlighted as the duplicate value in the first method. While the sorting can help the author find these duplications.

Example 2

INV-DA4: Identify the closed POs with not fully receive to verify the reasons and supporting documents

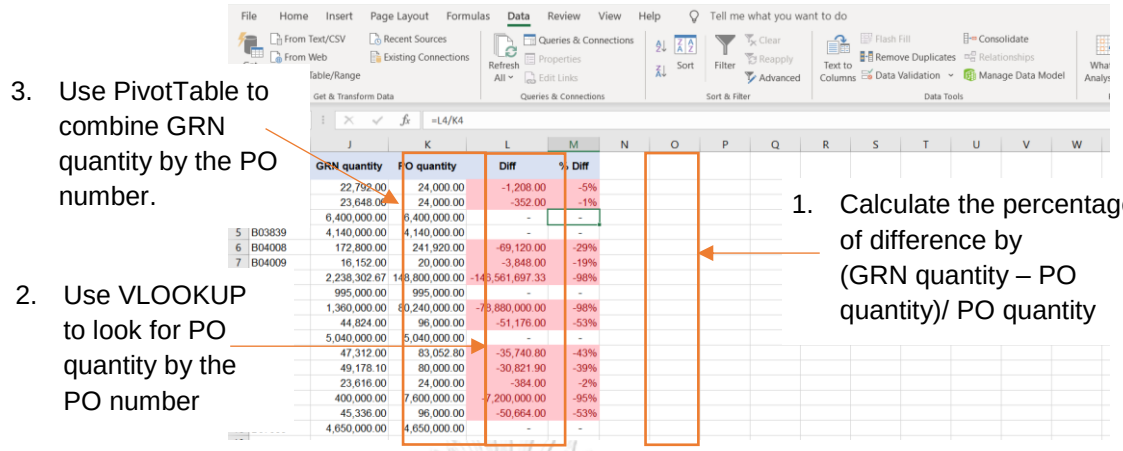
For each PO, the company may require a vendor to deliver material in different periods per a scheduling agreement. That is, a PO may have several GRNs. On the contrary, a GRN is created to only a PO as an example in the following figure.

Figure 36: Example of reference GRN number for each PO line

PO number	Mat. Group	Vendor name	Material name	PO amount	Reference GRN number
B01151	1	Sun agriculture company limited	Rice bran oil – feed grade	568,000.00	C13773, C13844, C13323
B01153	1	Kittipong Thummanonkul	Local feed corn	202,640.00	C11318
B01154	1	Pawares nawasamrith	Local feed corn	219,016.80	C11246
B01158	1	Somsamai Tanasinkul	Local feed corn	200,138.40	C11173, C11726
B01162	1	Pornlada Damneunsawang	Local feed corn	203,968.80	C11149
B01175	1	Siam cooperative	Cassava chip 87	996,000.00	C11314
B01196	1	Central farming company limited	Wheat mix	997,500.00	C11219
B01198	1	Kirati Suksripaiboon	Rice bran oil – feed grade	995,000.00	C11354
B01203	1	Central farming company limited	Rice bran oil – feed grade	995,000.00	C11745
B01292	1	Pro plant company limited	Palm oil	7,200,000.00	C13847, C43290
B01293	1	Pro plant company limited	Palm oil	5,040,000.00	C11153
B01295	1	Charoenkaset company limited	Local Jasmin rice	4,820,000.00	C11159
B01296	1	Siam cooperative	Local barley 70/30	4,480,000.00	C11407
B01298	1	JQ Argo sourcing company limited	Soybean grade B	999,200.00	C11327
B01320	1	JQ Argo sourcing company limited	Soybean oil	4,850,000.00	C11815
B01373	1	Siam cooperative	Cassava starch	4,700,000.00	C21199
B01477	1	Kirati Suksripaiboon	Rice bran oil – feed grade	995,000.00	C11455
B01483	1	Kirati Suksripaiboon	Rice bran oil – feed grade	995,000.00	C01189
B01533	1	Charoenkaset company limited	Local feed corn	4,650,000.00	C11357
B01595	1	Charoenkaset company limited	Local feed corn	7,160,000.00	C11889, C11355
B01661	1	Central farming company limited	Rice bran oil – feed grade	995,000.00	C11702
B01737	1	Kirati Suksripaiboon	Rice bran oil – feed grade	995,000.00	C11569, C11201
B01740	1	Pro plant company limited	Palm oil	998,000.00	C13250, C13994
B02195	2	A.K. food supply company limited	Local pork grade B	5,161,267.14	C13578, C13138, C13706
B02575	3	Midway sugar 1991 company limited	Molasses 7Cv	4,600,000.00	C13319
B02577	2	One chemical specialties company limited	Protein hydrolysates	4,600,000.00	C22301, C12687
B03608	3	Asia ingredient PTE.	Optimum vit mix	6,400,000.00	C33562, C13352
B03833	3	Asia ingredient PTE.	Zinc integrate 100	4,140,000.00	C13616

From the list of closed POs, the author firstly combined the GRN quantity as a reference in each PO line by the function of PivotTable. Subsequently, the PO quantity is taken to compare through the function of VLOOKUP by the PO number as reference data. The percentage of difference was then calculated. Lastly, by the Conditional Formatting of values less than 0, the negative values were highlighted as the company received goods less than the request in the PO for further review.

