INTEGRATION AND UTILISATION OF BIG DATA IN PERFORMANCE MANAGEMENT SYSTEM: A CASE STUDY OF AN INDONESIAN TRANSPORTATION COMPANY

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by

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LIST OF ABBREVIATIONS

AI	Artificial Intelligence
AKAP	Antar Kota Antar Provinsi (Inter-city and inter provincial)
API	Application Programming Interface
AVL	Automatic Vehicle Location
BA	Business Analytics
BDA	Big Data Analytics
BI	Business Intelligence
BPA	Business Performance Analytics
BPM	Business Performance Management
CPS	Cyber Physical Systems
ERP	Enterprise Resource Planning
GM	General Manager
GPS	Global Positioning System
HRD	Human Resource Development
GA	General Affairs
IoT	Internet of Things
IS	Information System
IT	Information Technology
ITS	Intelligent Transportation Systems
KPIs	Key Performance Indicators
MA	Management Accounting
MIS	Management Information Systems
LOC	Levers of Control
PMM	Performance Management and Measurement
PMS	Performance Management System
SAP	System Application and Product in Processing
STS	Socio-Technical System

INTEGRASI DAN PENGGUNAAN DATA RAYA DALAM SISTEM PENGURUSAN PRESTASI: KAJIAN KES DI SYARIKAT PENGANGKUTAN INDONESIA

ABSTRAK

Tujuan kajian ini dilakukan adalah untuk mengkaji proses penyatuan dan penggunaan data raya dalam Sistem Pengurusan Prestasi (PMS). Satu kajian kualitatif telah dilaksanakan, dengan menggunakan *constructivist grounded theory* untuk menganalisa data, dibantu oleh teori *Socio-Technical System* (STS) dalam membina rangka kerja secara teori. Kajian kes ini telah dijalankan di sebuah syarikat pengangkutan di Indonesia, dengan data dikumpul secara temu bual dan penganalisaan dokumen. Kajian ini memfokuskan kepada data raya yang diperoleh dari Sistem Penentudududukan Global (GPS). Dapatan kajian ini, telah membuktikan bahawa proses penyatuan data GPS dengan data dari PMS telah melancarkan proses pengoperasian, penyeliaan dan membuat keputusan. Pemacu utama dalam proses mengadaptasi dan menggunakan data GPS adalah termasuk pematuhan penggunaan, harapan dan tuntutan pihak kepentingan, kekangan kewangan dan ekonomi, dan mengurangkan risiko perusahaan. Proses integrasi merangkumi dimensi teknikal, organisasi dan kognitif yang melibatkan enam elemen penting dalam teori STS: matlamat, sumber manusia, teknologi, infrastruktur, proses dan budaya. Selain itu, proses kolaborasi telah muncul sebagai satu elemen baru dalam rangka kerja ini. Proses integrasi ini membolehkan data raya digunakan untuk membantu menjayakan objektif operasi organisasi, dan juga membantu membina budaya berpacukan data dalam organisasi. Kajian ini mempunyai implikasi kepada pihak pengurusan dengan memberi pencerahan bagaimana menggabungkan data raya ke dalam PMS dan juga menambah

baik budaya berpacukan data. Kajian ini turut memberi pencerahan kepada pihak kerajaan untuk melaksanakan polisi yang mengarahkan penggunaan teknologi di pelbagai industri. Selain itu, kajian ini memberikan implikasi secara teori tentang keberkesanan penyatuan data raya di dalam PMS, terutamanya dalam konteks pengangkutan awam, dengan membangunkan rangka kerja teori yang menggabungkan teori STS dan *constructivist grounded theory*. Kerangka kerja ini juga mengenal pasti elemen-elemen baharu yang melampaui ruang lingkup tradisional teori STS.

INTEGRATION AND UTILISATION OF BIG DATA IN PERFORMANCE MANAGEMENT SYSTEM: A CASE STUDY OF AN INDONESIAN TRANSPORTATION COMPANY

ABSTRACT

This study aimed to explore the integration and utilisation of big data into the Performance Management System (PMS). A qualitative case study approach was employed, utilising a constructivist grounded theory approach for data analysis, complemented by Socio-Technical System (STS) theory to guide the co-construction of the resulting theoretical framework. A case study was conducted at a transportation company in Indonesia, with data collected through in-depth interviews and document reviews. The study focused on Global Positioning System (GPS) data as the primary form of big data analysed. The findings revealed that integrating GPS-derived big data into PMS enhances operational efficiency, control, and decision-making processes. Key drivers of GPS data adoption and usage included regulatory compliance, stakeholder expectations and demands, financial and economic constraints, and the need to mitigate business risks. The integration process spans technical, organisational, and cognitive dimensions, involving six key elements of STS theory: goals, people, technology, infrastructure, processes, and culture. Additionally, collaboration emerged as a new element in the developed theoretical framework. This integration enables the alignment of big data capabilities with organisational performance objectives while enhancing data-driven culture within the organisation. This study provides implication for managers with insights on how to integrate big data into PMS and enhancing data-driven culture. This study also provides insights for governments to implement policies that promote the adoption of technology across different industries. In addition, this

