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Data-Driven Decision-Making in the Public Procurement System

The Case of Norway

Doctoral thesis

NTNU
Norwegian University of Science and Technology
Thesis for the Degree of
Philosophiae Doctor
Faculty of Economics and Management
Dept. of Industrial Economics and Technology
Management

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Abstract

The government's procurement choices shape our everyday routines and the environment in which we exist. Public procurement is defined by the EU Commission (2017, p. 3) as 'the process by which public authorities, such as government departments or local authorities, purchase work, goods, or services from companies. The process aims to fulfil government needs, efficiently utilise public resources, and promote competition in the market. Lately public procurement has also been seen as a central policy tool for promoting societal goals, such as innovation, CO2 reduction, and improved work conditions. This thesis recognises public procurement as consisting of multiple stakeholders at different government levels and, in line with Thai (2001), defines public procurement as a system. This understanding conforms with the Organisation for Economic Co-operation and Development (OECD, 2023), which claims that to ensure that the procurement system reaches its goals, it must include five key elements: (1) a sufficient legislative framework; (2) a suitable institutional and administrative infrastructure; (3) an efficient sanctions regime; (4) an effective review and accountability regime; and (5) adequate human, financial, and technological resources to support all system components.

The Norwegian public procurement system involves ca. 3,000 public procurement officers (Meld.St.22, 2018–2019), which is around 0.3% of the government workforce (Ministry of Labour and Inclusion, 2022). In 2022, this group was involved in roughly 41% of the total public expenditure (Ministry of Finance, 2022). In 2022, €63 billion was spent on the procurement of services and supplies, as reported by Statistic Norway (2023a). An assessment of Norway's public procurement system by the OECD's Methodology for Assessing Procurement Systems (MAPS, 2018) identified that the Norwegian system has an acceptable legislative framework and sanctions regimes with a decentralised institutional and administrative infrastructure that involves stakeholders at the national policy and operational levels. At the policy level, national governments, government agencies, and regulatory authorities make guidelines and regulations and impose sanctions. The operational level consists of procurement officers who conduct the procurement processes, suppliers who deliver goods and services, and end users of the product or service (MAPS, 2018). However, the OECD assessment indicated that a challenge for the Norwegian public procurement system was a lack of evaluation and feedback mechanisms. There is an absence of systems that utilise procurement data to assist decision-makers in making informed decisions and evaluating the effects of the procurement process (MAPS, 2018, 2020). The need for better information in public procurement systems is also supported by the European Commission (2017), which has emphasised the importance of improved data, feedback mechanisms, and data-driven decision-making (DDDM) for the management of public finances.

Provost and Fawcett (2013) define DDDM as 'the practice of basing decisions on the analysis of data rather than on intuition'. Based on the above discussion, this thesis seeks to answer the following primary research question: *What are the mechanisms that drive the adoption of DDDM in the public procurement system of Norway, and how does DDDM influence organisational performance?* Three subsequent sub-questions are examined to answer the primary research question:
- *RQ1: What is the state of the art in research and practice on the adoption of DDDM within public procurement systems?*
- *RQ2: Which mechanisms within the public procurement system of Norway stimulate or suppress the adoption of DDDM?*

- *RQ3: How can DDDM adoption potentially impact organisational performance in Norway's public procurement system?*

To answer these questions, the thesis employs a theoretical framework with perspectives from systems theory and management cybernetics, decision-making, and technology adoption. The thesis adopts a pragmatic philosophical perspective in the sense that it emphasises practical outcomes and looks at the problem from different perspectives and with different methods. Four research projects have been conducted with the application of multiple research methods. The empirical element involved qualitative and quantitative data from Norway and a multi-method research design. The main findings from the four projects are presented below.

Paper I shows an uneven distribution of research on public procurement, where research on feedback and DDDM has received little attention. Only nine out of 335 papers in the last two decades are related to these topics. Paper II reveals that 61% of Norwegian government procurement entities have not adopted spend analytics, with variations in adoption across different public entity types. The study finds that the adoption of DDDM in the form of spend analytics correlates with procurement analysis expertise and organisational factors such as procurement volume and organising a centralised procurement. Paper III shows that the adoption of DDDM is low at both the policy and operational levels. Feedback loops are missing both among stakeholders at the operational level (horizontal) and between the operational and policy levels (vertical). Mechanisms that suppress DDDM adoption include a lack of structural relationships, information systems, and guidelines to standardise the assessment of effects. The shortage of standardised assessment results in subjective and inconsistent interpretations of, for example, the sustainability effects of public procurement among different stakeholders within the system. Paper IV demonstrates that structural mechanisms stimulate the adoption of DDDM in public procurement. The structural relationship that best stimulates adoption is digital motivation, which drives digital proactive behaviour. This digital drive positively impacts the development of goals for digitalising public procurement. To be data driven, public organisations must also establish business intelligence systems to collect and analyse data. The procurement organisations that include all these elements are more data driven and show better performance through reduced inefficiency and improved effectiveness.

The findings from the four papers are summarised and combined in a new proposed framework for DDDM in the Norwegian public procurement system, presented in the discussion section. The framework illustrates how the operational level and policy level can interact via a new technology information layer, influencing the procurement process. Horizontal feedback loops at the operational level encourage cooperation among stakeholders, while vertical loops facilitate policy modification based on insights from practice. Moreover, the circular description of procurement stages emphasises a continuous improvement process, based on feedback. The findings of the study can provide grounds for several important implications for both policy and practice. At the policy level, this understanding can help policymakers identify where vertical and horizontal feedback mechanisms are required to better manage the procurement system. At the operational level, the findings indicate that public companies should begin by setting goals for digitalisation, train staff in analytical skills, and invest in business intelligence systems. While this thesis focuses specifically on the public procurement system of Norway, the findings and contributions can also be relevant outside of Norway. The challenges of collecting and using public procurement data to aid decision-makers in making informed decisions are not exclusive to Norway and can be seen in public procurement systems worldwide.

The limited attention given to research on DDDM in public procurement systems and the limitations of this thesis also have implications for future research. Future studies could explore the adoption of DDDM and its impact on performance in other cultural contexts, DDDM's technical aspects, and how new technologies such as AI and blockchain can affect decision-making. Additionally, investigating the influence of organisational characteristics on the adoption of DDDM can be rewarding. Overall, adopting DDDM in the public procurement system enables government officials to make informed decisions at both policy and operational levels. This approach, fostering enhanced communication and system feedback, improves public procurement performance. The adoption of DDDM in the public procurement system can thereby benefit us all.

Abstract in Norwegian

Det offentlige sine innkjøpsvalg former våre daglige rutiner og miljøet vi lever i. Offentlige anskaffelser er definert av EU-kommisjonen (2017, s.3) som 'prosessen hvor offentlige myndigheter, som departementer eller kommuner, kjøper arbeid, varer eller tjenester fra private bedrifter.' Prosessen har som mål å oppfylle offentlige behov, effektivt utnytte offentlige ressurser og fremme konkurranse i markedet. I det siste har offentlige anskaffelser også blitt sett på som et sentralt politisk verktøy for å fremme samfunnsmål som innovasjon, CO2-reduksjon og forbedre lønns og arbeidsvilkår. Denne avhandlingen tar utgangspunkt i at offentlige anskaffelser består av flere interessenter på forskjellige nivå i det offentlige og definerer i tråd med Thai (2001) offentlige anskaffelser som et system. Denne forståelsen er i samsvar med organisasjonen for økonomisk samarbeid og utvikling (OECD; 2023), som hevder at for å sikre at anskaffelsessystemet når sine mål, må det inkludere fem nøkkelelementer: (1) et tilstrekkelig lovverk; (2) en passende institusjonell og administrativ infrastruktur; (3) et effektivt sanksjonsregime; (4) ett effektivt feedback og ansvarlighetsregime; og (5) tilstrekkelige menneskelige, økonomiske og teknologiske ressurser for å støtte de andre systemkomponentene.

Det norske offentlige anskaffelsessystemet involverer ca. 3000 offentlige innkjøpere (Meld.St.22, 2018-2019) som utgjør ca. 0,3% av den norske arbeidsstyrken (Arbeids- og inkluderingsdepartementet, 2022). I 2022 var disse offentlige innkjøperne involvert i omtrent 41% av Norges totale offentlige utgifter (Finansdepartementet, 2022). I 2022 ble det brukt 743 NOK milliarder til anskaffelse av varer og tjenester (SSB 2023a). En vurdering av Norges offentlige anskaffelsessystem ved OECDs metodikk (MAPS; 2018) identifiserte at det norske systemet har et akseptabelt lovverk og sanksjonsregime med en desentralisert institusjonell og administrativ infrastruktur som involverer interessenter på nasjonal policy nivå og operasjonelt nivå. På policy nivå lager politikere, nasjonale myndigheter og tilsynsmyndigheter retningslinjer, forskrifter og pålegger sanksjoner. Det operasjonelle nivået består av offentlige innkjøpere som gjennomfører anskaffelsesprosessene, leverandører som leverer varer og tjenester, og sluttbrukere av produktet eller tjenesten (MAPS, 2018). Imidlertid indikerte OECD-vurderingen at en utfordring for det norske offentlige anskaffelsessystemet var mangel på evaluerings- og feedbackmekanismer. Det mangler systemer som bruker anskaffelsesdata for å hjelpe beslutningstakere med å ta informerte beslutninger og evaluere effekten av anskaffelsesprosessene (MAPS, 2018 og 2020). Behovet for bedre informasjon i offentlige anskaffelsessystemer støttes også av EU-kommisjonen (2017), som har understreket viktigheten av forbedret data, feedbackmekanismer og datadrevet beslutningstaking (DDDM), for forvaltningen av offentlige finanser. Provost og Fawcett (2013) definerer DDDM som 'praksisen med å basere beslutninger på analyse av data i stedet for på intuisjon'.

Basert på diskusjon ovenfor søker denne avhandlingen å svare på følgende primære forskningsspørsmål: *Hvilke mekanismer driver bruk av DDDM i det offentlige anskaffelsessystemet i Norge, og hvordan påvirker DDDM organisatorisk ytelse?* Tre etterfølgende underspørsmål undersøkes for å svare på det primære forskningsspørsmålet:
- *RQ1: Hva er status på forskning og praksis knyttet til bruk av DDDM i offentlige anskaffelsessystemer?*
- *RQ2: Hvilke mekanismer innen det offentlige anskaffelsessystemet i Norge stimulerer eller hemmer bruk av DDDM?*
- *RQ3: Hvordan kan bruk av DDDM påvirke organisatorisk ytelse i det norske offentlige anskaffelsessystemet?*

For å besvare disse spørsmålene benytter avhandlingen et teoretisk rammeverk med perspektiver fra systemteori, styringskybernetikk, beslutningstaking og teknologiadopsjon. Avhandlingen tar utgangspunkt i et pragmatisk vitenskapssyn i betydningen at den vektlegger praktiske resultater og ser på problemstillingen fra ulike perspektiver og med ulike metoder. Fire forskningsprosjekter er gjennomført med bruk av ulike forskningsmetoder. Det empiriske elementet har bestått av kvalitative og kvantitative data fra Norge og et multimetodisk forskningsdesign. De viktigste funnene fra de fire prosjektene presenteres nedenfor.

