Enhancing Invoice Management Transparency and Efficiency Through AI Visualization

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Abstract

Invoice processing systems are critical components of financial operations. They are responsible for managing the receipt, obtaining validation, or approval, and posting of vendor invoices within the Procure-to-Pay cycle. Despite having high service level agreement compliance rates, the current semi-automated invoice processing system lacks real-time visibility in individual staff productivity. This causes delays, recurring accuracy errors, and operational inefficiencies. Manual data consolidation and limitations in optical character recognition accuracy further hinder timely decision-making. Therefore, there is a need for an intelligent, automated solution to enhance transparency and streamline performance monitoring. This study adopts a Design Science Research methodology to develop and evaluate an AI-supported interactive dashboard for invoice processing within a Shared Services Centre. The operational framework consists of five structured phases: investigation, research design, data collection and analysis, dashboard development, and reporting. The proposed solution integrates AI-driven data extraction with dynamic visualisation capabilities in Power BI, guided by Shneiderman's Eight Golden Rules to ensure usability, clarity, and human-AI collaboration. The dashboard comprises four core modules focused on processor performance, turnaround time tracker, processing time variation, and workload distribution. Findings demonstrate that the dashboard enables real-time performance monitoring, facilitates data-driven decisions, and improves transparency across financial operations. This research contributes a practical tool to address current system limitations and sets the stage for future enhancements, including integration with SAP Intelligent Robotic Process Automation (iRPA) and real-time monitoring features for proactive process management.

Keywords: *Artificial Intelligence, Business Intelligence, Dashboard Design, Data Visualization, Invoice Management, Invoice Processing*

1. Introduction

Invoice processing refers to the end-to-end workflow that encompasses the handling of incoming invoices from suppliers' receipt to final payment and accounting entry. It constitutes a fundamental business function managed by the accounts payable department, encompassing the tracking, validation, and settlement of supplier invoices [1]. Invoice processing is a critical financial operation within the Procure-to-Pay (P2P) cycle. Figure 1 shows the key steps in the invoice process encompassing sequential steps such as (i) an invoice is received, (ii) the invoice is

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recorded and matched, (iii) the invoice is approved (iv) the invoice is submitted for payment and processed and (v) the invoice data is recorded and archived into accounting systems. Traditionally, these processes were carried out manually and could take weeks to process [2]. In summary, invoice processing serves as a core element of organisational financial management that directly influences cash flow, compliance, and operational efficiency.

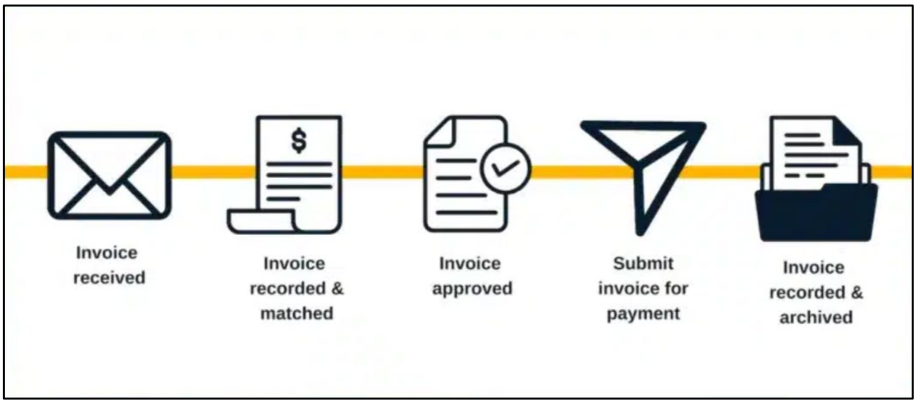

Figure 1. Key Steps in the Invoice Process [2]

During the second step, which is the recording and matching of the invoice, the finance team conducts a three-way matching process to ensure consistency among the purchase order, the goods receipt note (GRN), and the supplier's invoice. This process verifies that the invoiced items, quantities, and prices are aligned with those documented in the PO and GRN. It serves to advocate financial accuracy, ensure compliance with regulatory standards, and strengthen supplier relationships. Any discrepancies identified during this step must be thoroughly investigated and resolved before payment can proceed [3]. An integral aspect of this stage is compliance with service level agreements (SLAs), where predefined performance benchmarks dictate how quickly and accurately invoices must be processed. A Service Level Agreement (SLA) is a formal contract between a service provider and a customer that outlines the agreed level of service to be delivered. It defines key performance metrics, responsibilities, and procedures to follow if service standards are not achieved. The SLA establishes clear expectations for both parties covering aspects such as uptime, response time, and overall performance while promoting accountability and transparency in service delivery [4]. For example, SLA may require that 95% of invoices be approved and paid within 30 days from the receipt date [5, 6]. SLAs help standardise expectations between internal departments and external vendors, promoting operational efficiency and accountability [7]. Failure to meet SLAs can lead to late payment penalties, strained vendor relationships, and disruptions to procurement cycles. As a cornerstone of accounts payable operations, efficient invoice processing is crucial for ensuring SLA adherence, enabling timely payments, and supporting data-driven financial decision-making within large-scale enterprises [8]. However, the rising volume and complexity of invoices, especially in global organisations, pose operational challenges. These include processing delays, manual errors, and risks of fraud. These issues are exacerbated in manual or semi-automated environments where finance teams rely heavily on time-consuming tasks such as data extraction and reconciliation via Excel-based logs [9].