study provides theoretical implications on the integration of big data in PMS, particularly within the context of public transportation, by developing a theoretical framework that combines STS theory with the constructivist grounded theory approach. This framework identifies emerging elements that extend beyond the traditional scope of STS theory.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This introduction chapter provides an overview of the research by discussing the background, problem statement, research objective, research questions, significance of the study, and key terms used in this study. The chapter starts with an overview of the phenomenon under study, followed by a problem statement explaining the issue of integrating big data into the PMS processes. Next, the objectives and research questions of the research are addressed. Chapter 1 also explains the rationale for the significance of integrating big data into the PMS processes, and the justification for the necessity of this research. The chapter concludes by detailing the organisation of the thesis.

1.2 Research Background

Technology development is transforming the business environment, necessitating companies' development of strategies and innovative processes to increase efficiency and adapt to changes (Konsek-Ciechońska, 2017). Innovation, uniqueness, and the application of cutting-edge technology are all necessary in meeting market needs and intense global competition (Godavarthi et al., 2023). Thus, a control system using technology focused on operational and strategic management to improve performance is required. Big data is one of the technologies that organisations need in order to facilitate real-time information processing and analysis for performance management (Daniri et al., 2023). Organisations utilise big data to build strategies that effectively address business trends by delivering real-time and valuable information, hence improving the decision-making process (Nudurupati et al., 2021). Consequently, big data can influence the way in which organisations manage their performance (De Mello et al., 2015). Therefore, the use of big data in an organisation allows it to improve its Performance Management System (PMS), which involves setting objectives, planning, measuring performance, controlling, rewarding, and managing performance in the organisation (Ferreira & Otley, 2009).

De Mello et al. (2015) found that big data can enhance a PMS to be more effective by providing real-time, valid, and accurate external data. This data affects business performance analysis, feedback, forecasting, and planning, enabling organisations to make decisions based on data effectively and profitably (De Mello et al., 2015). Many researchers have been working on transforming big data into meaningful information through big data analytics (BDA) (Ranjan et al., 2023; Jankova et al., 2023; Anitha et al., 2020). The information provided is crucial to PMS in determining suitable and appropriate Key Performance Indicators (KPIs), and for monitoring, reporting, and evaluation, thus enabling effective operational and strategic decision-making (Ferreira & Otley, 2009). Therefore, the use of information for decision-making is fundamental for diagnostic control and strategic validity control (Ferreira & Otley, 2009).

Big data usage in PMS supports the control system in organisations and facilitates data-driven decisions (Spanò & Ginesti, 2021). Managers should develop a data analytical culture among employees, in which decision-making is based on data and information analysis (Raffoni et al., 2018). This is crucial given how dynamic changes in the environment present challenges for a PMS in accurately assessing real-time performance. The analytical culture is essential for increasing the effectiveness of big data integration into an organisation's PMS.

Despite having many advantages, the practical implementation of effective big data integration in a PMS remains challenging. Moreover, traditional PMS frameworks face limitations in addressing this issue, as these frameworks do not incorporate emerging technology and external data usage into the PMS processes. Hence, some researchers developed new PMS frameworks by incorporating emerging technology and big data into the PMS (cf. Abai et al., 2015; Nudurupati et al., 2016; Appelbaum et al., 2017; Raffoni et al., 2018; Yin & Qin, 2019; Nudurupati et al., 2021; Robert et al., 2022). For instance, a study by Nudurupati et al. (2021) suggests three changes in performance management: transparency in sharing performance measures with stakeholders, accessibility of performance measures through visual management systems, and the use of information technology (IT) platforms such as social media in measuring performance.

Previous empirical research has addressed the use of big data in a PMS, covering issues related to changes in performance management and measurement (PMM) (Nudurupati et al., 2021), such as changes in KPIs that need to be monitored (Mawed & Hajj, 2017); the capability to store, retrieve and manage data in the system (Kokina et al., 2017); the analytics skills required for managerial decision-making (Delen & Ram, 2018; Raffoni et al., 2018); and the development of an evidence-based PMS using Business Performance Analytics (Raffoni et al., 2018). However, studies regarding the investigation of integrating big data within a PMS framework are still very limited in number. Understanding how to integrate big data into performance management remains a significant challenge (Nudurupati et al., 2016; Ji-fan Ren et al., 2017; Maulana et al., 2019; Sardi et al., 2020a).