Artikkel I viser en ujevn fordeling av forskning på offentlige anskaffelser, der forskning på feedback og DDDM har fått lite oppmerksomhet. Bare ni av 335 artikler de siste to tiårene var relatert til disse temaene. Artikkel II viser at 61 % av norske offentlige virksomheter ikke gjennomfører forbruksanalyser, med variasjon i bruk på tvers av ulike offentlige enhetstyper. Studien finner at bruk av DDDM i form av forbruksanalyse har sammenheng med kompetanse i anskaffelsesanalyse og organisatoriske faktorer som anskaffelsesvolum og organisering av en sentralisert anskaffelsesenhet. Artikkel III avdekker at bruk av DDDM er lav på både policy og operasjonelt nivå. Feedbacksløyfer mangler både mellom interessenter på operasjonelt nivå (horisontalt) og mellom det operasjonelle og policy nivået (vertikalt). Mekanismer som hemmer bruk av DDDM inkluderer mangel på strukturelle relasjoner, informasjonssystemer og retningslinjer for å standardisere vurderingen av effekter. Mangelen på standardiserte vurderinger fører til subjektive og inkonsistente tolkninger av for eksempel bærekraftseffekter av offentlige anskaffelser blant ulike interessenter innenfor systemet. Artikkel IV demonstrerer at strukturelle mekanismer stimulerer implementering av DDDM i virksomheters offentlige anskaffelser. Den strukturelle relasjonen som best stimulerer implementering er digital motivasjon, som driver digital proaktiv atferd. Denne digitale drivkraften påvirker positivt utviklingen av mål for digitalisering av offentlige anskaffelser. For å være datadrevet må offentlige organisasjoner også etablere datasystemer for å samle inn og analysere data. Anskaffelsesorganisasjonene som inkluderer alle disse elementene, er mer datadrevne og viser bedre ytelse gjennom redusert ineffektivitet og økt effektivitet.

Funnene fra de fire forskningsartiklene er oppsummert og kombinert i et nytt foreslått rammeverk for DDDM i det norske offentlige anskaffelsessystemet, presentert i diskusjonsdelen av avhandlingen. Rammeverket illustrerer hvordan det operasjonelle og policy nivået kan samhandle via et nytt teknologiinformasjonslag for å påvirke anskaffelsesprosessen. Horisontale feedbacksløyfer på operasjonelt nivå oppmuntrer til samarbeid mellom interessenter, mens vertikale feedbacksløyfer bidrar til policyutvikling basert på innsikt fra praksis. I tillegg understreker den sirkulære beskrivelsen av anskaffelsesprosessen en kontinuerlig forbedringsprosess, basert på feedback. Funnene fra studien kan gi grunnlag for flere viktige implikasjoner for både policy og praksis. På policy nivå kan denne forståelsen hjelpe beslutningstakere med å identifisere hvor vertikale og horisontale feedbackmekanismer er nødvendig for å bedre styre anskaffelsessystemet. På det operasjonelle nivået indikerer funnene at offentlige selskaper bør begynne med å sette mål for digitalisering, trene ansatte i analytiske ferdigheter og investere i nye datasystemer. Selv om denne avhandlingen spesifikt setter søkelys på det offentlige anskaffelsessystemet i Norge, kan funnene og bidragene også være relevante utenfor Norge. Utfordringene med å samle inn og bruke offentlige anskaffelsesdata for å hjelpe beslutningstakere med å ta informerte beslutninger er ikke unike for Norge og kan ses i offentlige anskaffelsessystemer over hele verden.

Den begrensede oppmerksomheten som er gitt til forskning på DDDM i offentlige anskaffelsessystemer og begrensningene i denne avhandlingen har også implikasjoner for fremtidig forskning. Fremtidige studier kan utforske bruken av DDDM og dens innvirkning på

ytelse i andre kulturelle sammenhenger, DDDM sine tekniske aspekter kan undersøkes nærmere og hvordan nye teknologier som AI og blockchain kan påvirke beslutningstaking. I tillegg kan undersøkelser av påvirkningen av organisatoriske kjennetegn på adopsjon av DDDM være givende. Totalt sett gjør bruk av DDDM i det offentlige anskaffelsessystemet at ansatte i systemet kan ta informerte beslutninger på både policy og operasjonelt nivå. Denne tilnærmingen, som fremmer forbedret kommunikasjon og feedback, forbedrer ytelsen til offentlige anskaffelser. Bruk av DDDM i det offentlige anskaffelsessystemet kan dermed komme oss alle til gode.

Acknowledgements

Part I Content

Part II Content: The papers

Paper I – Appendix I
Langseth, M., De Boer, L., & Moe, H. T. (2023). Two decades of Journal of Public Procurement: Content Analysis and Theoretical Expansions of the Thai Model. Submitted to *Journal of Public Procurement*.

Paper II – Appendix II
Langseth, M., & Haddara, M. (2023). Spend Analytics in Norwegian Public Procurement: Adoption Status and Influencing Factors. Under review in *International Journal of Information Systems and Project Management*.

Paper III – Appendix III
Langseth, M., & Moe, H. T. (2022). Driving through dense fog: a study of the effects and control of sustainable public procurement of electric cars. Published in *Environment Systems and Decisions*.

Paper IV – Appendix IV
Similiä, J. O., Mwesiumo, D., Langseth, M., & Haddara, M. (2023) Antecedents and implications of Data-Driven Decision-Making in public procurement. Accepted in *International Journal of Procurement Management*.

*The composition of this thesis follows the conventions of British English. However, due to specific publication prerequisites, Papers I, II, and IV are composed in American English, while Paper III maintains British English. This language variance is related to the requirements of the corresponding academic journals.

List of Figures and Tables

Figures

Tables

Abbreviations and terms

Abbreviations

ANT: Actor network theory
DDDM: Data-driven decision-making
EU: European Union
EV: Electric vehicle
JoPP: Journal of Public Procurement
MAPS: Methodology for Assessing Procurement Systems
OECD: Organisation for Economic Co-operation and Development
PLS-SEM: Partial least squares structural equation modelling
RBV: Resource-based view
SPP: Sustainable public procurement
TAM: Technology acceptance model
TOE: Technology, organisation, and environment framework
TPB: Theory of planned behaviour

Terms

Feedback control loop: The idea behind feedback control is that the system's output is constantly measured and fed back into the system to manage the resulting outputs. This allows the system to adjust its behaviour, which consequently results in the system becoming effective and efficient.

Operational level: The operational level relates to the level accountable for managing daily operations in the public procurement system. This level makes decisions related to the implementation of strategies and plans made at the policy level, ensuring the effective functioning of public procurement processes and activities.

Paper: The individual papers as attached in the appendix.

Policy level: The policy level relates to central government decision-making, wherein central objectives and strategies are established. Decision-making at this level tends to possess a wide breadth and may affect numerous individuals or organisations.

Public procurement officer: The public procurement officer is the person responsible for conducting the procurement process. The public procurement officer works at the operation level and is involved in decision-making about, for example, supplier selection.

Study: The overall case study of the Norwegian public procurement system in the thesis.

1 Introduction

1.1 Background

The government's procurement choices shape our everyday routines and the environment in which we live our lives. According to the EU Commission (2023, p. 3), public procurement is defined as 'the process by which public authorities, such as government departments or local authorities, purchase work, goods, or services from companies'. The public procurement process involves several steps, including identifying internal needs, specifying requirements, running competitions to select suppliers, and implementing and enforcing contracts (Trepte, 2007). Public procurement is a significant process for governments because a substantial part of their budgets goes to purchasing goods and services from private sector companies. Recent research, such as that by Grandia et al. (2023), has shown that public procurement also serves as a strategic policy tool for stimulating various political objectives, such as inclusiveness, work conditions, and environmentally friendly products or services. Public procurement also encourages competition and innovation in the market by letting suppliers compete for government contracts (Rolfstam, 2009).

As a significant process within public administration, public procurement plays a vital role in the functioning of societies and economies (Trammell et al., 2020). However, the scale of public procurement also brings with it a set of challenges. The complexity and considerable resources involved require not only a process but also a public procurement system that is efficient, transparent, and fair (Thai, 2001; Arrowsmith, 2018). The Organisation for Economic Co-operation and Development (OECD, 2023) outlines five elements that are fundamental to ensure that the procurement system meets the needs of citizens and promotes the efficient and effective use of government money: (1) an adequate legislative framework; (2) an adequate institutional and administrative infrastructure; (3) an effective review and accountability regime; (4) an effective sanctions regime; and (5) adequate human, financial, and technological resources.

In 2022, the Norwegian procurement system involved ca. 3,000 public procurement officers (Meld.St.22, 2018–2019) or around 0.3% of the government workforce (Ministry of Labour and Inclusion, 2022). In 2022, these people spent around €63 billion on purchasing services and supplies (Statistic Norway, 2023a), which accounted for ca. 40% of Norway's total public spending (Ministry of Finance, 2022). The Norwegian public procurement system supported a population of 5.4 million people in 2022 (Statistic Norway, 2023b). An assessment of Norway's public procurement system by the OECD Methodology for Assessing Procurement Systems (MAPS, 2018) identified that the system has an acceptable legislative framework and sanctions regime. The institutional and administrative infrastructure is decentralised and consists of stakeholders at the national policy and operational levels. At the policy level, national governments, government agencies, and regulatory authorities make guidelines and regulations and impose sanctions. The operational level consists of procurement officers who conduct the procurement processes (MAPS, 2018), suppliers who deliver goods and services, and end users who eventually use the product or service.

However, the OECD assessment indicated that a challenge for the Norwegian public procurement system was the lack of evaluation and feedback mechanisms. There is an absence of systems that utilise procurement data to assist decision-makers in making informed decisions and evaluating the effects of the procurement process (MAPS, 2018). This challenge was reiterated in a parliamentary report from the Norwegian government (Meld.St.22, 2018–2019), which identified a lack of systems or strategies to inform decision-making in the public procurement system. The lack of such systems was once again noted when the OECD carried out a new evaluation in 2020, focusing on sustainable public procurement (SPP). The final report highlighted the fact that statistics on the sustainability effects of public procurement are not available (MAPS, 2020). The need for better information in public procurement systems is also supported by the European Commission (2017), which has emphasised the importance of improved data, feedback mechanisms, and data-driven decision-making (DDDM) for the management of public finances.

1.2 Decision-making in the public procurement system

The Norwegian public procurement system meets its goals by employing political, legal, and managerial aspects and involves multiple stakeholders (Schapper et al., 2006) with decision-makers at the policy and operational levels (Schooner et al., 2008). These stakeholders include national authorities, policymakers, regulatory authorities, procurement officers, suppliers, and end users. The considerable resources involved and the complexity of the public procurement system emphasise the importance of stakeholders making informed decisions to accomplish government goals (McCue et al., 2015; Schapper et al., 2006). On a policy level, informed decisions refer to the formulation of strategies, guidelines, and regulations that govern the procurement process. On the operational level, public procurement decision-makers are involved in decisions that should not only deliver value for money but also support broader policy objectives, such as promoting innovation, supporting small and medium-sized enterprises, and achieving social and environmental goals (Lerusse & Van de Walle, 2021). Decision-making is done in dynamic market settings and must consider the expectations of policymakers, as well as the needs of internal stakeholders and suppliers (Patrucco et al., 2017). Given this complexity, it is vital to recognise that the value of the decision-making process in public procurement is dependent not solely on adherence to laws and regulations but also on the capacity of the public sector in different countries (Bosio et al., 2022). To ensure better decision-making, Mintzberg (1976) argues that information can improve performance in organisations, and the World Bank (2022) argues that DDDM can improve performance in the public procurement system. Performance in this context is related to reduced inefficiency, such as prices paid, and efficiency gains, such as better control of the use of allocated funds (Patrucco et al., 2016).