Figure 37: Example of identifying closed POs with partial goods receipt amounts



Example 3

P2P-DA9: Review the PR approver against the company's table of authority

The function of PivotTable is used to arrange and summarise PRs approved by different persons. Regarding Table 44, the author had to group PR amount into three ranges: less than 1 million THB, 1-5 million THB and over 5 million THB. Thus, in the beginning, the author applied PivotTable to summarise the PR amount and PR approver for each PR number. Next, the PivotTable results were filtered as follows.

For PRs less than 1 million THB, the author highlighted approvers who are not Pakorn, Arisa, Samantha, and Orawan, regardless of material group. Because, in last 12 months, some department heads resigned and the remaining managers are responsible for approval. Figure 38 shows the example that PRs approved by Samart are suspicious transactions since the company assigned him as an authorised person for the higher ranges of PR amount. So, these PRs were marked for investigation.

Table 44: Company X's table of authority - PR approver

Material group	PR < 1 million THB (Department head)	PR 1 – 5 million THB (Managing Director)	PR > 5 million THB
1: Grain and oil	Pakorn	Samart	Executive committee
2: Protein base	Arisa		
3: Vitamin, enzymes, and additive	Samantha		
4: Office supply and overhead	Orawan		

Figure 38: PivotTable of approvers for PRs less than 1 million THB

1. From PivotTable result, filter the PR amount less than 1 million THB

Approver		Column Labels					
PR number	PR amount	Arisa	Orawan	Pakorn	Samantha	Samart	Grand Total
	680,400.00	1					1
	700,000.00				1		1
	705,600.00				1		1
	730,800.00	1					1
	740,080.00	1					1
	750,720.00				1		1
	760,000.00	1					1
	776,000.00	1					1
A01579	777,600.00	1					1
A02538	797,760.00	1					1
A03376	817,920.00					1	1
A12897	829,440.00					1	1
A03992	840,000.00					1	1
A12880	872,320.00					1	1
A12881	950,400.00					1	1
A13889	978,000.00					1	1

2. The results show suspicious transactions.

Similarly, the PivotTable was then filtered for PRs between 1-5 million THB. Compared against the table of authority, PRs which were approved by anyone who is not Samart are anomalies for analysis. The examples are illustrated in Figure 39.

Figure 39: PivotTable of approvers for PRs between 1 and 5 million THB

4. From PivotTable result, filter the PR amount between 1 and 5 million THB

rover		Column Labels				
umber	PR amount	Arisa	Pakorn	Samantha	Samart	Grand Total
058	1,038,000.00				1	1
056	1,050,000.00				2	2
732	1,068,000.00		1			1
042	1,072,000.00				1	1
700	1,085,800.00				1	1
A24166	1,134,480.00				1	1
A21752	1,173,600.00				2	2
A24190	1,232,800.00				1	1
A23949	1,252,800.00				1	1
A23299	1,256,000.00				1	1
A02405	1,288,000.00		2			2
A02447	1,296,000.00		1			1
A21352	1,300,800.00				1	1
A22371	1,342,000.00				1	1
A12624	1,372,800.00				1	1
A02448	1,382,400.00		1			1
A22654	1,400,000.00				1	1
A23460	1,401,120.00				1	1
A03925	1,403,000.00			1		1

3. The results show suspicious transactions.

Lastly, the PivotTable was then filtered to seek PRs with an amount greater than 5 million THB. Figure 40 depicts a part of those approved by Samart who was not authorised person.

Figure 40: PivotTable of approvers for PRs greater than 5 million THB

6. From PivotTable result, filter the PR amount greater than 5 million THB

5. The results show suspicious transactions.

pprover		Column Labels	
R number	PR amount	Samart	Grand Total
03008	5,229,178.00	1	1
02713	5,784,606.00	1	1
01933	6,200,800.00	1	1
01987	6,252,201.00	1	1
A21300	6,460,000.00	1	1
A12631	6,560,000.00	1	1
A12956	6,829,803.00	1	1
A13586	6,930,794.00	1	1
A11160	7,088,167.00	1	1
A12341	7,394,260.00	1	1
A11493	7,495,659.00	1	1
A12334	8,380,467.00	1	1
A11293	8,808,619.00	1	1
A21172	9,877,416.00	1	1
A21463	10,432,000.00	1	1

VITA

NAME	Penpak Rangsipunyaporn
INSTITUTIONS ATTENDED	Bachelor of Engineering, Industrial Engineering, Chulalongkorn university