Therefore, this study aims to investigate the integration of big data into the PMS processes, and to develop a theoretical framework to best describe the integration process. The case company in this study is an Indonesian transportation company utilising the Global Positioning System (GPS). The company uses GPS as per the Indonesian government regulation established in 2019 (Peraturan Direktur Jenderal Perhubungan Darat No. KP.2081/AJ.801/DRJD/2019, 2019), which requires all public transportation companies to use GPS in their vehicles. The Indonesian government plays a crucial role in driving the adoption of GPS-derived big data, showing that technology development in the country has been growing in recent years. Indonesia's big data ecosystem in the transportation industry is a collaborative network involving government agencies, private companies, technology providers, and research institutions. Key players include the Ministry of National Development Planning, which leads initiatives like the "Satu Data" platform to centralize dataset including transportation infrastructure (Satu Data, 2025), and Ministry of Communication and Information Technology, which supports digital infrastructure and data governance into transportation system. In urban areas, smart city initiatives in Jakarta, Bandung, and Surabaya utilize big data platforms to monitor traffic, optimize public transit, and enhance urban mobility. Private-sector players, including ride-hailing services like Gojek and Grab, contribute significantly by providing real-time data for route optimization and demand forecasting. Logistics companies and technology providers, such as Telkom Indonesia, play critical roles in supporting real-time tracking and analytics (Jakarta Smart City, 2025). This ecosystem enables efficient data sharing and decision-making, highlighting the importance of integrating big data into performance management systems to improve operational efficiency, policy-making, and service delivery across the transportation sector.

Indonesia is a vast archipelagic country and one of the nations with a large population. As Indonesia's urban population continues to grow, the government has prioritised transportation infrastructure improvements to meet increasing demands (Kementerian Keuangan Republik Indonesia, 2024). The Ministry of Transportation's Strategic Plan for 2020-2024 focuses on enhancing performance, safety, and connectivity, recognizing the critical need for substantial transformation in the public transportation sector. However, the sector faces several challenges. The Covid-19 pandemic severely impacted transportation, with inter-city and inter-provincial businesses (AKAP) incurring losses of IDR 1 trillion in just one month, alongside a significant decline in passenger numbers and workforce (merdeka.com, 2020; CNBC Indonesia, 2020). Post-pandemic, rising fuel prices and spare part costs, such as the high price of bus tyres, have increased financial pressures on companies, leading to higher ticket fares and a focus on cost efficiency (Kompas.com, 2022). Furthermore, traffic congestion in urban areas has worsened inefficiencies, increasing fuel expenses and travel times (Phiboonbanakit & Horanont, 2021). Hence, cost efficiency and service delivery have become challenges in the Indonesian transportation sector.

Big data is increasingly used in the transportation sector to enhance performance management systems (PMS) through various metrics. GPS data, for instance, helps measure punctuality, travel time, buffering time, and service levels (Li et al., 2015; Dock et al., 2017), while also contributing to the reduction of energy consumption and pollution (Cottrill & Derrible, 2015). Transportation providers leverage big data to identify service improvements such as rerouting, stop adjustments, and route optimisation (Hanft et al., 2016). GPS data is also used to monitor vehicle movement and predict road traffic, which enhances route planning (Singh et al., 2021; Xu et al., 2020). Furthermore, big data analytics (BDA) can improve employee performance by tracking vehicle and driver movements (Tseng & Levy, 2019; Van Waeyenberg et al., 2020). Additionally, BDA aids in identifying asset issues and predicting necessary maintenance, thereby improving asset management and leading to cost efficiency (Zhu et al., 2019; Nguyen et al., 2022). However, empirical research exploring big data and performance management in transportation companies is very limited. Previous studies in a transportation context have mainly focused on technical aspects, traffic control in particular (Venkata Ramana et al., 2018; Zhu et al., 2019; Shengdong et al., 2019; Xu et al., 2020). Research is required to investigate how transportation companies should effectively manage and utilise big data (Welch & Widita, 2019).

The motivation to conduct this study is driven by the fact that an empirical study is necessary to provide additional knowledge to the PMS literature by developing a theoretical framework that incorporates big data integration into the PMS processes. This study also has implications for organisations, providing insights for managers about the effective integration of big data into the PMS processes, which may allow the improvement of their business performance. The study investigation will be carried out in a transportation company, focusing on the integration of big data into the PMS of the case company. The insights and theoretical framework derived can potentially provide valuable direction for organisations to fully utilise the potential of big data.