Provost and Fawcett (2013, p. 52) define DDDM as 'the practice of basing decisions on the analysis of data rather than purely on intuition', and according to the World Bank (2022), DDDM in public procurement refers to 'using data to generate actionable insights and evidence'. The information obtained from data can serve as a foundation for policy discussions, directing reform activities, and evaluating the effectiveness of the public procurement process (Cernat & Kutlina-Dimitrova, 2015; Christodoulou et al., 2018). The request for more DDDM in the public procurement system is also stated in the EU Commission's (2017) strategy for public procurement, which says that more accessible data on public procurement will make it possible to assess the performance of

procurement policies and shape future strategic decisions. Finally, DDDM is also reinforced by the OECD, which, according to van Ooijen et al. (2019), claims that the adoption of DDDM in public procurement offers new approaches to detecting illegal and unethical behaviour in ways that can reduce fraud, corruption, and error. The underlying rationale for this increased focus on DDDM is that collecting and analysing data before making decisions will positively impact the quality of decisions and enable better performance in the form of more efficient use of public resources (Synyutka et al., 2019). One interesting study that supports better performance is an analysis by Brynjolfsson et al. (2011), which claims that firms in the private sector that adopt DDDM show 5–6 % higher productivity. When Khi Thai founded the *Journal of Public Procurement* (JoPP) in 2001, he suggested a model of the public procurement system (see Figure 4) and claimed that feedback in such a system was extremely important. According to Thai, by continually evaluating the procurement system and its outcomes, decision-makers can identify areas for improvement and make required modifications (Piga & Thai, 2006; Thai, 2001). Feedback can come from various sources and reveal the need for changes to any element of the procurement system, including outdated regulations or policies, ineffectiveness in the procurement process, or a lack of integrity (Thai, 2017).

Although considerable research has been conducted on the procurement process and operational aspects of public procurement (Rejeb et al., 2023; Trammell et al., 2020), so far, research connected to feedback or DDDM in the public procurement system has been limited and has focused on the importance of performance metrics (Randall et al., 2004) and value assessment tools (Schiele, 2005). Previous research on the adoption of DDDM in the public procurement system has also focused on the technical aspects, such as data quality data management (Soylu et al., 2022). One example is a study by Halsbenning and Niemann (2019), who found that a lack of structured data in the EU affects policymaking in public procurement. Sanchez-Graells (2019a) and Sangil (2020) claim that open government data can increase confidence in bidding and reduce the cost of information acquisition for bidders. Although research on DDDM within public procurement is mostly on the importance of metrics and the technical side (Van Donge et al., 2020), research interest is growing in the potential of DDDM to improve performance. Recent research has explored how DDDM can be used to detect unbalanced bidding (Li et al., 2023) or fraud (Velasco et al., 2021), or to improve environmental performance (AlNuaimi et al., 2021). Arinder (2016) and Pencheva et al. (2020) argue that the absence of information and feedback can make it challenging to manage the system and that management decisions are therefore not evidence based (Harland et al., 2007, 2013). A lack of evidence-informed decisions can influence decisions made at both the policy and operational levels. Limited information makes it difficult to determine necessary improvements to the procurement system and assess the outcomes of its functioning (Moretto et al., 2017). In a Norwegian context, a review by Similä and Langseth (2021) found that only 31 research papers related to public procurement were published by Norwegian authors between 2001 and 2019, none of which explored DDDM or analytics. While some public organisations have begun to adopt data-driven tools and platforms in public procurement, there is a gap in research related to the understanding of the mechanisms that affect the adoption of DDDM in public procurement (Richardson, 2021). Another aspect with limited understanding is how the public procurement system's information flow and feedback mechanisms function between the policy and operational levels (Audet, 2003). Hafsa et al. (2021) state that there is also a need to better understand how

stakeholders from different levels in the procurement system use data to understand and measure the size and effects of sustainable public procurement (SPP).

1.3   Research objectives and research questions

Despite its potential promised benefits, the above background demonstrates the limited research on, and challenges of adopting, DDDM in the public procurement system. Given the significant resources involved in public procurement, changes in performance can exert significant impacts; it is thus vital to devote efforts to understanding and addressing the problem of DDDM. As such, the objective of this thesis is to examine the adoption of DDDM and its impact on performance in the public procurement system, with the public procurement system of Norway used as a case study. Accordingly, the primary research question is as follows: *What are the mechanisms that drive the adoption of DDDM in the public procurement system of Norway, and how does DDDM influence performance?*

To address the primary question, a series of supplementary sub-questions were formulated, sequenced in such a way as to gradually explain the various aspects of the primary question, each one further expanding upon the previously provided information, thus bringing us closer to the desired understanding. The following subsequent sub-questions were asked:

- *RQ1: What is the state of the art in research and practice on the adoption of DDDM within public procurement systems?* This question seeks to review existing literature about DDDM in public procurement research and current practice of DDDM in the Norwegian setting.

- *RQ2: Which mechanisms within the public procurement system of Norway stimulate or suppress the adoption of DDDM?* This question directly addresses the first part of the primary question by focusing on the mechanisms that encourage or discourage the adoption of DDDM in a Norwegian context.

- *RQ3: How can DDDM adoption potentially impact organisational performance in Norway's public procurement system?* This third question seeks to explore the potential effects of DDDM adoption on the performance of public sector organisations.

To answer these questions, the study uses a combination of theoretical perspectives from systems theory (Von Bertalanffy, 1950), management cybernetics (Beer, 1972), decision-making theory (Simon, 1979), and technology adoption (Tornatzky & Fleischer, 1990). Systems theory helps in understanding the levels and parts of the system, and management cybernetics aids in understanding the connections between feedback and performance. Decision-making theory connects to the DDDM aspect and technology adoption relates to mechanisms for adoption. The framework is used to explore feedback loops, barriers to adoption, and the implications of DDDM for organisational performance.

Figure 1 provides an outline of the structural composition of the thesis. This encompasses three research questions with contributions developed from four academic papers that form the body of work. These contributions merge to answer the overarching research question. Moreover, Figure 1 explains the individual contribution each paper brings, concluding in the outcome of the thesis – a

proposed framework for the adoption of DDDM and its impact on performance. Each paper contributes individually to this framework with its respective findings. This graphic illustration thus not only provides a snapshot of the thesis structure but also outlines the role and value of each element in contributing to the larger research objective.
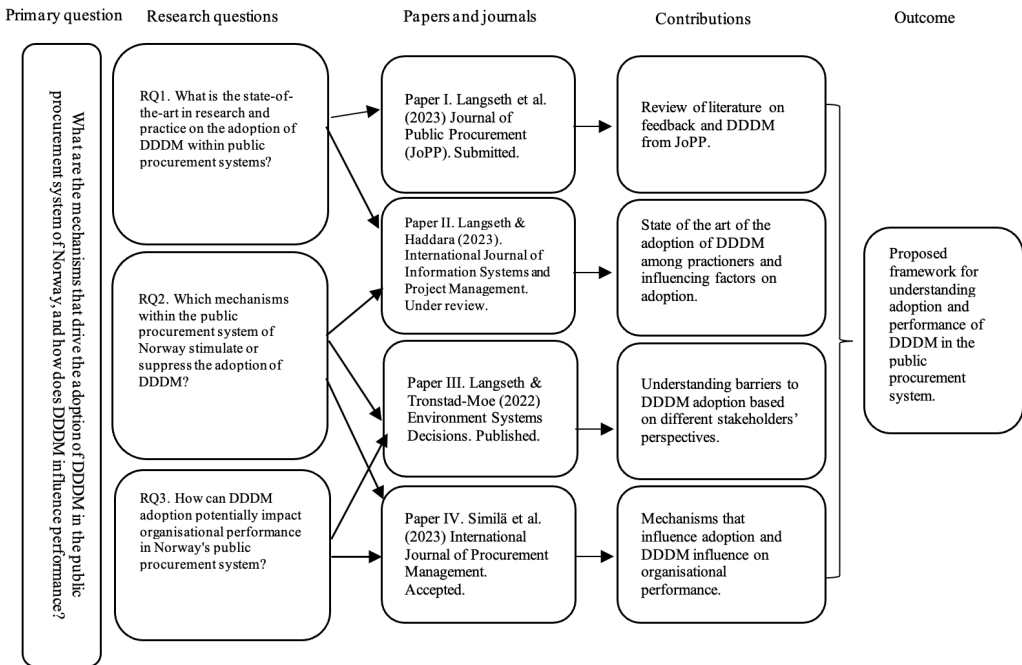
Figure 1 Structure of the thesis

1.4 Reading guide

The structure of this thesis consists of two parts. Part I comprises six chapters, while Part II consists of four research papers, one of which has already been published and one accepted, while two are in process but remain unpublished. The purpose of Part I is to combine the separate pieces of work and provide an overall discussion and explanation of how the research papers in Part II are connected.

Part I is structured as follows: Chapter 1 gives an overview of public procurement and public procurement systems, clarifying the need to focus on the adoption and performance of DDDM within the public procurement system of Norway. It introduces the topic and outlines the primary objectives and research questions. Chapter 2 reviews previous literature on DDDM in public procurement systems and presents the theoretical framework used in the study. Chapter 3 introduces the research context of the Norwegian public procurement system and reflects on the philosophical positioning of the thesis. Afterwards, it gives a description of the methodology, including the research design, data collection, analysis, and validity and reliability of the study. Chapter 4 presents

a summary of the four research papers (provided in the appendix) and highlights the findings, before Chapter 5 discusses the research questions connected to the findings and presents a proposed framework for DDDM in the public procurement system. The chapter also discusses the contributions and implications of the study and considers the study's limitations. Chapter 6 summarises the contributions of the thesis and concludes, based on the primary research question. Finally, suggestions for further research are proposed.

2   Related research and theoretical framework

This chapter begins with an overview of related research on DDDM adoption and performance in procurement systems. The chapter then presents relevant theoretical perspectives for studying DDDM adoption and its impact on performance before; at the end, the theoretical framework adopted in this study is presented. The framework combines four theoretical perspectives to address the research questions. The perspectives discussed are systems theory, management cybernetics, decision-making theory, and technology adoption. In addition, at the end of the chapter, four alternative theoretical frameworks are discussed, with arguments for why the adopted framework has been a suitable approach for addressing the research questions. By establishing this foundation, the chapter provides a basis for further study.

2.1   Related research

As stated in the introduction, the EU Commission, the OECD, and the World Bank have all published reports emphasising the importance of adopting DDDM in public procurement systems (World Bank, 2022; EU Commission, 2017; OECD, 2021). Based on the conducted literature review of the JoPP (Paper I), the findings reveal increased research attention to public procurement in the last two decades with an extensive focus on the procurement function within operations, policymaking, and management. Feedback and DDDM within procurement systems are less examined. The following subsections present previous literature related to DDDM and DDDM adoption and performance.

2.1.1   *Data-driven decision-making*
DDDM represents a shift in organisational decision processes, where decisions are predominantly informed by data analysis rather than solely by intuition or experience (Provost & Fawcett, 2013). This approach to decision-making is increasingly gaining traction across various sectors, including public procurement, due to its potential for enhancing efficiency, transparency, and policy effectiveness (Elgendy & Elragal, 2016). The technological infrastructure for DDDM typically includes structured or unstructured data with advanced data analytics, big data technologies, and increasingly, machine learning (ML) algorithms. These technologies together with human knowledge facilitate the extraction of meaningful insights from large, often complex data sets (Wamba et al., 2017).

Academic research on DDDM has focused on various aspects, including its impact on organisational performance (Brynjolfsson et al., 2011), the role of leadership in fostering a data-driven culture (Marsh & Farrell, 2015), and the technological and human resource capabilities required to implement DDDM effectively (Korherr & Kanbach, 2023). The role of analytical technologies in DDDM is fundamental. Business intelligence (BI) systems, data warehousing, and analytics platforms support DDDM, providing the tools necessary for data processing, analysis, and visualisation. For example, BI systems enable organisations to integrate data from various sources, apply analytical models, and produce actionable insights (Chen et al., 2012). In the context of public procurement, DDDM intersects with public procurement as a strategic tool that can help identify sustainable suppliers, optimise resource allocation, and evaluate the environmental and social impact of procurement decisions (Grandia et al., 2023; Walker & Brammer, 2012).