A preliminary assessment of the existing invoice processing system identified key limitations in tracking individual staff productivity. The organisation X currently employs a semi-automated system integrated with SAP, which captures transactional data but lacks built-in features for real-time monitoring of individual processor performance. Approximately 74,000 invoices are processed each month. For invoices with complete data, the average processing time is around 30 minutes. However, when data is incomplete and requires communication with clients, the processing time increases to between 40 and 50 minutes. Several issues contribute to these delays. First, the approval process itself does not present major obstacles, but delays frequently occur when obtaining missing information from clients, particularly when responses are slow. Second, the optical character recognition (OCR) system often fails to capture essential information. This is due to the presence of handwritten documents or invoices that are not generated in a standardised digital format like PDF. Third, supporting documents are frequently disorganised, making it difficult for processors to locate critical information such as invoice amounts. Consequently, team leaders must manually extract and consolidate data from multiple Excel-based reports to determine who processed specific invoices and whether service-level agreements were met. This manual method is time-consuming, prone to human error, and lacks the analytical sophistication and scalability necessary for efficient financial operations in contemporary organisational environments. According to Table 1, the overall SLA compliance across key financial processes remains consistently high, ranging between 99.6% and 99.9%. In terms of vendor invoice posting timeliness, China achieved 99.93% and Indonesia 99.99%, indicating near-perfect adherence. However, China reported 37 timeliness misses year-to-date (YTD) 2025, falling below target, while Indonesia had 12, staying within acceptable limits. Both countries recorded 116 accuracy errors YTD 2025. The term year-to-date (YTD) refers to the cumulative performance or total count measured from the beginning of 2025 up to the current reporting date. Despite maintaining a strong service quality score of 99.6% to 99.7%, well above the industry benchmark of 95% [6], the recurring errors and missed deadlines may signal the onset of an operational slump if not addressed promptly. Therefore, previous studies highlight semi-automated systems often lack real-time visibility into performance metrics, limiting the ability to monitor productivity and identify inefficiencies promptly [8]. These inefficiencies have highlighted the need for innovative solutions to enhance transparency and streamline operations.

Table 1. Service Level Agreement compliance and Performance Metric for Invoice Processing [6]

Country	SLA Compliance (%)	Service Quality Score (%)	Timeliness Misses YTD 2025	Accuracy Errors YTD 2025
China	99.93	99.6	37	116
Indonesia	99.99	99.7	12	116

To address this issue, the present article proposes an integrated interface that leverages AI capabilities alongside visualisation techniques rooted in Ben Shneiderman’s; eight design principles [10]. Therefore, the objective of this study is to improve usability, enhance transparency, and strengthen decision-making within shared service environments, ultimately transforming the Procure-to-Pay cycle into a more efficient, collaborative, and data-driven process.

2. Literature Review

Artificial Intelligence is playing an increasingly important role in transforming the Procure to Pay (P2P) cycle by automating traditional manual and repetitive tasks. These include data capture, anomaly detection, and invoice reconciliation [11]. Technologies such as OCR, Natural Language Processing (NLP), and Machine Learning (ML) are leading this transformation by shifting invoice processing from manual data entry into smart, automated workflows. For example, a recent study developed an AI-based invoice management application that combines OCR, NLP, and supervised machine learning models to improve data extraction and detect fraud, resulting in faster processing and greater accuracy [12]. Building on this, another study introduced a hybrid model that uses NLP for text analysis along with machine learning for anomaly detection. This approach further enhanced the classification accuracy for complex, unstructured financial documents [13]. These developments show how AI can turn invoice processing into a strategic business function rather than just a back-office task. It helps organisations reduce delays, minimise errors, and detect irregularities before they become major issues. More recent advancements have extended the application of AI through the use of energy-efficient models and generative tools. For instance, research on Green AI has demonstrated that thoughtful feature engineering can reduce computational demand while maintaining high performance in financial systems [14]. At the same time, Generative AI has been used to support accounts receivable processes by predicting payment behaviour and improving cash flow cycles [15].