1.3 Problem Statement

Organisations are utilising big data to respond to business trends. Big data is crucial for decision-making and operational management in organisations, as they shift from intuition to data-driven management due to dynamic economic conditions and the need to effectively utilise resources for competitiveness (Abai et al., 2019). A PMS enables management to establish organisational objectives and targets and facilitate decision-making in order to enhance operational efficiency and effectiveness in achieving organisational objectives (Tung et al., 2011). Big data usage in performance measures can offer an advantage in providing more accurate, real-time data (Nudurupati et al., 2022). However, traditional PMS framework has limitations in providing guidance for incorporating big data into PMS processes. It was developed with a focus on stable environments, making it challenging for PMS to adapt to dynamic environment settings, address rapid changes effectively, and deliver timely feedback. Traditional PMS framework typically rely on periodic performance reviews, such as annual or quarterly assessments (Ahid & Augustine, 2012), which may cause delayed feedback and hinder the ability to address issues promptly. These traditional PMS frameworks – for instance: the Balanced Scorecard by Kaplan and Norton (1992), the Levers of Control framework by Simons (1995), the Performance Prism by Neely (1999), and the PMS framework by Ferreira and Otley (2009) – also do not incorporate emerging technology and external information into the processes. Thus, their implementation often relies on manual data collection and reporting processes, which can cause the process not to capture relevant and up-to-date information.

Therefore, integrating big data into the PMS processes has become essential in improving the efficiency and effectiveness of PMS.

Li et al. (2022) found that BDA enhances decision-making quality and analytical capabilities, while Fatorachian and Kazemi (2021) found that big data improves real-time problem-solving, forecasting, and planning, thus enhancing decision-making quality and performance. However, a study by Reid et al. (2015) from PwC suggested that 35.8% of businesses across the UK, Europe and the US, despite having access to big data and related skills, have been unable to unlock value from big data. The study also showed that 25.8% of businesses do not employ big data or the skills needed in the organisation. Only 38.4% of organisations demonstrate that they derive value from the information acquired through big data. A recent study, conducted by Davenport and Bean (2022), surveyed senior corporate executives who were responsible for data and AI initiatives within their respective firms. The study found that 53.0% of organisations have developed a corporate data strategy to achieve business value, with only 59.4% of those organisations having positive results, suggesting that most organisations have not yet implemented a strategy for data-driven business outcomes. Organisations might face barriers such as a lack of coordination, a lack of courage and talent, cyber security concerns, and uncertainty about data sources, which could all hinder the successful utilisation of big data in their strategy (McKinsey&Company, 2016).

Hence, organisations need to address how to manage big data effectively in order to obtain value from the information acquired from big data. This requires the integration of big data into the PMS processes, which will lead to a more effective PMS. To effectively harness big data, organisations need to integrate it into the key processes of PMS. First, the determination of Key Performance Indicators (KPIs) involves setting organisational goals, aligning them with the organisation’s vision and mission. Big data enhances this process by providing real-time data on performance metrics, which can help refine the KPIs and set more accurate targets (Nudurupati et al., 2022). Second, the reporting, monitoring, and control process focuses on monitoring the implementation of strategies and controlling operational performance to ensure that organisational objectives are met (Tung et al., 2011). Big data facilitates this by offering continuous feedback through automated reporting systems, enabling organisations to track performance and make timely adjustments (Nudurupati et al., 2016). Third, performance evaluation and appraisal assess individual, departmental, or organisational performance. Big data enhances this process by providing a comprehensive view of performance, allowing for data-driven evaluations. Lastly, big data plays a crucial role in decision-making by offering insights that help management make informed decisions. It can identify areas for improvement, provide feedback, and inform reward systems based on performance. By enabling more data-driven decision-making, big data strengthens the feedback loop and leads to better outcomes in the future (Davenport & Bean, 2022). Thus, by integrating big data into these four PMS processes, organisations can enhance their ability to make more informed, real-time decisions, improve performance, and ultimately achieve their strategic goals. However, despite its potential, many organisations still face challenges in fully utilising big data due to issues such as lack of coordination, talent, or security measures, as highlighted in McKinsey&Company’s (2016) report. Therefore, the effective management of big data within the PMS framework is crucial for organisations seeking to gain a competitive advantages.

This is illustrated in Davenport and Bean's (2022) study that shows the significance of integrating big data into PMS to establish a data-driven culture within an organisation, from which value may be derived to improve company performance. Cultural impediments, such as evolving business processes, outdated structures, and human resistance, remain the greatest barrier, with 91.9% of respondents identifying these as the most significant challenges, while only 8.1% identified technological limitations as the greatest. The study shows how the challenge of integrating big data into organisational processes not only concerns the technological limitations of the company, but also its people, processes, and cultural factors. Consequently, big data needs to be organisationally, technically, and cognitively integrated into the PMS processes. Organisational integration refers to how the integration process is organised and structured (Moon et al., 2011) in the company, with defined roles to facilitate common integration practices between different departments (Gond et al., 2012). Technical integration refers to the methodological links describing how tools are used between the two interconnected systems (Gond et al., 2012), which are big data usage and the PMS processes. Furthermore, cognitive integration refers to the way in which people think to achieve shared cognition or perception of reality (Moon et al., 2011; Gond et al., 2012), which leads to the culture in which the usage of big data in the PMS processes occurs. Despite how important the integration process is in big data usage implementation, empirical investigation of big data integration into the PMS processes remains limited (Sardi et al., 2020a, 2020b).