The adoption of DDDM in the private sector can offer valuable insights for the public sector, particularly in procurement (Diadia et al., 2022). Techniques such as predictive analytics for demand forecasting, spend analytics for supplier management, and performance analytics for contract management have been effectively employed in the private sector procurement (Gunasekaran et al., 2017; Thai, 2017). Applying these insights from the private sector to public procurement, however, may require consideration of the unique challenges and objectives of the public sector. These include regulatory compliance, transparency, and the need to balance multiple stakeholder interests (OECD, 2016; MAPS, 2018).

2.1.2   Data-driven decision-making adoption

The body of knowledge regarding the adoption of DDDM in public procurement systems is limited, but the available literature has highlighted common challenges and opportunities that organisations may face in DDDM adoption projects and efforts. The most common challenges identified in the literature are related to skill scarcity and procurement data quality (Soylu et al., 2022). Halsbenning and Niemann (2019) argue that data structures and quality levels vary among EU countries and highlight the importance of proper information management for sound policymaking. To facilitate DDDM, the EU strategy for data (Carvalho & Kazim, 2022) highlights the importance of open data in public procurement, emphasising that citizens also have the right to see government data, thus enabling transparent public procurement (Jetzek et al., 2014). According to Handfield et al. (2019), barriers to the successful adoption of advanced procurement platforms include the lack of data management, cultural readiness, and skills development. Bienhaus and Haddud's (2018) findings indicate that digitising the procurement process can yield several benefits, including supporting daily business and administrative tasks, supporting complex decision-making processes, and ensuring that procurement becomes more focused on strategic decisions and activities.

While not specifically centred on DDDM, existing literature has investigated the adoption of electronic procurement (e-procurement) within public procurement systems, which had a boost around 20 years ago. Research suggests that the adoption of e-procurement is primarily driven by political factors and as a push to obtain better economic outcomes (Panayiotou et al., 2004). According to Henriksen and Mahnke (2005), while economic considerations are essential, particularly those emphasising efficiency, political–structural mechanisms drive the advancement of e-procurement adoption. Hawking et al. (2004) identify a spectrum of barriers to e-procurement adoption within public procurement, which span organisational culture, resistance to change, and a dearth of managerial support. Moreover, Moe (2004) asserts that institutional aspects, such as community objectives, might significantly shape the adoption process of e-procurement. Veit et al. (2011) acknowledge that e-procurement adoption is formed by an interplay of organisational, technological, and environmental elements. Taking a more individualistic approach, Reunis (2007) discovered a relationship between the strategies of social influence and the uptake of e-procurement. These studies collectively underscore the intricate web of factors influencing the adoption of e-procurement, ranging from individual opinions to wider organisational and institutional contexts.

Studies outside the public procurement domain argue that the effective implementation of DDDM within the public sector in Norway requires technology readiness and maturity (Broomfield & Reutter, 2021). Others have stressed the importance of enhancing employees' competence regarding

data analytics (Veale & Brass, 2019). Choi et al.'s (2021) study of the adoption of DDDM in a US government agency highlights the fact that quality data and advanced analytic competence alone do not guarantee DDDM adoption; organisational and institutional support are also central. The study identifies nine determinants that enable or constrain DDDM practices: data quality/coverage, compatibility/interoperability, external data, information technologies/software, analytical techniques, cooperation, culture, privacy/confidentiality, and public procurement. Verma and Chaurasia (2019) found that technological, organisational, and environmental contexts impact firms' successful adoption of DDDM in a private sector context. Other studies have also argued that the types and level of sophistication of the digital tools used by employees positively affect the organisational readiness for the adoption of DDDM (Merhi & Bregu, 2020; Zhang et al., 2022). Beyond the public sector, Brynjolfsson and McElheran (2016) suggest that the adoption of DDDM is more likely to be observed in larger firms with more employees with analytics competence and supportive information technology.

In summary, the literature suggests that data quality, employee competence, company size, and organisational culture stimulate the adoption of DDDM; thus, barriers to adoption are organisational readiness and the leadership's involvement in, and promotion of, DDDM culture. Table 1 presents the identified mechanisms from the literature influencing DDDM adoption.

Table 1 Mechanisms influencing adoption of data-driven decision-making (DDDM)

Mechanisms influencing DDDM adoption	Authors
Data quality, data structure, and open data	Soylu et al., 2022 Halsbenning and Niemann, 2019 Jetzek et al., 2014 Choi et al., 2021 Verma and Chaurasia (2019)
Employee competence and skill scarcity	Handfield, 2019 Bienhaus and Haddud, 2018 Veale and Brass, 2019 Brynjolfsson and McElheran, 2016
Organisational culture and support	Hawking et al., 2004 Gelderman et al., 2015 Reunis, 2007 Verma and Chaurasia (2019)
Institutional and political–structural mechanisms	Henriksen and Mahnke, 2005 Moe, 2004 Choi et al., 2021 Panayiotou et al. (2004)
Technological readiness and maturity	Broomfield and Reutter, 2021 Merhi and Bregu, 2020. Zhang et al., 2022 Brynjolfsson and McElheran, 2016

2.1.3 Data-driven decision-making performance

The existing research on public procurement performance has emphasised the importance of performance measurement in public procurement; however, the research has limited connections to the adoption of DDDM (Flynn, 2018; Randall et al., 2004; Schiele, 2005; Smirnova et al., 2016). Futia et al. (2017) claim that technical solutions that enhance information consistency can improve performance in public organisations, and Gelderman et al. (2015) argue that a DDDM culture in public organisations promotes positive performance by facilitating sustainability initiatives among employees. Sanchez-Graells (2019b) also argues that sustainability analytics is connected to performance and finds that digitalisation can promote more sustainable procurement in the EU context. Related to digitalisation and public procurement performance, Moretto et al. (2017) suggest that data are instrumental in shaping public procurement decisions, from identifying internal needs and market conditions to evaluating award criteria and selecting contract types. This is also supported by Sanina et al. (2021) and van Weele (2018), who claim that information systems can enhance efficiency in procurement organisations. There has also been an interest in the role of information technology in advancing public procurement performance, taking into consideration not only the data and technology but also the organisational and institutional context (Panayiotou et al., 2004). Reddy et al. (2022) argue that the value generated by DDDM can be either functional or symbolic. Functional value can be related to economic performance, where cost savings and profits are key They argue that symbolic value is linked to factors such as environmental, social, and corporate governance and that the adoption of a data-driven approach is linked to organisations with a clear strategy and management involvement (Reddy et al., 2022).

Discussions on the performance of DDDM beyond the domain of public procurement are numerous and suggest a positive impact on performance across diverse settings, such as manufacturing plants and large publicly traded firms (Brynjolfsson & McElheran, 2016). This is supported by Elgendy and Elragal (2016) and Elgendy et al. (2021), but they argue that individuals and organisations that are good at combining data analytics and human experience produce better performance. Table 2 summarises the research related to the importance of performance measurement in public procurement and DDDM's influence on performance.

Table 2 Performance measurement and DDDM influence on performance

DDDM influence on performance	Authors
Importance of performance measurement in public procurement	Sanina et al., 2021 van Weele, 2018 Flynn, 2018 Randall et al., 2004 Schiele, 2005 Smirnova et al., 2016
DDDM shows better performance	Moretto et al., 2017 Futia et al., 2017 Brynjolfsson et al., 2011 Brynjolfsson and McElheran, 2016

DDDM influences sustainability performance	Gelderman et al., 2015 Sanchez-Graells, 2019b
DDDM combination of analytics and human experience for performance	Elgendy and Elragal, 2016 Elgendy et al., 2021 Reddy et al., 2022

From the review above, the findings show arguments for the importance of adopting DDDM and the potential for better performance in public procurement. Research related to DDDM performance claims that DDDM has the potential to enhance performance by assisting decision-makers in making informed decisions. Informed decision-making can have a positive impact on efficiency and sustainability. Better performance demands a broader approach, integrating data, technology, and organisational factors. Large firms and well-educated personnel support successful DDDM adoptions, and other identified key determinants of success include data quality, information technology, and analytical competence. Existing literature on adoption and performance has delivered valuable insights into the potential benefits, challenges, and applications of DDDM in the private sector; however, research within the public procurement context is still limited.

Nutt (2006) argues that the public and private sectors' decision-making practices differ in their objectives, constraints, and operational dynamics. The adoption and impact of DDDM in public procurement may consequently manifest distinctively (Adam et al., 2012; Tadelis, 2012). Existing literature underscores the increasing prominence of DDDM in both public and private sectors. Highlighted by global bodies such as the EU Commission and the OECD, DDDM is posited as a tool for enhancing efficiency, transparency, and policy effectiveness within public procurement (EU Commission, 2017; OECD, 2021; World Bank, 2022). However, while there's a robust body of work on the impact of DDDM on organisational performance, its application in public procurement remains underexplored. Specifically, the interplay of data quality, employee competence, and organisational culture as drivers, or barriers, to DDDM adoption stands out (Soylu et al., 2022; Handfield et al., 2019). While the potential of DDDM for enhancing performance is acknowledged, its actualisation in public procurement is yet to be thoroughly assessed. Current research offers a foundational understanding, but gaps persist, notably around the challenges and implications of DDDM in public procurement. There's a need for more nuanced, public procurement-specific studies, taking into consideration the unique constraints and goals of public entities. While the private sector's experiences provide a helpful starting point, one must exercise caution in applying these findings to the public sector without thorough empirical investigations. Hence, this calls for theoretical perspectives and a framework to address the public procurement system domain.

2.2   Theoretical perspectives for studying DDDM in the public procurement system

To answer the primary question concerning mechanisms that drive the adoption of DDDM in the public procurement system and how DDDM potentially impacts performance, knowledge from various research fields is necessary. This includes understanding the Norwegian public procurement system, decision-making in the system, and how public organisations adopt technology to make data-driven decisions. In this thesis, the choice of systems theory, management cybernetics, decision

theory, and technology adoption theory forms a theoretical framework for studying DDDM in the public procurement system. Systems theory and management cybernetics provide insights into the public procurement system and the complex interactions within the system and shed light on how the various components of the system interact with each other. In addition, systems theory and management cybernetics highlight the importance of feedback loops and meta-control mechanisms between various levels of the system (De Leeuw, 1976; Wallis, 2009). Decision theory explains the limitations of human decision-making and the processes involved in making public procurement decisions and facilitates identifying how the decision-making process can be more data driven. Technology adoption theory aids in understanding mechanisms that may stimulate or suppress the successful adoption of DDDM in organisations and how these mechanisms can be influenced by technology readiness or user skills, organisational characteristics, and the environmental context.

2.2.1 Systems theory and management cybernetics

Systems theory is an interdisciplinary perspective with the goal of explaining principles that can be applied to all types of systems in all fields of research (Von Bertalanffy, 1950). Systems theory focuses on understanding the general principles and properties of systems and is concerned with the interrelationships and interactions between the components of a system and how these interactions emerge in the collective behaviours of the system. These systems are characterised by connecting borders, structural and functional properties, roles, and interactions with external systems (Ackoff, 1971; Beer, 1984). To study communication and control in systems, Wiener (1948) introduced the classic cybernetic model (see Figure 2), which represents a system functioning via system feedback control managed by a controller.
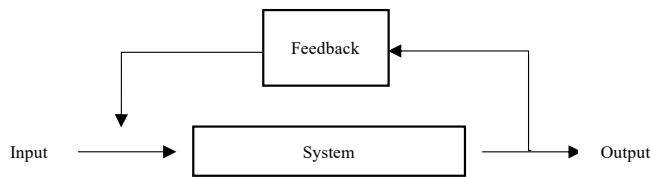
Figure 2 System feedback control model based on Wiener (1948)

The idea behind feedback control is that the system's output is constantly measured and fed back into the system to manage the resulting outputs. This allows the system to adjust its behaviour, which consequently results in the system becoming effective and efficient (Wiener, 1948). Management cybernetics, which focuses on applying cybernetic principles of feedback control within organisational and managerial contexts (Beer, 2002), is a subset of systems theory that specifically considers the study of organisational systems and management mechanisms. It focuses on understanding how information and control processes can be used to effectively manage complex systems. According to De Leeuw's (1976) 'control paradigm', organisational systems are not static but adaptive entities controlling and redesigning their environments. The paradigm underscores the importance of understanding, and effectively managing the environmental characteristics of the organisation. The paradigm is structured around three key elements, namely the controlled system, the controller, and the environment (Figure 3), and proposes three levels of control: strategic, tactical, and operational.