While AI brings intelligence and automation to invoice processing, tools like Power BI play a key role in turning data into actionable insights. Power BI dashboards enable finance teams to monitor invoice performance in real-time, track adherence to service level agreements, and swiftly identify any issues or irregularities flagged by AI models [16]. For example, when an AI system detects a potentially fraudulent invoice or an overdue payment, Power BI can immediately highlight the issue through visual reports, which allows for quick response and better decision-making [17]. Together, AI and dashboards provide a powerful combination. AI handles the heavy lifting in processing and analysis, while platforms like Power BI give users the visibility and control they need to manage financial operations more strategically. This integrated approach not only offers greater efficiency but also transparency, accountability, and smarter financial planning across an organisation [18].

Data visualisation plays a crucial role in facilitating evidence-based decision-making in financial operations by transforming raw data into actionable insights. Business Intelligence tools such as Power BI, Tableau, and SAP Analytics Cloud provide real-time access to key performance indicators, enabling managers to monitor activities, detect anomalies, and respond promptly to operational issues. The effectiveness of these tools is rooted in sound design principles that emphasise user-centred, task-oriented interfaces, which reduce cognitive load and facilitate intuitive interaction with data [19]. These principles are essential in developing tailored dashboards that support different stages of decision-making and bridge the communication gap between analysts and executive stakeholders [20]. Empirical evidence supports this approach; interactive dashboards that integrate structured financial data have been shown to significantly improve decision accuracy, speed, and quality [21, 22]. However, challenges remain, particularly in supporting advanced features like scenario analysis and fostering collaborative interpretation of visual information [23]. As such, dashboards evolve from static reporting tools into dynamic, interactive platforms that align with core design principles to sustain strategic and collaborative decision-making across financial ecosystems.

Table 2 outlines the characteristics of the key dashboard design principle which are essential for effective invoice processing systems. These features are affiliated with Ben Shneiderman's Eight Golden Rules, which were originally formulated to guide user interface design and were later referenced and applied to dashboard development [24]. The Ben Shneiderman's Eight Golden Rules of Interface Design are: (1) Strive for consistency by using familiar layouts, terminology, and actions across the system. (2) Enable frequent users to use shortcuts so they can navigate and complete tasks faster. (3) Offer informative feedback so users know the outcome of every action they take. (4) Design dialogs to yield closure by giving users a clear sense of completion after each task. (5) Offer simple error handling and easy ways to undo mistakes, reducing user frustration. (6) Allow easy reversal of actions so users feel confident exploring without fear of permanent errors. (7) Support internal locus of control by ensuring users feel in command of the interface rather than controlled by it. (8) Reduce short-term memory load by keeping information visible and minimizing the need for users to remember details between screens or actions. The eight principles of design can be implemented in the developing and evaluation of the process of an interactive system [25]. For instance, usability focuses on intuitive navigation and consistent layouts. Meanwhile, filter reduces cognitive load. Transparency is achieved through explainable AI outputs with traceable decision paths, enabling users to understand how anomalies are flagged and decisions are made. Human-AI collaboration is supported through features such as override functions and scenario analysis tools to allow user oversight. Real-time monitoring provides continuous visibility into SLA compliance and workload metrics, supporting immediate feedback and operational closure. In addition, secure and authenticated visualisation methods have been recommended to maintain data integrity and ensure provenance, which is especially critical in financial domains [26]. Collectively, these design considerations contribute to dashboards that enhance user trust, accountability, and the quality of decisions concerning financial matters.

Table 2. Dashboard Design Characteristics for Invoice Processing Systems [24]

Characteristic	Description	Linked Principle
Usability	Intuitive navigation, filters, and consistent layouts	Consistency, Reduce Memory Load
Transparency	Explainable AI outputs with traceable decision paths	Informative Feedback, Error Prevention
Human-AI Collaboration	User oversight with override options, scenario analysis	User Control, Reversal of Actions
Real-Time Monitoring	Live tracking of SLA compliance and workload metrics	Immediate Feedback, Closure

Traditional invoice processing methods, which rely heavily on manual workflows and lack real-time visibility, remain inefficient and error-prone. These limitations emphasise the pressing need for innovative solutions that integrate Artificial Intelligence and interactive data visualisation. Recent developments indicate that combining AI-driven data extraction, automation, and dynamic dashboards can significantly enhance accuracy and speed up the verification process. These technologies also provide timely insights that improve transparency and boost operational efficiency in financial management [27]. Despite these advancements, there remains a significant gap in current systems, particularly the absence of integrated applications that unify back-end automation with front-end, user-focused visualisation. This disconnect limits the potential for effective human-AI collaboration in both operational monitoring and strategic oversight.

3. Methodology

This study adopts a Design Science Research approach, with an operational framework that has five structured phases, as depicted in Figure 2. The operational framework is designed to guide the development and evaluation of a visualisation-driven solution for invoice processing. It enables a systematic transition from problem identification to dashboard implementation and assessment, ensuring the research process remains aligned with the study's objectives and contributes both theoretically and practically.