Given that the development of PMS in the digital era is crucial, theories explaining technology usage in PMS remain limited. Some theories, such as organisational control theory and contingency theory, are often used to explain PMS in organisations; however, these theories provide only vague representations of the relationships between elements in organisations. Furthermore, there is no clear guidance on coordinating or integrating these elements, making it challenging to select an appropriate theory for empirical research (Wu et al., 2015). Thus, this study employs a constructivist grounded theory approach together with Socio-Technical Systems (STS) theory to uncover the elements that interplay in the process of big data integration into the PMS process. This study used STS theory as its guiding framework, which is highly relevant for exploring big data usage (Wadan & Teuteberg, 2019). STS theory highlights the interaction between social factors (e.g., goals, culture, and people) and technical factors (e.g., technology, infrastructure, and processes) within organisational systems (Sony & Naik, 2020). STS theory provides a holistic perspective on integrating big data into PMS by addressing both social and technical dimensions. While previous studies have primarily focused on either management capabilities (Delen & Ram, 2018; Raffoni et al., 2018) or factors influencing PMS implementation and outcomes (Fatorachian & Kazemi, 2021; Mawed & Hajj, 2017; Nudurupati et al., 2016), research combining these aspects is limited. This study fills this gap by examining the integration of GPS-based big data into PMS in a publicly listed Indonesian transportation company.

Public transportation systems in metropolitan cities face significant challenges, including travel time variability, congestion, and environmental pollution, which increase costs and reduce sector competitiveness (Harsha et al., 2020; Phiboonbanakit & Horanont, 2021). These issues are particularly acute in Indonesia, where the Covid-19 pandemic caused substantial losses, with inter-city and inter-provincial transportation businesses (AKAP) losing IDR 1 trillion in a single month due to declining activities, which also led to significant workforce reductions. (merdeka.com, 2020; CNBC Indonesia, 2020). Post-pandemic recovery has been hindered by rising fuel prices, spare-part costs, and persistent traffic congestion, which increases travel times and fuel expenses (Phiboonbanakit & Horanont, 2021; Kompas.com, 2022). A well-functioning public transportation system can alleviate these issues by reducing traffic congestion and offering a cost-effective alternative. Integrating technologies like GPS, sensors, and big data analytics (BDA), offer solutions to improve route planning, reduce delays, and predict maintenance needs, enhancing cost efficiency and competitiveness (Zhu et al., 2019). Big data applications in PMS have proven effective in monitoring travel time reliability, optimising routes, and improving service quality while reducing costs (Li et al., 2015; Dock et al., 2017; Singh et al., 2021). However, empirical studies regarding the integration of big data into the PMS in transportation sector are still rarely investigated. The majority of PMS development research consists of case studies focused on a firm operating in a single sector, which restricts its generalisability to other sectors (Hani et al., 2015; Yahaya et al., 2016; Leoni & Parker, 2019; Sanchez-Marquez et al., 2020; Nica et al., 2021). As such, this study aims to address the existing gap in the literature, theory and practice by using a case study to investigate the integration of big data into the PMS processes in a transportation company. The use of a qualitative case study could improve understanding of the phenomenon being studied.

1.4 Research Objectives

This study aims to investigate the integration and utilisation of big data into an organisation's PMS processes and developed theoretical framework that described the integration. Hence, the research objectives of the study are as follows:

1. To investigate the key factors that drive the adoption and usage of big data in the PMS processes.
2. To investigate the data used in the PMS processes, analysing the utilization and integration of data in the PMS processes, specifically in
   i) the determination of KPIs;
   ii) reporting, monitoring, and control;
   iii) performance evaluation and appraisal; and
   iv) decision-making.
3. To analyse the impact of the integration of big data into the PMS processes for the case company.

1.5 Research Questions

To address the research objectives of this study, research questions have been developed as follows:

1. What are the key factors that drive the adoption and usage of big data in the PMS processes?
2. What data are used and how they are integrated and utilised in the PMS

processes, specifically in

i) the determination of KPIs;

ii) reporting, monitoring, and control;

iii) performance evaluation and appraisal; and

iv) decision-making.

3. What is the impact of the integration of big data into the PMS processes for the case company?

1.6 Significance of the Study

Research regarding technology development and its impact on business trends has been widely discussed. Studying the impact of technology on a PMS is essential for organisations to properly utilise the advantages of technology, to improve employee performance and satisfaction, and to align their workforce with company goals in a constantly changing work environment. This study should contribute significant insight, both practically and theoretically, to performance management literature.