Environment (S3)

Controller (S2)

Controlled system (S1)
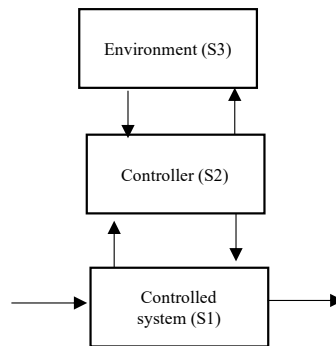
Figure 3 Control paradigm by De Leeuw (1976)

Kickert and Van Gigch (1979) expand De Leeuw's control paradigm with the concept of meta-control, which refers to the control of control processes. In a public procurement system, strategic control sets long-term goals for the system, tactical control determines procurement strategies for the organisations, and operational control ensures performance and compliance with procedures in the procurement process. Meta-control monitors and adjusts these control levels for effective procurement management (Kickert & Van Gigch, 1979). Hence, from a systems theory and management cybernetic perspective, public procurement can be perceived and viewed as a dynamic system involving multiple actors at different levels, with interactions and feedback loops necessary for control. In the context of public procurement, the control paradigm can be used to identify the levels, stakeholders, and interactions between the levels for communication and control necessary to manage the system. Thai (2001) was the first to systematically study public procurement as a dynamic system, identifying five core elements of such a system: (1) policymaking and management; (2) procurement regulations; (3) procurement authorisation and appropriations; (4) public procurement function in operations; and (5) feedback (Figure 4).
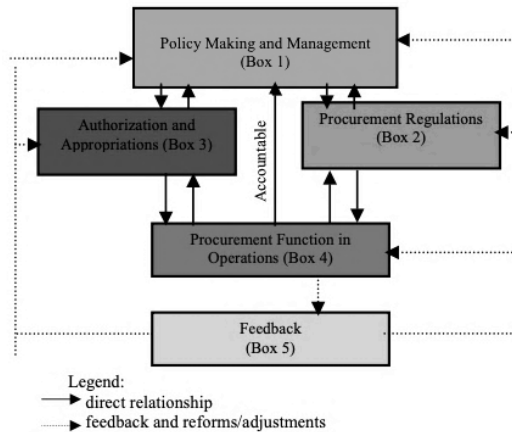
Figure 4 Public procurement system by Thai (2001)

Thai (2001) described the core elements of any public procurement system and the relationships between and among them. In his model of the procurement system, he also states that for control to be successfully and efficiently exercised, the system needs constant communication in the form of a feedback mechanism (Box 5). Based on Thai's (2001) model, Prier and McCue (2009) developed a new model of the public procurement system. This model, shown in Figure 5, is characterised by four fundamental elements that they claim are universally applicable to any public procurement system: the legal framework guiding practitioners, the organisational boundaries of operative activities, the intended outcomes of these activities in fulfilling governmental duties, and a feedback loop to inform and monitor the system. According to Prier and McCue (2009), their model aligns with the conception of public procurement as a feedback control system (Wiener, 1948).
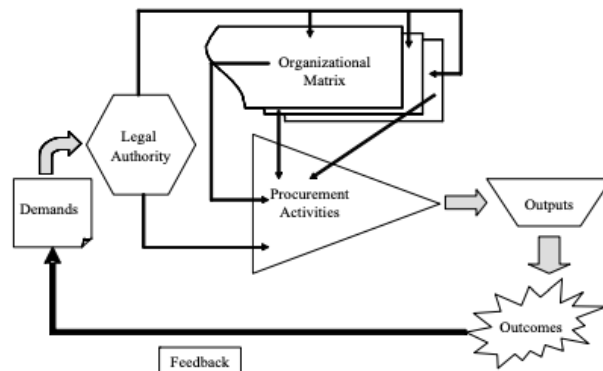
Figure 5 Public procurement system by Prier and McCue (2009)

In summary, systems theory and management cybernetics aid in understanding public procurement as a wholistic system where feedback loops can help monitor and improve the performance of that system (Gee & Uyarra, 2013; Thai, 2001).

2.2.2 Decision-making in the public procurement system

Decision theory is a field that seeks to establish general principles to guide decision-makers in situations involving risk or uncertainty (Hastie & Dawes, 2009). It is a theory covering many academic disciplines, with numerous sub-specialties. As discussed above, the public procurement system is characterised by several stakeholders that operate at multiple levels (Schooner et al., 2008). The stakeholders at the policy level are involved in strategic decisions about goals and the formulation of legislation for the procurement system. At the operational level, stakeholders create procurement strategies and make operational decisions in the procurement process based on strategies and laws. Decisions at the operational level consider the needs of internal stakeholders, and examples of decisions can include which demands to ask for in a competition, which supplier should win the tenders, and which contracts need to be followed up.

Public procurement decisions are influenced by many interests and factors, including government goals, political preferences, resources, and procurement laws. Ulen (1999) states that rational choice theory has been the dominant perspective in explaining governmental decision-making behaviour. The influence of rational choice is visible in the Norwegian public procurement law, which is formed as a rational decision-making process that is also reflected in the purpose of the law. As the purpose of the law says, '[t]he law shall promote efficient use of society's resources. It shall contribute to the public sector acting with integrity so that the public has confidence that public procurement takes place in a way that benefits society' (Ministry of Trade, Industry and Fisheries, 2017, p. § 1). Connected to decision theory, the law matches the ideal of the decision-maker as an 'economic man', who should choose the action that results in the most optimal outcome. Simon's (2013) concept of 'administrative man' challenges the classical theory of the rational 'economic man', suggesting a 'bounded rationality' model instead. This model recognises human cognitive limitations, time limits, and the complexity of real-world situations as constraints to rational decision-making. Due to these constraints, Simon (2013) argues that individuals (decision-makers) seek satisfactory rather than optimal solutions. The notion of 'satisficing' consequently arises, where decision-makers strive for an acceptable solution (Conlisk, 1996). Tversky and Kahneman (1989) further support this view by emphasising how individuals deviate from rationality in their decision-making processes. In the realm of public procurement, the foundation of legislative intention is an orderly, rational decision-making process (Trepte, 2007). This assumes that every step – from the identification of a public need to the final acquisition of goods or services – should ideally be governed by an unbiased, logical assessment. The purpose is to guarantee transparency, efficiency, and unbiased treatment for all stakeholders involved, thereby securing maximum public interest, and maintaining a high degree of integrity in the use of public funds (Trepte, 2007). However, empirical evidence suggests that this assumption may not always hold and that public procurement officers 'satisfice' and use heuristics in their decision-making (Igarashi et al., 2015). This underscores the need for a broader understanding of decision-making in the public procurement system (Kukutschka, 2021).

In the context of the public procurement system, decision-making at the national policy level focuses on strategic control that aligns with long-term objectives and legislation in the system (Grandia & Meehan, 2017). These decisions are influenced by political goals, such as environmental considerations or innovation in procurement processes (Glas et al., 2017). The formulation of long-term objectives, however, is not executed in isolation but instead occurs within an arena where numerous interested parties attempt to influence the policymaking process. According to Joensuu and Niiranen (2018), decision-making at the policy level involves political leaders and public administrators, and the dynamic nature of this relationship is a balance of trust and information, which are central to responding to external changes and managing internal reforms in the public sector (see Figure 6).
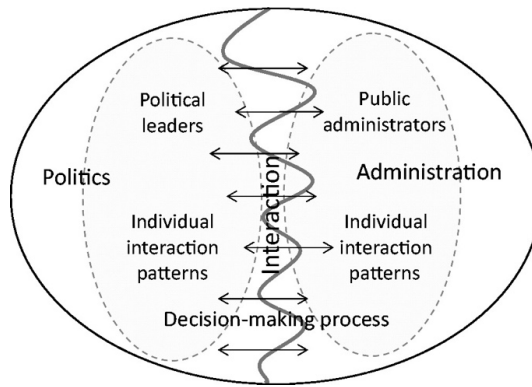
Figure 6 Decision-making on a policy level by Joensuu and Niiranen (2018)

At the operational level, decision-makers are involved in tactical and operational decision-making based on policy-level objectives and regulations (Csaba, 2006). Critical aspects of decision-making at this level encompass public procurement strategies and operational tasks in the procurement process, involving needs assessments, supplier selection, contract awarding, and supplier relationship management (Igarashi et al., 2015). Conducting the procurement process follows government procedures, where, for example, reverse auctions and competitions among suppliers for government contracts are meant to stimulate competition and a fair selection/procurement process. These decision-making processes are complex and often consist of weighing multi-criteria goals and factors based on pressures from the various interest groups in the environment (Csaba, 2006; see Figure 7).

execute individual
purchasing decisions

high-level and
strategic
policy goals

market pressure
(technological and
economic reality)

procuring entity /
Decision Maker

decision making
environment

expectations from the
recipients of services

interpretations of
the law
- incl. Court appeal
(judicial) decisions

regulatory (legal) framework
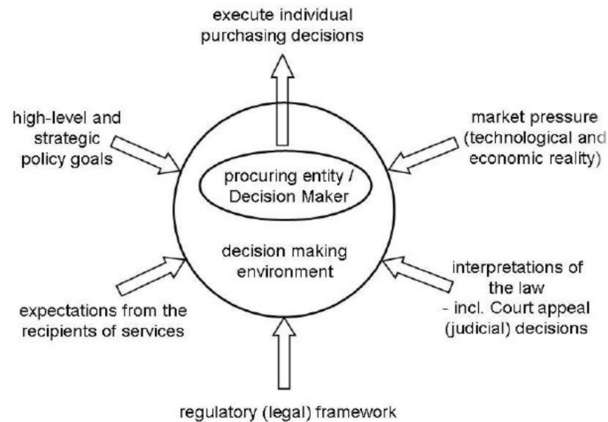
Figure 7 Decision-making on an operational level by Csaba (2006)

As illustrated in Figure 7, procurement decision-making at the operational level is a complex process with information flowing from many sources that may have multiple and conflicting objectives. In the public procurement system, decision-making can therefore be seen as an information processing task. Galbraith (1974) suggests that executing complex decisions demands a significant amount of information processing and argues that technologies that enhance information collection or improve distribution within the organisation (referred to by Galbraith as 'vertical information systems') will improve performance. Galbraith's ideas have been employed as a framework for understanding the impacts of information technology and related theoretical advancements known as the 'information processing view of the firm' (Galbraith, 1974). In line with Galbraith, Conant (1976) further explores information processing and the principles that support information flow in systems. He proposes that the process of decision-making is a fine balance between three elements: the decisions that are made (output), the exclusion of non-essential data (blockage), and the collaborative efforts of the team (coordination; Conant, 1976). However, these elements are often in competition with each other; for example, in public procurement, decision-making involves balancing cost efficiency (output), filtering supplier reliability (blockage), and coordinating among stakeholders (coordination). For instance, inexpensive suppliers may not always be reliable (output–blockage competition) and coordinating consensus among stakeholders may sacrifice cost efficiency or supplier reliability (coordination–output/blockage competition). Thus, these elements constantly compete and interact in procurement decisions. De Wit and Meyer (1998) introduced 'the strategic reasoning model' as a framework for understanding and analysing the goals, intentions, roles, and rationale behind strategic actions in organisations. The model emphasises the importance of collecting, analysing, and interpreting data to inform strategic decisions. The organisation is seen as an information processor, where data are continuously gathered from the internal and external environment. This data are then processed to create meaningful information that can be used for strategic reasoning. The model suggests that effective strategic management is dependent on the organisation's ability to efficiently process information (De Wit & Meyer, 1998).