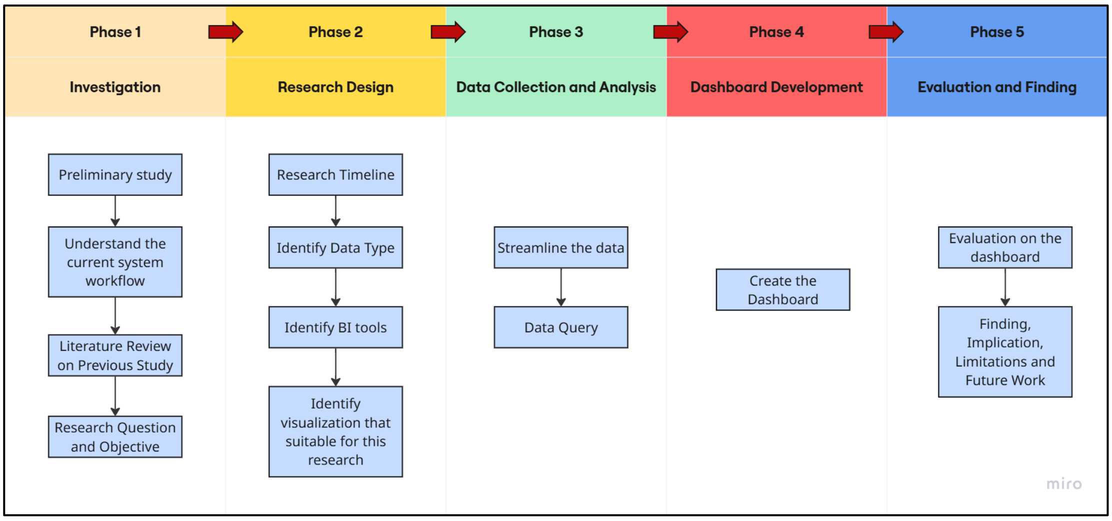

Figure 2. Five-phase operational framework for developing a visualization-driven invoice processing system

3.1 Operational Research Framework

The operational framework includes five phases that structure the proposed development of the visualisation-driven invoice processing solution.

3.1.1 Phase 1: Investigation

This study began with examining the existing invoice processing workflow within a shared service environment. To do this, a comprehensive literature review on data visualisation, Business Intelligence (BI) tools and the key attributes of invoice processing systems was conducted. Based on the review, the objectives and research questions were formulated to address challenges in transparency, service level agreement (SLA) compliance tracking, and processor productivity monitoring.

3.1.2 Phase 2: Research Design

A comprehensive research timeline was established using a Gantt chart to organise major milestones and deliverables. The study identified relevant data types, emphasising both structured data, for example, invoice logs and SLA metrics, and semi-structured data that includes scanned invoices. Business Intelligence tools, particularly Power BI, were assessed for their suitability based on criteria such as integration flexibility, interactive capabilities, and scalability. To guide the design of effective dashboards, visualisation principles were adopted based on Shneiderman's Eight Golden Rules, ensuring usability, transparency, support for human-AI collaboration, and real-time operational monitoring.

3.1.3 Phase 3: Data Collection & Analysis

Invoice data was obtained from the organisation's exportable system logs, encompassing key attributes such as invoice ID, vendor information, invoice value, posting dates, SLA compliance indicators, and processor assignments. The preprocessing phase involved data cleaning to remove duplicates and invalid records, normalisation to scale numerical fields, and categorical encoding to convert non-numeric attributes into analyzable formats. An exploratory analysis was then conducted to uncover performance patterns, highlight SLA compliance gaps, and assess workload distribution among processors. Insights obtained served as the basis for defining the dashboard metrics.

3.1.4 Phase 4: Dashboard Development

An interactive dashboard prototype was developed using Power BI, visualising key KPIs such as processing cycle times, SLA compliance rates, and workload distribution per processor. Drill-down features enabled managers to analyse performance at both aggregate and individual processor levels. The dashboard's design adhered to Shneiderman's Eight Golden Rules and incorporated feedback from preliminary user testing to improve layout clarity and usability.

3.1.5 Phase 5: Evaluation and Finding

In this phase, the dashboard's effectiveness was measured by synthesising findings gathered which were related the objectives of the study. A discussion on the implications of shared decision making, identification of limitations of the prototype developed and suggestions for future works, including integration of AI-driven analytics were also conducted in this phase.

3.2 Data Preparation

This stage corresponded to Phase 2 in the research framework. The dataset for this study was obtained from a Shared Services Centre (SSC) responsible for managing invoice processing within the P2P cycle. It contained transaction-level records with attributes such as unique document identifiers (URN), company codes, document types, invoice categories, received dates and times, processing sites, and SLA-related timestamps. Processor names were anonymised and replaced with generic identifiers to protect organisational confidentiality. These attributes collectively provided a comprehensive view of the invoice lifecycle, supporting the analysis of processing cycle times, workload distribution, and compliance with service level agreements (SLAs).