1. Practical significance

This study highlights how big data is integrated into the PMS processes of an organisation. This is significant because, although there are several advantages to using big data to enhance operational management efficiency, the empirical investigation of its utilisation in a PMS remains limited, particularly in the transportation industry. The findings of this study are advantageous for a diverse range of readers. Moreover, the study can help companies to assess the efficacy of utilising big data and integrating the data into the PMS processes. This facilitates the enhancement of the company's PMS processes through an investigation of the process and its influential elements. This study provides company managers with a guide for enhancing both operations management and strategy.

The findings are also significant for industrial needs in the strategic advancement of big data utilisation – not only in their operational management, but also at a strategic level. This study provides organisations with valuable insights and knowledge to enhance business performance by integrating big data into the PMS processes. Insights include the challenges that influence the integration of big data into the PMS processes, how companies utilise information from big data in the PMS processes, the integration process, and the impact of integration. This study highlighted the need for government to implement policies that promote the use of emerging technology across different industries. This study provides good example in formulating and implementing the mandatory use of GPS in transportation which enabled the optimisation of business operations. Therefore, well-designed policies can improve both organisational performance and the overall economic performance of the sector**.**

2. Theoretical significance

This study is important in seeking new insights into big data integration into the PMS framework, which involves complex interrelationships between internal and external factors. Existing theoretical frameworks that can be used to explain the integration of big data into the PMS processes are inadequate. For instance, organisational control theory, which is employed to define social and technical control in the PMS processes (Nudurupati et al., 2021); contingency theory, which is used to discover the factors that influence the PMS processes in organisations (Abugalia & Mehafdi, 2018; Azudin & Mansor, 2018; Hakmaoui & Loukili, 2017; Ibrahimi &

Naym, 2019; Issam et al., 2022; Rahim & Lotfi, 2018); and socio-technical systems theory, which is used to investigate the connection between social and technical aspects in the design and operation of complex systems (Sony & Naik, 2020) in a PMS (Bostrom & Heinen, 1977; Fabio et al., 2023; Ghaffari et al., 2019; Wadan & Teuteberg, 2019). However, due to the complexity of the technology, those existing frameworks only provide rough elements of the framework, with no guidance regarding the coordination or integration of each element within the framework (Wu et al., 2015).

This study employs a Constructivist Grounded Theory approach (Charmaz, 2000) to generate theoretical insights and fill gaps in the existing literature. This methodology was selected for two primary reasons. Firstly, Charmaz's (2000) approach supports the creation of a structured theoretical framework through systematic coding and categorisation, which helps build a more detailed and clearer framework. Secondly, the integration of big data into the PMS process involves complex social and technical components, necessitating a solid theoretical foundation to understand the issue relate to the topic of the research. This approach is both systematic and adaptable, offering flexibility to adjust to the research context and objectives while facilitating a multidisciplinary analysis of the data.

To incorporate Socio-Technical System (STS) theory into the research process, Mitchell's (2014) approach to data collection and analysis was utilised, which guided the development of research questions, interview questions, data coding, analysis, and theoretical integration. The combination of STS theory with constructivist grounded theory co-constructs the study, providing valuable insights into the social and technical dimensions of the system, which require further exploration to address the research issue. Hence, the constructivist grounded theory approach is utilised as it goes beyond the framework offered by STS theory, revealing additional elements and generating a theoretical framework that explains the integration of big data into PMS processes. It highlights the drivers of big data adoption and usage, and provides guidance on how its integration can lead to improvements in PMS and business performance.

1.7 Organisation of the Thesis

The thesis consists of six chapters. Chapter One focuses on the study's background and objectives, providing a brief explanation of the problem statement regarding the usage of big data in PMS, and PMS in the transportation context. It also covers the research objective, research questions, and the significance of the study.

Chapter Two focuses on reviewing previous research concerning big data and PMS. It emphasises technology development and its impact on the management control system, including PMS. The literature review also explores PMS in public transportation companies, identifying research gaps. By highlighting the findings from case study research, it emphasises the need for further research in this area. The chapter also explains PMS theories that may be relevant, but are not sufficiently comprehensive to explain the study's phenomena, leading to the adoption of a constructivist grounded theory approach.

Chapter Three discusses the study's adopted methodology. The chapter addresses the ontological and epistemological assumptions of the research, followed by an explanation of the rationale for choosing the interpretive qualitative case study method. The chapter further elaborates on the process of accessing and obtaining data from the case organisation, before outlining a brief background for the case company. The chapter concludes with an explanation of the data analysis using the constructivist grounded theory approach.

Chapter Four presents the findings derived from the case study and the data analysis. It demonstrates the evolution of the case organisation since the early 2010s technology adoption, and its changes following the adoption of GPS in the early 2020s. Specifically, the chapter illustrates the development of the organisation's PMS through the integration of big data. This chapter also explains how the data coding process led to the identification of categories related to the issue under study.