The above discussion highlights the fact that effective public procurement decision-making in the public procurement system requires the ability to efficiently process relevant data, filter out irrelevant data, and apply strategic reasoning to anticipate the implications of the choices. As mentioned above, the information processing view of decision-making implies that decision-making in procurement systems must be data driven. DDDM proposes a process that utilises technology and analytics to inform stakeholders in public procurement, both at policy and operational levels, in their decision-making processes (Elragal & Haddara, 2019; Provost & Fawcett, 2013). Colson (2019) presents a framework for a data-driven approach to decision-making. The framework is adjusted to conform to the procurement decision-making context (see Figure 8).
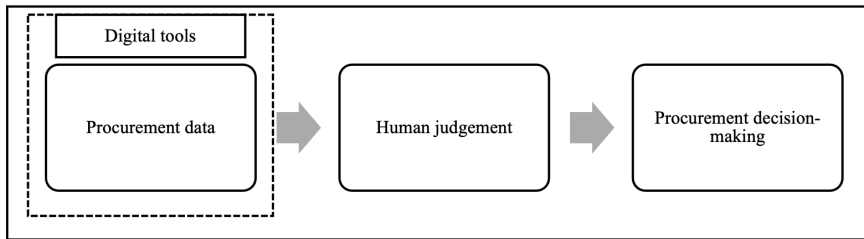
Figure 8 Data-Driven Decision-Making (DDDM) by Colson (2019)

Translated into the context of the public procurement system at an operational level, DDDM refers to using digital tools that produce data in public procurement processes (Strohmer et al., 2020). Data refers to the information generated and collected using these digital tools (World Bank, 2022). This can include data about the products or services being procured, the suppliers involved, the cost and terms, or the environmental footprint. These data, combined with human judgement, can be used to track and manage procurement activities in the procurement process, analyse trends and patterns, and inform decision-makers about future procurement, sustainability, or which contracts should be followed up (Bienhaus & Haddud, 2018).

DDDM at a policy level refers to the monitoring and evaluation of critical elements in the public procurement system to ensure fairness, sustainability, and the best value for money (Bernal et al., 2019; Patrucco et al., 2016; van Berkel & Schotanus, 2021). Monitoring and evaluating the public procurement system at a policy level involves feedback and mechanisms for coordinating and managing the behaviour of the system (Tan & Lee, 2015). This includes, for example, collecting data on the number of bids received or resources needed in the procurement process, as well as identifying areas of improvement or concern (World Bank, 2022). Decision-making in the public procurement system involves stakeholders at both policy and operational levels, guided by laws assuming rational decision-making. Despite the legal intent, empirical evidence indicates that 'bounded rationality' and a deviation from rationality occur in the decision-making process due to the complexity and lack of relevant information. Hence, DDDM has the potential to improve performance by aiding stakeholders in making informed decisions in the public procurement system.

2.2.3 *Technology adoption*

The adoption of DDDM in the Norwegian public procurement system is related to technology adoption (Brynjolfsson & McElheran, 2016). The technology adoption perspective is helpful for understanding how individuals, organisations, and systems adopt and integrate new technologies into their decision-making practices (Rogers, 2010). Theoretical models and frameworks, such as the technology acceptance model (TAM; Davis, 1985), theory of planned behaviour (TPB; Ajzen, 2002), diffusion of innovations (DOI; Rogers, 2010), and the technology–organisation–environment (TOE) framework (Tornatzky & Fleischer, 1990), have been influential in understanding the adoption of DDDM. The TAM and TPB frameworks, while useful, are primarily focused on the individual level. In contrast, the DOI and TOE frameworks are better suited to organisation- and system-level studies, as evidenced by most IT adoption studies at the organisational level being derived from these theories (Oliveira & Martins, 2011). In the context of public procurement, the related research presented in Section 2.1 revealed that the adoption of DDDM is a complex process that involves various factors. This research states that the adoption of e-procurement is influenced by the technological readiness of the organisation, the skills and knowledge of the staff, the support and involvement of the leadership, and the availability of the necessary technology (Panayiotou et al., 2004). Similarly, the adoption of DDDM is influenced by factors such as data quality, data integration, and the skills and knowledge of the staff (Choi et al., 2021).

Drawing on this background, the TOE framework (see Figure 9) emerges as a relevant structure, incorporating three contextual elements for adoption – 1) technological, 2) organisational, and 3) environmental – which may influence the successful adoption of DDDM in the public procurement system (Tornatzky & Fleischer, 1990).
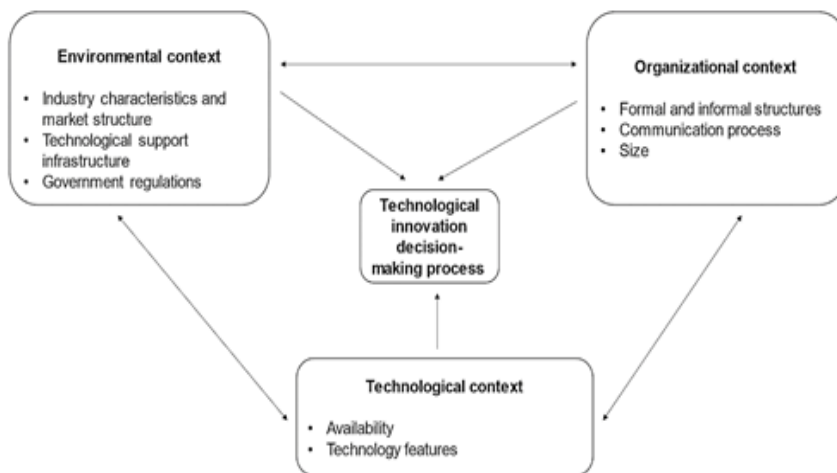
Figure 9 TOE framework by Tornatzky and Fleischer (1990)

The TOE framework provides a lens through which one can understand and study the adoption of DDDM in public procurement. It enables an understanding of the various factors that influence the

adoption process and offers insights into how to facilitate the successful adoption of new technologies.

2.3   Theoretical framework

DDDM in the public procurement system is complex, and, as discussed in the sections above, several perspectives are applicable for understanding its adoption, utilisation, and impact on performance. In this study, the adoption of DDDM is rooted in systems theory and an information processing view of the firm, which suggests that organisations are complex systems (Von Bertalanffy, 1950) that need information and feedback loops for performance (Beer, 1984; Galbraith, 1974; Thai, 2001). In a public procurement system, decision-making is generally influenced by regulations and market conditions (Thai, 2001). Decision-making in public procurement systems is not always, despite good intentions, a rational process (Igarashi et al., 2015; Simon, 2013) due to the involvement of multiple stakeholders with limited information and time constraints. Based on that argument, the adoption of DDDM can potentially enhance the performance of the public procurement system by informing decision-makers, which in turn would lead to less bounded rationality (World Bank, 2022; Brynjolfsson et al., 2011).

The theoretical perspectives from systems theory, management cybernetics, decision theory, and technology adoption perspectives can contribute to understanding mechanisms that stimulate or suppress DDDM adoption and the impact of DDDM on performance in the public procurement system. Despite their different viewpoints, these perspectives share a common interest in the alignment between technology, feedback mechanisms, and decision-making processes. Figure 10 displays the utilised theoretical framework and highlights how the elements from each theory/framework contribute to addressing the adoption and performance of DDDM in the public procurement system.
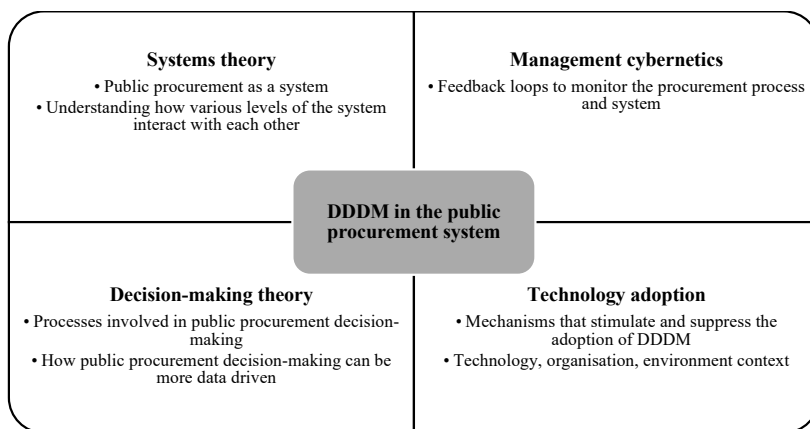
Figure 10 Theoretical framework of the thesis

In summary, this study adopts a theoretical perspective inspired by systems theory, management cybernetics, decision theory, and a technology adoption perspective.

2.4   Other related theoretical perspectives

Although the above theoretical framework has provided a useful approach to answering the research questions in this study, these research questions could also have been studied from other theoretical perspectives, such as institutional theory, the resource-based view (RBV), actor–network theory (ANT), and the socio-technical perspective.

Institutional theories claim that institutions are socially constructed and play a significant role in shaping organisational behaviour. The institutions guide and govern organisations by setting the rules, regulations, and practices (Meyer & Rowan, 1977). An institutional perspective could be a valuable lens, by focusing on how procurement regulations, policy frameworks, and social norms shape the adoption and employment of DDDM (Elgendy et al., 2021). The RBV is another potential perspective that proposes that organisations can establish competitive advantages by exploiting their unique resources and capabilities (Barney, 2001). An application of the RBV to public procurement systems may involve examining the role of technological infrastructure, human capital, and organisational capabilities in the adoption of DDDM. However, Ray et al. (2004) argue that adopting the effectiveness of the business processes as a dependent variable may be more appropriate than overall firm performance, which is the typical dependent variable used in RBV studies. This aligns with the argument in Paper IV that the adoption of DDDM improves the effectiveness of activities in the procurement process, which in turn leads to an improvement in procurement performance.

Another useful perspective could have been actor–network theory (ANT), which underscores the relationships, interactions, and dependencies among human and non-human actors within a network (Latour, 1983). ANT's application to public procurement systems could enable the investigation of the roles and interactions of diverse stakeholders, technologies, and processes involved in DDDM, and its relationship to systems theory further explains the complex interdependencies between elements within a system. Where systems theory emphasises the holistic perspective of a system as an integrated and interacting organisation of parts, ANT focuses on the non-hierarchical and dynamic network of relationships between actors – both human and non-human – that influence system behaviour. A final interesting and potential perspective is the socio-technical view (Trist & Emery, 2005) of data-driven organisations (Wulff & Finnestrand, 2023). That perspective could involve design choices, decentralised information flows, and reskilling for data design tasks. In the context of DDDM in the public procurement system, it would allow for exploring how social norms and technological developments may shape the adoption of DDDM.

Even though I acknowledge that other perspectives discussed would also be valuable, in summary, the integrated framework of systems theory, management cybernetics, decision theory, and technology adoption has provided a suitable foundation for understanding the complexities inherent in decision-making processes in the public procurement system, the role of technology in facilitating DDDM, and the mechanisms that affect the adoption and performance of DDDM in public procurement systems. The selected theoretical framework is chosen for its direct relevance to the technological and systemic dimensions of DDDM. Whilst other perspectives such as institutional theory, the resource-based view (RBV), actor–network theory (ANT), and the socio-technical perspective offer compelling angles – especially in explaining organisational behaviour, resource

utilisation, stakeholder interactions, and the interplay between social norms and technology – they are not employed in this study as the vast scope and potential conceptual variance of these additional perspectives might diffuse the study's focus, complicating the analysis without necessarily enhancing the understanding of the core technological and cybernetic processes at play. By maintaining a precise theoretical focus, this study aims to provide clarity and depth in its analysis, facilitating the derivation of specific insights that can directly impact the practice and performance of DDDM in public procurement systems. This deliberate theoretical framing ensures a consistent narrative, which is deemed most suitable for the study's objectives and for the advancement of knowledge in the field of public procurement and DDDM.