To ensure reliability and consistency, the dataset underwent a series of data cleaning and normalisation procedures. Duplicate and incomplete entries were removed, and missing values were imputed using context-appropriate methods. Date and time fields, including received and scan dates, were standardised to a YYYY-MM-DD HH:MM: SS format to facilitate temporal analysis. Numeric variables, such as processing times and ageing metrics, were normalised using min-max scaling, ensuring comparability across processors and departments. The data was then consolidated into a unified structure, integrating information from multiple logs and reports to establish relational links between processor identifiers, invoice stages, and processing durations.

This clean and structured dataset was prepared for import into Power BI, forming the foundation for the dashboard visualisations developed in the subsequent phase. An excerpt of the anonymised dataset, showcasing its key fields and structure, is presented in Figure 3.

URN	Wave	Company Code	Document Type	Invoice Category	Received Date	Received Time	URN Aging	Spoke Site	User Name	Scan Dat	Scan Time	Due On Date
1000390594	W3_4_5 BU17	8897	PO	STANDARD PO	05/02/2025	21:45:29	0	CMI DI	Person 1	05/02/2025	21:10:37	05/07/2025
2000013209	W7.5 Tjiwi Kimia_Sindopex	8688	TE	Other Claims	05/02/2025	21:45:22	0	FIORI DI	Person 2	05/02/2025	21:01:12	05/07/2025
2000013208	W7.5 Tjiwi Kimia_Sindopex	8688	TE	Other Claims	05/02/2025	20:51:43	0	FIORI DI	Person 3	05/02/2025	20:02:01	05/07/2025
1000390587	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	21:16:45	0	CMI DI	Person 4	05/02/2025	19:13:17	05/07/2025
1000390586	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	21:16:41	0	CMI DI	Person 5	05/02/2025	19:12:17	05/07/2025
602010030066	Wave 2a1-Serpong	8371	TE	Other Claims	05/02/2025	20:51:58	0	Serpong	Person 6	05/02/2025	19:07:08	05/07/2025
602010030065	Wave 2a1-Serpong	8371	TE	Other Claims	05/02/2025	20:52:14	0	Serpong	Person 7	05/02/2025	19:07:08	05/07/2025
602010030064	Wave 2a1-Serpong	8371	TE	Other Claims	05/02/2025	20:52:19	0	Serpong	Person 8	05/02/2025	19:07:08	05/07/2025
602010030063	Wave 2a1-Serpong	8371	TE	Other Claims	05/02/2025	20:52:04	0	Serpong	Person 9	05/02/2025	19:07:08	05/07/2025
602010030062	Wave 2a1-Serpong	8371	TE	Other Claims	05/02/2025	20:50:55	0	Serpong	Person 10	05/02/2025	19:07:08	05/07/2025
1000390585	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	21:16:41	0	CMI DI	Person 11	05/02/2025	19:04:15	05/07/2025
2000013207	W3 Karawang	8288	TE	Other Claims	05/02/2025	19:46:58	0	FIORI DI	Person 12	05/02/2025	19:03:50	05/07/2025
2000013206	W3 Karawang	8788	TE	Other Claims	05/02/2025	19:46:59	0	FIORI DI	Person 13	05/02/2025	19:03:44	05/07/2025
1000390582	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	21:16:44	0	CMI DI	Person 14	05/02/2025	19:02:14	05/07/2025
2000013205	W1 IK Serang	8368	TE	Other Claims	05/02/2025	19:46:54	0	FIORI DI	Person 15	05/02/2025	19:01:38	05/07/2025
1000390580	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:48:37	0	CMI DI	Person 16	05/02/2025	19:01:13	05/07/2025
1000390579	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:48:09	0	CMI DI	Person 17	05/02/2025	19:00:13	05/07/2025
1000390578	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:47:38	0	CMI DI	Person 18	05/02/2025	18:59:12	05/07/2025
1000390577	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:47:49	0	CMI DI	Person 19	05/02/2025	18:59:12	05/07/2025
1000390576	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:47:32	0	CMI DI	Person 20	05/02/2025	18:57:11	05/07/2025
1000390575	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:47:28	0	CMI DI	Person 21	05/02/2025	18:56:10	05/07/2025
1000390574	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:47:45	0	CMI DI	Person 22	05/02/2025	18:56:09	05/07/2025
1000390571	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:46:50	0	CMI DI	Person 23	05/02/2025	18:55:08	05/07/2025
1000390569	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:46:47	0	CMI DI	Person 24	05/02/2025	18:55:07	05/07/2025
1000390567	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:46:19	0	CMI DI	Person 25	05/02/2025	18:54:06	05/07/2025
1000390564	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:46:44	0	CMI DI	Person 26	05/02/2025	18:53:04	05/07/2025
1000390563	W2_4_5 Univenus	8213	PO	STANDARD PO	05/02/2025	20:46:47	0	CMI DI	Person 27	05/02/2025	18:53:03	05/07/2025
1000390562	W3_4_5 BU17	7012	PO	STANDARD PO	05/02/2025	20:50:51	0	CMI/BU17 DI	Person 28	05/02/2025	18:51:00	05/07/2025
1000390561	W3_4_5 BU17	7012	PO	STANDARD PO	05/02/2025	20:51:06	0	CMI/BU17 DI	Person 29	05/02/2025	18:50:59	05/07/2025