Chapter Five provides a discussion of the findings, while answering the research questions. This chapter also explains the theoretical integration. Constructivist grounded theory analysis explains the findings, covering causal conditions, core phenomena, intervening conditions, strategy development, and the consequences of integrating big data usage into the PMS. Finally, the developed theoretical framework – based on socio-technical systems theory and enriched by the emerging theory using a constructivist grounded theory approach – is detailed.

The final chapter concludes the study, discussing its implications and limitations. It offers suggestions for future research, with the aim of enhancing understanding of the complex and dynamic process of integrating big data usage into PMS.

1.8 Key Terms Used in the Study

The study uses some important key terms. These key terms are briefly explained as follows:

Table 1.1 Key Terms

No	Key Terms	Definition	Source
1.	Performance Management System	A PMS represents formal and informal mechanisms, processes, systems, and networks used by organisations to	Ferreira and Otley (2009)

No	Key Terms	Definition	Source
		communicate the key objectives and goals defined by management, and assist the strategic process and ongoing management through analysis, planning, measurement, control, rewarding, managing performance, and facilitating organisational learning and change.	
2.	Big data	Data that is generated at a high speed and in large quantities, often coming from various sources and in different formats. Big data are characterised by various vectors, such as the volume, variety, velocity, veracity, and value of data. Volume is the size of data set generated from various sources. Variety is the heterogeneous nature of data, including textual data, data from social media, data traffic information, and data from any field (such as health information, business, politics, etc.). Velocity focuses on the data collection process and the speed of data generated in real time. Veracity is the reliability of data sources. Finally, value focuses on hidden insights and values within the dataset.	Ajah and Nweke (2019)
3.	Big data analytics (BDA)	BDA is the process of using analysis algorithms running on platforms to obtain competitive advantage information from data.	Sardi, Sorano, Cantino, et al., (2020)
4.	Descriptive analytics	A data analysis process which gathers historical and current data from external sources and displays the data in an understandable manner for managers.	Ajah and Nweke (2019)
5.	Diagnostics analytics	The analysis of collected data patterns from descriptive analytics to ascertain the cause of certain events in the past.	Ajah and Nweke (2019)
6.	Predictive analytics	The analysis of collected data to predict what will happen in the future.	Ajah and Nweke (2019)
7.	Prescriptive analytics	The analysis of data to produce future opportunities or advantages, prescribing the best way to exploit them.	Ajah and Nweke (2019)
8.	Constructivist Grounded Theory	Constructivist grounded theory is a research methodology that uses inductive–abductive logic, where researchers iteratively move between data and conceptualisation, generating initial observations, formulating theoretical explanations, and then validating or refuting them through further data and theoretical sampling. It combines	Charmaz (2017)

No	Key Terms	Definition	Source
		data-driven insights with existing theories to enhance theoretical sensitivity, guided by a literature review and a clearly formulated research question	
9.	Integrated information system	An integrated information system is a system consisting of various interconnected data components, applications, and technologies to support information needs.	Perdana (2012)
10.	Global Positioning System	The GPS is a range-based positioning system that yields an obscure object's 3D position on top of the earth. This system collects estimates or range data from realised emanating sources to determine the position of obscure objects, and the system is also called a positioning system based on satellites.	Kumar and Dutt (2019)
11.	Data coding	A data analysis process in which the researcher identifies patterns, themes, and concepts from the data collected.	Strauss and Corbin (2015)
12.	Open coding	The first data coding process, generating a list of initial codes, which are words or phrases that describe the content of the data.	Strauss and Corbin (2015)
13.	Axial coding	The second data coding process, which organises the initial codes from the open coding step into categories and subcategories.	Strauss and Corbin (2015)
14.	Selective coding	The final step of the data coding process, generating a core category, which is used to tie together the other categories and codes, providing a framework for the theory.	Strauss and Corbin (2015)
15.	Theoretical sampling	A data sampling process involving the selection of new participants or sources based on emerging concepts and categories (to be subsequently interviewed), who can provide rich information and insights to enhance the development and refinement of the theory.	Shiau and George (2014)
16.	Memoing	Documenting comparisons and analytical reflections on the data to generate theoretical ideas and guide theoretical sampling.	Rieger (2019)
17.	Theoretical saturation	The point at which the data analysis process has generated a theory that explains the phenomenon being studied, with further data collection being no longer necessary	Strauss and Corbin (2015)
18.	Theoretical integration	The process of creating a narrative that explains the relationships between the concepts, categories, and themes identified in the data analysis, and producing a	Strauss and Corbin (2015)