3   Research context, philosophy, and methodology

This chapter begins by presenting the research context and then discusses the research philosophy, which is rooted in the researcher's ontological and epistemological views. Afterwards, it presents the methodical choice and strategies. The choice of a multi-method case study based on cross-sectional data shapes the techniques and procedures for data collection and analysis. Finally, the chapter discusses the validity and reliability of the study's findings based on the research design.

3.1   Research context: The public procurement system of Norway

The setting of this research is the public procurement sector, noted for its distinct challenges and goals. Telgen et al. (2012) note that public procurement operates under stringent regulations and limited budgets, with a mandate to deliver social value and uphold transparency, often navigating through intricate bureaucratic procedures and extended decision-making. In contrast, the private sector has more financial flexibility, faces fewer regulatory hurdles, and emphasises profit and efficiency. Decision-making in private procurement tends to be quicker and more independent, with a sharper focus on meeting business targets rather than achieving social objectives (Telgen et al., 2012). In relation to the public procurement system, Thai (2017) states that each nation maintains its own unique administrative, legal, and review traditions. As such, adopting a predetermined procurement system is unlikely to be effective or appropriate. This perspective underscores the need to carefully consider the specific context of the research and offer an overview of the system in focus – in this case, that of Norway.

The specificity of Norway's procurement framework is clarified through various detailed sources, including the OECD nation report of 2021 and MAPS assessments from both 2018 and 2020. Complementary perspectives from the 2019 white paper by the Norwegian Parliament (Meld.St.22, 2018–2019) and the researcher's own expertise further deepen the understanding of the system's unique characteristics. This foundational context underscores the congruence of Norway's procurement system with EU regulations, affirming its commitment to competitive equity and adherence to international procurement standards. In addition, the Norwegian system is grounded in a trust-based philosophy, like the philosophy governing all Norwegian institutions (Meld.St.22, 2018–2019). The philosophy emphasises the importance of individual procurers and entrusts them with wide-ranging responsibilities. The system's success thus centres on the information quality, skills, honesty, expertise, and information of the individual procurers (MAPS, 2018, 2020). Regulatory authorities, including the legal system and independent supervisory bodies, such as the Norwegian Complaints Board for Public Procurement (KOFA) and the Auditor General of Norway, oversee compliance with established policies and legal frameworks. They conduct frequent audits, investigations, and assessments to ensure that public procurement promotes competition among suppliers and that practices are fair and transparent (MAPS, 2018, 2020; Meld.St.22, 2018–2019). KOFA and the legal systems can enforce sanctions against those who are not compliant in the form of fines.

The Norwegian procurement system involves ca. 3,000 public procurement officers (Meld.St.22, 2018–2019), who spent around €63 billion in 2022 on purchasing services and supplies (Statistic Norway, 2023a). This accounts for about 41% of Norway's total public spending (Ministry of Finance, 2022) and 0.3% of the government workforce (Ministry of Labour and Inclusion, 2022). Public procurement in Norway supported a population of 5.4 million people in 2022 (Statistic Norway, 2023b). According to the OECD (2021), a distinction of the context is that Norway features the highest percentage of public sector employment relative to its workforce within the OECD, with 30.7% of its working population engaged in general government roles. The distribution of these public employees is more geographically dispersed than the OECD norm with a workforce that is significantly more female dominated than the OECD average (OECD, 2021). In the public procurement system, policy-level stakeholders include national authorities, public agencies, and regulatory authorities (Fet et al., 2011). These stakeholders shape the public procurement environment by developing and implementing policy frameworks, legal requirements, and regulatory guidelines. They are responsible for ensuring that procurement processes are transparent and efficient and follow international best practices. The policy-level stakeholders also aim to achieve policy objectives, such as best value for money spent, environmental sustainability, and social equity. Policymakers in the Norwegian parliament formulate procurement laws and policies influenced by politics. They are members of committees or specialised commissions tasked with reviewing, revising, and adopting public procurement EU law, policy, and regulations (Meld.St.22, 2018–2019), and strong interest groups, such as the Association of Local and Regional Authorities, labour unions, and the Confederation of Norwegian Enterprises, influence the policymakers. National authorities such as the Ministry of Trade, Industry and Fisheries, and governmental agencies such as the Agency for Public and Financial Management, are responsible for implementing the policy. They provide training and develop guidelines and recommendations on public procurement practices.

At the operational level, stakeholders include public procurement officers, suppliers, and end users. A distinction of the public processes in Norway is their decentralised nature (OECD, 2021). Central and local self-governments adopt procurement strategies that best suit their specific needs (MAPS, 2018). Public procurement officers are responsible for conducting procurement projects and managing the procurement process within public institutions and authorities, following the guidelines and regulations established by national policy-level stakeholders. According to the Norwegian Agency for Public and Financial Management, the public procurement process generally involves three major steps: first, the government entity identifies goods and/or services that it needs; second, procurement officers hold competitions to find the best supplier to fulfil the needs; and third, the contracts are awarded and implemented. The procurement officers are responsible for conducting the procurement process based on the needs of internal stakeholders, with tasks including preparing tender documents, evaluating bids, selecting suppliers, negotiating contracts, and ensuring the delivery of procured goods and services. Suppliers to the government, including private companies and organisations, participate in public procurement competitions by offering bids and proposals in response to public tenders. The suppliers are responsible for providing the required goods, services, and work according to the terms and conditions of the contracts awarded. Lastly, end users, or the public, use the goods, services, and works procured by public institutions, which contribute to fulfilling public needs (MAPS, 2018, 2020; Meld.St.22, 2018–2019). Inspired

by Sætertrø et al. (2023), Figure 11 provides a broad visual representation of the institutional and administrative infrastructure of the public procurement system in Norway. The purpose of the model is to visualise the difference between the policy and operational levels, both of which are involved in the procurement process.
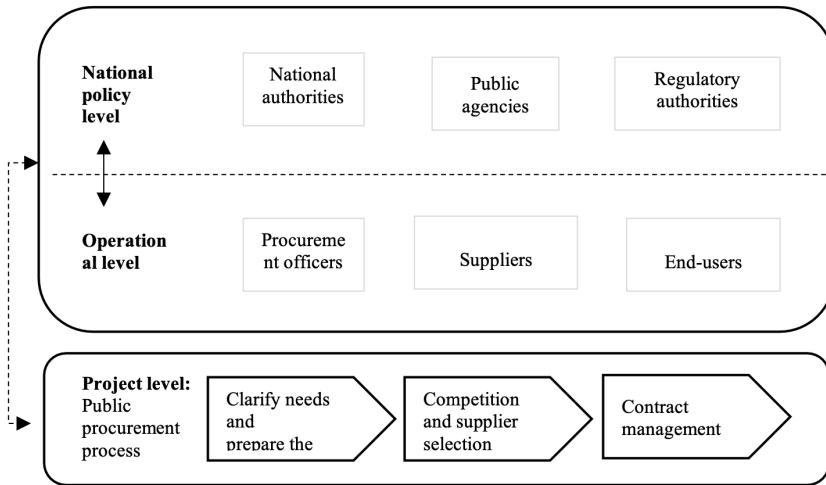
Figure 11 Stakeholders and levels in the public procurement system of Norway based on Sætertrø et al. (2023)

In his paper, Flynn (2018) claims that Norway performs well in most aspects of procurement practice, compared to other countries in the OECD. However, the quality of reporting presents a contrast and is below satisfactory levels. Flynn suggests that this shortcoming might indicate the existence of underdeveloped monitoring mechanisms within the public procurement system. This impression reiterates findings by the OECD (MAPS, 2018, 2020), which found that a challenge in the Norwegian public procurement system is the lack of systematic collection and proper use of public procurement data and claimed that a more robust DDDM approach could enhance the system's performance. From a management cybernetics perspective, better performance hinges on the availability of feedback mechanisms inside and between government levels (De Leeuw, 1976; Thai, 2001). Table 3 sums up the characteristics of the Norwegian system and the implications for DDDM.

Table 3 Characteristics of the Norwegian system and the implications for DDDM

Characteristics	Implication for DDDM
Highest percentage of public sector employment relative to its workforce within the OECD	Requires comprehensive data collection and analysis tools

Decentralised administration	Necessitates systems for effective data sharing and integration
Strict regulations and policy driven	Demands data solutions that support transparency and regulatory compliance
Stakeholder diversity	Calls for standardised data practices considering multiple perspectives

Understanding these characteristics is necessary for developing and applying DDDM methodologies that are not only technologically advanced but also contextually aligned with the Norwegian public sector's unique environment and objectives.

3.2 Research philosophy

In examining Norway's procurement system, the research is shaped by the investigator's philosophical stance, which is informed by foundational beliefs and assumptions (Holden & Lynch, 2004). Research philosophy is anchored in ontology, i.e. how the researcher perceives reality, and epistemology, namely how the researcher believes one should acquire knowledge (Killam, 2013). The initial section delves into the interplay between ontology and epistemology within three primary research philosophies: positivism, interpretivism, and pragmatism.

Positivism, supported by an ontological conviction in an objective reality, contends that the world exists autonomously and can be comprehended through empirical investigation (Park et al., 2020). Epistemologically, it presumes that knowledge is optimally obtained through quantifiable, observable metrics, attempting to detect causality and devise general laws that are testable and confirmable via empirical evidence (Antwi & Hamza, 2015). This philosophical approach prefers methodologies that separate the observer from the subject, seeking to uncover truths about the world via scientific enquiry (Guba & Lincoln, 1994).

In contrast, subjectivism accentuates the interpretative nature of research, positing that reality is constituted through human interpretations and experiences, which are intrinsically subjective and culturally relative. Researchers who adopt a subjectivist lens strive to understand the meanings and viewpoints within cultural or individual contexts, typically utilising qualitative methods such as interviews and ethnographic observations. Ontologically, subjectivism perceives the world as a compilation of individual experiences that can be interpreted only within their context, while epistemologically, it views knowledge as inherently subjective, derived from interpreting individual perspectives (Guba & Lincoln, 1994).

Pragmatism as a research philosophy prioritises the utility and practical consequences of knowledge, with a focus on real-world applications and outcomes (Goodman, 1995). It supports a diverse methodological approach, often aligning with action research but not limited to it to encompass broader inquiries aimed at practical problem solving (Greenwood, 2007). Pragmatic

research is not restricted to immediate change or stakeholder collaboration but is concerned with the application of theoretical insights in various contexts (Feilzer, 2009. Ontologically, it views reality as a construct of human engagement, while epistemologically, it treats knowledge as an instrument for solving problems and learning from experience (James, 1907; Dewey, 1998). Pragmatists call for a flexible approach to research, tailoring methods to the research question and drawing on both positivist and subjectivist perspectives to achieve a balanced understanding (Craig, 2007).

Despite the strengths of positivism and subjectivism, both approaches present limitations when applied to DDDM in public procurement systems. Positivism, often criticised for its assumption that an objective reality can be studied accurately (Bryman, 2016), relies on methods that may not fully capture the complexity of human practices and behaviours (Crotty, 1998). In contrast, subjectivism – based on individual experience and limited generalisability – raises concerns about the validity and relevance of the findings (Guba & Lincoln, 1994). Given these limitations and the previous practical experience of the researcher, the perspective of pragmatism best aligns with the researcher's world view. The researcher believes that reality is many sided and is like an interconnected system, where both objective and subjective aspects have value in generating research outcomes with practical implications. This perspective allows for the use of multiple research methods to address the research questions, combining quantitative and qualitative data. This flexibility can be beneficial when studying complex systems such as the public procurement system.