Figure 3. Excerpt of the anonymized dataset from the Shared Services Centre's invoice processing system

3.3 Data Analysis

The data analysis and visualisation process were conducted using Microsoft Power BI, and it was selected due to its scalability, real-time interactivity, and seamless integration with structured financial datasets. Once the operational data was exported from the Shared Services Centre's invoice processing system, it was transformed and prepared using Power BI for detailed analysis and dashboard development.

The analysis focused on key productivity and performance indicators, aligned with the study's objectives, particularly monitoring individual processor performance and enhancing managerial decision-making through tailored visualisations. To evaluate process efficiency, average invoice processing times were calculated for each processor and visualised using box-and-whisker plots, enabling the identification of outliers, anomalies, and deviations from standard performance. This analysis provided managers with insights into targeted interventions, such as retraining or workload redistribution. Additionally, turnaround times, measured from the receipt of the URN to the final posting, were visualised using line graphs and Gantt charts. This approach enabled the identification of process bottlenecks and delays at various stages of the invoice processing workflow.

Productivity metrics were analysed by measuring both the number of invoices processed per individual and the average duration of processing per processor, displayed via comparative bar charts to benchmark performance across the team. Workload distribution was analysed using heatmaps and pie charts, revealing disparities in task allocation and aiding the creation of equitable, balanced workload strategies. Further analyses addressed performance variability by tracking individual processor performance trends over time, highlighting fluctuations caused by operational changes or external factors. This longitudinal assessment supported proactive interventions for declining performance and provided evidence of best practices for sustaining consistent output.

Finally, delay trend analysis was conducted by correlating multiple timestamps, such as received, scanned, processing, and posting dates, to uncover recurring patterns in delays. These insights informed the refinement of standard operating procedures (SOPs) and scheduling practices to minimise inefficiencies. The dashboards incorporated a range of visual techniques, including bar charts, Gantt charts, heatmaps, line graphs, and box plots, to transform complex datasets into interactive, decision-oriented visual narratives. The visualisation design process followed an iterative approach, incorporating continuous feedback from stakeholders to ensure that the dashboards were user-centred, transparent, and aligned with organisational goals. By translating raw operational metrics into intuitive, real-time visualisations, the analysis approach empowered decision-makers to monitor processor performance, identify inefficiencies, and implement timely corrective actions, directly supporting the research objectives.

4. Findings

This section reports the findings from the development of the proposed Power BI-based dashboard for monitoring processor performance and operational efficiency in the P2P invoice processing workflow. The visual analytics framework was designed to translate complex operational data into actionable insights, directly addressing the study's objectives of improving transparency, workload visibility, and decision-making support in Shared Services Centres (SSCs).

4.1 Dashboard Overview

The developed dashboard functions as a centralised interface for monitoring processor-level performance and overall workflow efficiency within the invoice processing system. Implemented using Microsoft Power BI, it consolidates multiple transaction-level data streams from the Shared Services Centre's (SSC) Procure-to-Pay environment, enabling real-time visibility into critical metrics such as processing volume, turnaround time, workload allocation, and performance variability. Guided by Shneiderman's Eight Golden Rules [10], the dashboard emphasises usability, transparency, human-AI collaboration and real-time monitoring through interactive visual components that support drill-down exploration. This design enables decision-makers to identify performance gaps, detect anomalies, and make informed decisions on resource reallocation, thereby mitigating operational bottlenecks and enhancing compliance with Service Level Agreements (SLAs).

4.2 Dashboard Components

Figure 4 illustrates the proposed dashboard, comprising four core modules, each aligned with the research objectives and developed following Ben Shneiderman’s Eight Golden Rules of interface design [10]. These modules not only adhere to the best practices in visualisation, they also ensure usability, consistency, and user control that establish a foundation for effective human-AI collaboration. Artificial Intelligence components, such as anomaly detection and performance prediction, are integrated to enhance analytical depth, while the dashboard’s structure ensures that users retain interpretive control. This synergy between AI and user-centered design enables data-driven decision-making, promotes trust in system outputs, and supports continuous improvement in invoice processing performance.