No	Key Terms	Definition	Source
		theoretical framework that best describes the phenomena being studied.	
19.	Core phenomenon in the Grounded Theory framework	The central issue that establishes connections among the emerging categories derived from the data, and encompasses the primary theme that elucidates the theory.	Strauss and Corbin (2015)
20.	Causal condition in the Grounded Theory framework	The factors that drive the emergence of the core phenomenon.	Strauss and Corbin (2015)
21.	Intervening condition in the Grounded Theory framework	The factors that influence how the core categories are connected or interact with each other. These intervening conditions are important in forming this understanding in order to explain the phenomenon under investigation.	Strauss and Corbin (2015)
22.	Actions in the Grounded Theory framework	A concept or action that individuals or groups employ to address challenges or achieve specific goals within the context of the studied phenomenon. These elements represent the tactics, approaches, or methods used by participants to address issues.	Strauss and Corbin (2015)
23.	Consequences in the Grounded Theory framework	The outcomes, effects, or results that emerge as a result of the actions, interactions, or strategies employed by individuals or groups within the context of the studied phenomenon.	Strauss and Corbin (2015)
24.	Traditional PMS framework	A traditional PMS framework is a structured approach to evaluating and managing performance using conventional methods and tools, typically without heavy reliance on digital technology.	Fu (2021)
25.	Contemporary PMS framework	A contemporary PMS framework is a framework for performance measurement and management in the context of the digital economy, which integrates modern technology to optimise organisational performance in dynamic environments. This framework leverages advanced digital technology tools and platforms to enhance agility, transparency, and efficiency in managing performance.	Nudurupati et al. (2016)

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter extensively reviews previous research on the topics of big data and PMS. It delves into advancements in technology and their influence on the management control system, with a particular focus on how these developments impact PMS. The literature review also examines the specific context of PMS within public transportation companies, aiming to identify any gaps in existing research. By synthesising the findings from case study research, the chapter highlights the need for further investigation in this field. Furthermore, the chapter explores various theories in the literature that explain PMS. While these theories offer valuable insights, they may not be sufficiently comprehensive to fully explain the phenomena under study. This chapter concludes by discussing the research gaps identified during the literature review.

2.2 Technology Development and Big Data

Technology innovation involving social media, IoT, internet connectivity, process automation, and big data is used by organisations to respond to business trends. In organizations with higher automation levels, advanced production facilities provide access to more real-time data, which not only increase production efficiency but also equips managers with valuable insights for decision-making (Papiorek & Hiebl, 2024). Social networks also enable organisations to monitor and analyse customer opinion, market trends, competitor issues, or employee behavioural issues (Nudurupati et al., 2021). IoT is one of the fastest-developing technologies. IoT has direct or indirect ability to make things and objects able to store, process, share, and exchange data information using internet connections both within companies and with stakeholders, in a shorter timeframe (Nudurupati et al., 2021; Szozda, 2017). The transformation of the economy and business can be seen in the integrated business processes of procurement, manufacturing, maintenance, delivery, and customer service connected through IoT systems (Özüdoğru et al., 2018). Big data refers to large datasets notable for their diversity, frequent updates, and rapid data expansion (Tang & Liao, 2021). Furthermore, as big data provides business insights to help companies develop their strategy (Rijmenam et al., 2019), its usage has altered how organisations manage their performance, moving away from intuition towards data-driven decision-making (Jia et al., 2015). Similarly, insights from Martins et al.'s (2024) study show that the adoption of business intelligence systems has improved management control by using process automation and standardization of reporting for strategic decision-making.

Contemporary businesses increasingly rely on technology, prompting management to prioritize enhancing system quality (Papiorek & Hiebl, 2024). As shown in McKinsey&Company's (2016) report. firms operating in digital era may be facing barriers that hinder the successful advanced technology implementation required to survive during the digitalisation era, as follows:

1. Difficulty in coordinating actions across different organisational units;
2. Lack of courage to push through radical transformations;
3. Lack of necessary talent;
4. Concerns about cyber security when working with third-party providers;
5. Lack of a clear business case to justify investments in underlying IT architectures;
6. Concerns regarding data ownership;

7. Uncertainty about which Industry 4.0 applications to source internally, and which to source from third-party providers, as well as a lack of knowledge about suitable providers; and
8. Challenges in integrating data from disparate sources in order to enable Industry 4.0 applications.

According to Davies (2015) and Fonseca (2018), there are some challenges that must be overcome by firms in response to the technology's development. First, investment in ICT technology is required to support the business process. Second is the adoption of new collaborative business models, including new possible partners. Technology development enables organisations to expand their networks, since organisations in the digital transformation era require strong leadership, collaboration, and stakeholder models and networks. Third is the protection of the data to ensure trust, confidentiality, and security.

Organisations utilise digital technologies such as social networks, IoT, and big data to enhance decision-making. For example, as previously stated, social networks enable organisations to monitor and analyse customer opinion, market trends, competitor issues, or employee behavioural issues (Nudurupati et al., 2021). Information obtained from big data could be used to improve an organisation's PMS, i.e. the process of establishing objectives, defining a set of performance measures, and collecting, analysing, reporting, interpreting, reviewing, and acting on performance data (Bititci et al., 2015). Therefore, a PMS plays a crucial role in decision-making,