Although all eight of Shneiderman’s rules are incorporated across the dashboard's overall architecture (such as consistent terminology and actions system-wide for Rule 1 and memory load reduction through visible tooltips for Rule 8), specific rules are selectively applied and highlighted in each module based on their relevance to the module's primary function. This targeted application avoids overabundance and focuses on the most impactful principles for that component, and ensures the design remains efficient and user-focused without forcing all rules into every element, which could complicate the interface. For instance, rules emphasizing feedback and control are prioritized in modules involving real-time interactions, while others like shortcuts are applied where frequent use is anticipated.

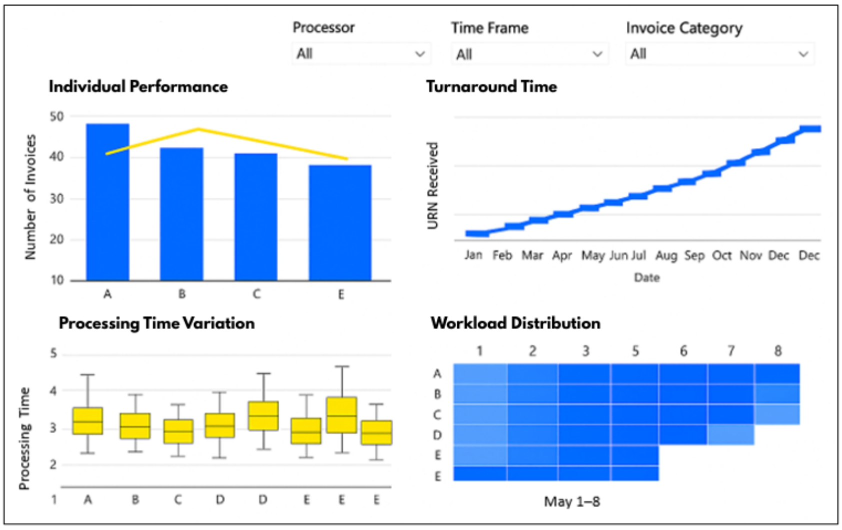

Figure 4. Proposed Four Core Module Dashboard for Invoice Processing Systems

4.2.1 Individual Performance Dashboard

This module utilises standardised bar charts to present both the volume of invoices processed by individual team members and their corresponding average processing times. This integrated visual approach enables direct benchmarking, allowing managers to quickly identify high-performing staff and those who need targeted support, such as retraining or workload adjustments. This design aligns with Rule 1: Strive for Consistency, by applying a uniform chart style across all processors, promoting intuitive navigation and interpretation. It also adheres to Rule

3: Offer Informative Feedback, as it delivers immediate visual insights into individual and comparative performance metrics. Furthermore, the inclusion of performance thresholds and comparative indicators supports Rule 4: Design Dialogs to Yield Closure, by enabling managers to make clear, data-driven decisions and take necessary corrective actions. These rules were chosen because this module focuses on comparative analysis and decision closure, where consistency and feedback are critical for quick insights; other rules such as shortcuts or error reversal are less central here but are implemented dashboard-wide for overall support.

4.2.2 Turnaround Time Tracker

A combination of line graphs and Gantt-style visuals to illustrate the complete invoice lifecycle from initial receipt (URN date) to final posting. This visual configuration allows users to detect processing delays and pinpoint bottlenecks at specific stages, facilitating informed decisions to streamline workflows and minimise cycle time. This component supports Rule 2: Enable Frequent Users to Use Shortcuts, as experienced users can quickly recognise timeline patterns using familiar chart types. It also follows Rule 3: Offer Informative Feedback by clearly highlighting performance gaps and delays that require managerial attention. When implemented with interactive filters, it satisfies Rule 6: Permit Easy Reversal of Actions, allowing users to switch views across timelines or departments without consequences, maintaining control and flexibility in data exploration. These rules were selected for their emphasis on efficiency and exploration in time-based tracking, rules like memory load reduction are applied more prominently in other modules but contribute here through simple, recognizable visuals.

4.2.3 Processing Time Variation

Box-and-whisker plots were used to evaluate the consistency of each processor's performance, highlighting anomalies, outliers, and variability in invoice processing times. By condensing complex data distributions into a single visual, the performance of the processors' irregularities was identified and a fair workload allocation and continuous performance monitoring can be achieved. This aligns with Rule 8: Reduce Short-Term Memory Load, as the compact visualisation minimises cognitive effort by summarising multiple metrics such as median, quartiles, and outliers at once. Rule 5: Offer Error Prevention is also addressed. This was due to the visualisation that highlighted abnormal values that could indicate data entry mistakes or workflow disruptions. Furthermore, it reinforces Rule 7: Support Internal Locus of Control, giving users autonomy to explore the data, diagnose inconsistencies, and initiate corrective actions independently. In this dashboard focus on these rules stems from the module's analytical nature, where preventing errors and empowering user control are key to handling variability; broader rules like consistency are enforced system-wide to complement this.

4.2.4 Workload Distribution View

This module employs a heatmap to depict the distribution of invoice processing tasks across individual processors over specified time intervals. The visualisation delivers immediate insight into workload disparities, enabling managers to make timely, data-driven decisions on resource reallocation to maintain operational balance. Aligned with Rule 1: Strive for Consistency, the use of a standardised colour gradient enhances pattern recognition and user familiarity. Rule 3: Offer Informative Feedback is fulfilled by clearly surfacing over- or under-utilisation, while Rule 4: Design Dialogs to Yield Closure is addressed by allowing users to validate the impact of adjustments through real-time visualisation of the updated workload distribution. These rules were prioritized because the module deals with distributional insights and action validation, making feedback and closure essential whereas other rules, such as reversal of actions, are integrated at the dashboard level for comprehensive usability.

5. Discussion

This study demonstrates the transformative potential of Artificial Intelligence (AI) and interactive visualization in optimizing financial operations within Shared Services Centres (SSCs). This aligns with previous study emphasis on efficient invoice processing mentioned in the introduction [1]. The dashboard integrates AI-enabled data extraction and real-time visualization, effectively addressing inefficiencies such as manual data handling and limited transparency, which identified as concerns with semi-automated systems [8]. Furthermore, this builds on the study's findings by reinforcing how AI-driven automation, as highlighted by previous study, alleviates the burden of routine tasks [12].

A key benefit is the dashboard's ability to lower human workload through automated performance data visualisation, enabling strategic decision-making, which supports the findings on minimising manual effort [12]. Explicitly tying back to the operational gaps in the problem statement the dashboard's real-time monitoring modules directly mitigate delays from slow client responses and disorganized documents by providing visual alerts for bottlenecks, reducing average processing times from 40-50 minutes to more efficient levels through proactive interventions. Regarding OCR limitations, the AI integration enhances data extraction accuracy beyond current semi-automated systems, addressing the recurring accuracy errors (116 YTD 2025 per country in Table 1) by flagging incomplete or handwritten data in visualizations like the Processing Time Variation module, thus preventing manual consolidation errors. The enhancement of SLA compliance through real-time alerts and drill-down features further validates insights on timely interventions to meet SLA targets [6], specifically resolving the timeliness misses (example, 37 in China YTD 2025) by enabling managers to track and adjust workflows in the Turnaround Time Tracker, ensuring adherence to benchmarks like 95% on-time processing. Visualising processing anomalies and workload imbalances, as noted in the study, optimises resource allocation, aligning with the conference theme of AI for enterprise efficiency and echoing emphasis on user-centred design [10]. This directly counters the monitoring challenges in the existing system, where lack of real-time visibility leads to inefficiencies, by offering dynamic views in the Workload Distribution module that facilitate balanced task assignment and reduce operational slumps.

Challenges, however, mirror those in the original discussion, with data quality issues like incomplete records requiring preprocessing, a point supported by [3] on data handling difficulties explicitly linked to OCR gaps in our problem statement. Integration with the SAP system presents interoperability challenges, consistent with observations on legacy systems [12]. Interpretability of AI insights remains a hurdle, necessitating clear communication, as addressed by [10] through Shneiderman's principles tying back to transparency needs in SLA monitoring.

Ethically, the dashboard's reliance on AI necessitates transparent oversight, which aligns with [10] emphasis on accountability. Auditability is essential for establishing trust, as highlighted in introduction section [1]. These elements foster human-AI collaboration, enhancing rather than replacing human judgment. This analysis complements the study's pathway for SSCs to achieve transparency and efficiency, building on [1, 6, 8, 10, 12] and suggests future focus on data quality and training to sustain this constructive collaboration.

6. Conclusion

This study highlights the potential of integrating Artificial Intelligence (AI) and interactive visualisation to enhance invoice management within the Procure-to-Pay (P2P) cycle. Through the application of AI-enabled data extraction and workflow automation, coupled with a Power BI–based dashboard, the proposed solution improves efficiency, accuracy, and transparency in Shared Services Centre operations. The dashboard provides real-time insights into processor performance and workload distribution, enabling data-informed managerial decisions, identifying bottlenecks, ensuring SLA compliance, and optimising resource utilisation. In addition to operational gains, the findings highlight the human-centred value of AI-powered visualisation by reducing manual oversight, simplifying the interpretation of complex data, and enabling more timely and effective interventions. Future research will focus on evaluating the dashboard's usability, performance, and impact through user studies and system testing. Additionally, enhancements will include integration with SAP Intelligent Robotic Process Automation (iRPA) to enable end-to-end automation, the addition of real-time monitoring functions for proactive decision-making, and deployment across multiple departments to support cross-functional performance management. These developments aim to establish a scalable and intelligent decision-support system that further promotes transparency and operational excellence in enterprise financial processes.

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Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this paper

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