3.3   Research design

The literature review revealed that limited research related to the adoption and performance of DDDM in public procurement systems exists. Considering the research questions and philosophical perspective, an exploratory multi-method case study approach has been identified as a suitable research design for examining DDDM in the public procurement system of Norway (Moran-Ellis et al., 2006). The design of the multi-method case study is guided by the goal of understanding the mechanisms for the successful adoption of DDDM in organisations, and DDDM can enhance the performance of the public procurement system. The case study approach enables an in-depth exploration of the public procurement system within the Norwegian context, as introduced in Section 3.1.

In line with the pragmatic perspective, the research design adopts an approach utilising both quantitative and qualitative data. Quantitative data can give a broad overview of the system, and qualitative data can offer in-depth insights into the experiences and motivations of the stakeholders involved (Webb & Auriacombe, 2006). This research builds on four studies with separate data collection and analysis to address the research questions and thereby qualifies as a multi-method study (Anguera et al., 2018). The data are based on a cross-sectional time horizon and involve analysing data from multiple subjects with data from 2018 to 2022. To limit the scope, the study primarily focuses on the national policy and operational levels, with less weight on the legal aspects, internal stakeholders and suppliers. Although internal stakeholders, the law, and suppliers are briefly discussed in the research papers, the focus of the overall study remains on the policy and operational levels. Adopting a pragmatic perspective, the study examines the Norwegian public

procurement system, focusing on feedback mechanisms, decision-making, and technology adoption. The multi-method approach offers insights into policy and operational levels, contributing to a deeper understanding of the public procurement system and potential improvements. Figure 12 summarises core decisions on the research philosophy and methodology in this thesis, based on the research onion by Saunders et al. (2019).
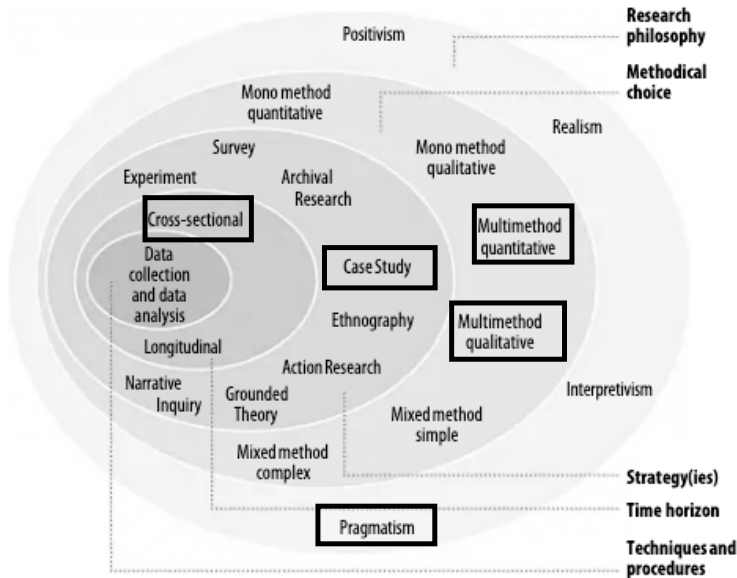
Figure 12 Research onion by Saunders et al. (2019, p. 108)

3.4 Data collection and data analysis

This study's pragmatic research philosophy underlines the methodology, employing various data collection techniques such as scientometric analysis, secondary survey data, and qualitative interviews to explore public procurement broadly. The following subsection clarifies the methods used in this study.

3.4.1 Data collection

Data collection is an essential part of any research process. For this study, data collection was vital for gathering information on the research topic and synthesising relevant information about the system under study. This study has used diverse data collection methods based on the multi-method approach (Anguera et al., 2018; Esteves & Pastor, 2003), where the research involves the application of multiple research methods within a single study. The study used the following methods: scientometrics, secondary survey data, document analysis, and qualitative interviews. A brief review of the methods in the separate papers follows below.

In Paper I, data were collected with the use of scientometrics and document analysis to study the JoPP's production, impact, and research topics over the last two decades. The data collection for this study was executed in a multi-stage process designed to provide a comprehensive understanding of the *Journal of Public Procurement* (JoPP). The first stage involved a scientometric review, where quantitative methods were applied to assess the academic contributions within JoPP. This step used databases such as the Web of Science and Scopus, supplemented by the 'Lens' database to ensure a wide-ranging collection, capturing 345 articles from 2001 to 2021. Significant to this stage was data cleaning to address the complexities inherent in the databases not specialised in scientometric analysis. Challenges included reconciling multiple author affiliations and filling in missing data, with an outcome of 335 articles ready for further analysis after excluding non-research materials like editorials and book reviews. The data collection process also entailed a qualitative document analysis, involving an examination of the collected articles to extract thematic insights. This step was critical for exploring the nuanced themes within the research topics, where detailed content examination led to the identification of patterns and deeper thematic analysis. The qualitative phase was complemented using Microsoft Excel for organising and categorising the content according to predefined categories from Thai's model and further thematic analysis where the model did not suffice. Furthermore, the study employed scientific mapping to identify the interconnections among research papers, which included a co-occurrence analysis of titles and abstracts using VOSviewer. This analysis yielded a term map visualising thematic clusters, offering insights into the journal's research focus areas.

In Paper II, the secondary survey data employed were obtained from the Norwegian Agency for Public and Financial Management. The survey's deployment in 2022 targeted a broad spectrum of 1,132 public procurement entities, spanning state, county, and municipal levels, with the intention of capturing a general procurement practice. The data collection was executed by the government agency, leading to a response rate of about 51%, or 578 entities. Out of these responses, 529 directly addressed the question related to the adoption of spend analytics, which was the main variable of interest for the study. The survey data breakdown in Table 4 reveals that 42% of the respondents were municipalities, followed by 29% representing municipal and state companies, and 28% from state enterprises, with a marginal 1% from county authorities. This distribution affords a representative cross section of the procurement landscape in Norway, ensuring that the insights garnered are reflective of national procurement practices. By providing a rich data set, the survey provided a solid foundation for empirically examining the theoretical model developed in the study, particularly concerning the technological-, organisational-, and environmental-related factors influencing the adoption of spend analytics in the public procurement sector. These data stands to inform the scholarly understanding and practical implications of the adoption of DDDM in public procurement. An overview of the 529 respondents and their organisations is provided in Table 4, below.

Table 4 Overview of respondents in survey 1

	State enterprises		Counties		Municipalities		Municipal and state companies	
	Number	Share	Number	Share	Number	Share	Number	Share
Respondents	149	28%	5	1%	222	42%	153	29%

In Paper III, we collected primary data through 12 semi-structured, in-depth interviews, each approximately an hour in length, conducted digitally due to the COVID-19 pandemic. This qualitative approach, approved by the Norwegian Centre for Research Data (NSD) to ensure adherence to privacy standards, was vital in uncovering how the different stakeholders assess the sustainability effects in the public procurement of electric vehicles (EVs). We grounded our interview protocol in a rich literature review and a thorough analysis of government documents, executed by querying Google Scholar with specific keywords such as 'sustainable public procurement', 'public procurement', 'green', 'car transport', and 'effects', which yielded 17 relevant academic contributions that informed our interview guide. The research participants were strategically chosen for their direct involvement in various stages of the EV procurement process and represented stakeholders at different levels – government agency advisers, procurement officers, suppliers in the car industry, and end users of government EVs. Such a selection enabled an exploration of the assessment practices from multiple angles and facilitated a deeper understanding of sustainability as interpreted and effects assessed by different actors within the system. The methodological framework, supported by the guidelines suggested by Thagaard (2009) for capturing informants' perspectives, and the strategic approach to sample selection as proposed by Yin (2018), was beneficial in achieving a balance between preformulated questions and spontaneous, exploratory dialogue. Data collection was considered complete when it reached saturation, a point at which no new information was forthcoming (Guest et al., 2006), ensuring a comprehensive understanding of the participants' experiences and perspectives. The aim of the anonymised findings was to provide insights into the motivations, experiences, and context-specific understandings of the stakeholders engaged in the sustainable procurement of EVs. An overview of the respondents in the interviews is provided in Table 5, below.

Table 5 Overview of respondents in interviews

Stakeholder	Role
Government agency	Senior adviser
Government agency	Senior adviser
Government agency	Adviser
Municipality	Procurement officer
Municipality	Procurement officer
Health trust	Procurement officer
Car supplier	Car salesman
Car supplier	CEO
Car supplier	Manager
Internal employee	End user
Citizen	End user
Citizen	End user/patient

Paper IV explores DDDM adoption and performance in Norwegian public procurement, building upon a survey data set from the Agency for Public Management and eGovernment (Difi). Conducted in the autumn of 2018, this survey targeted various public authorities at state, county, and municipal levels, where the data were collected to evaluate the digital maturity within public procurement. The survey was constructed and administered online by the government agency to capture the perceptions and experiences of procurement personnel within their respective organisations with a total of 196 valid responses. The respondents represented a broad mix of 69 state enterprises, 45 state- or municipality-owned companies, eight county authorities, and 74 municipalities (see Table 6). This composition mirrors the entities in the public procurement system. Despite the lower response rate from county authorities, with eight out of 19 counties participating, the 42% response rate was acceptable for analysis. Similarly, the responses from state-owned companies, though not large in number, were considered satisfactory for the intended analysis. This stratified sample strengthens the generalisability of the study's conclusions, affirming the representativeness and reliability of the findings.

Table 6 Overview of respondents in survey 2

	State enterprises		Counties		Municipalities		Municipal and state companies	
	Number	Share	Number	Share	Number	Share	Number	Share
Respondents	69	35%	8	4%	74	38%	45	23%

In summary, data collection has been a central component of the research process in the thesis. The study followed a pragmatic research philosophy and collected both quantitative and qualitative data to understand the research context and construct valid evidence about the adoption and performance of DDDM in the Norwegian public procurement system.

3.4.2 Data analysis

Data analysis is the analytical step in the study and involves examining, organising, and interpreting the collected data (Crowe et al., 2011). This study involved quantitative and qualitative data, and the data analysis had to consider both types. One critical challenge in analysing both quantitative and qualitative data is that the data types fundamentally differ and require different approaches to analysis (Brannen, 2004). For example, quantitative data are typically structured and organised and can be analysed using statistical techniques. Qualitative data, on the other hand, are often unstructured and open-ended and require more interpretive analysis. The approach in this study has been to analyse both quantitative and qualitative data from the separate studies and then integrate the findings from both analyses to provide an overall understanding of the research questions (Bryman, 2006).

In Paper I, the data analysis was carried out in a structured, multi-phase approach. The first phase involved scientometric analysis, where quantitative methods were employed to assess the scholarly landscape of the *Journal of Public Procurement* (JoPP). This phase included identifying key metrics and trends. The second phase of analysis was qualitative, involving a detailed review of the collected documents. This phase aimed to identify and interpret themes within the articles, using systematic methodologies to extract, document, and analyse the content. The final phase of the analysis focused on the development of a new model. This entailed a gap analysis informed by both the scientometric

review and qualitative document analysis. In Paper II, the study employed descriptive statistics to summarise and describe the features of the data collected, providing a clear snapshot of the sample's characteristics. This approach allowed for an initial examination of the data, presenting central tendencies, dispersions, and graphical representations that laid the groundwork for further analysis. Correlation analysis was then utilised to explore the relationships between variables, seeking to understand the extent to which they moved together and whether these movements suggested any association. Hypothesis testing served as a component of the research methodology, enabling the study to test theories about the data.

Paper III used qualitative data, and the analysis involved analysing non-numerical data from the interviews to identify the data's themes and meanings (Thorne, 2000). The paper's analysis involved thematic analysis techniques to identify patterns in the qualitative data. Thematic analysis attempts to identify, analyse, and interpret recurrent patterns – themes – within the data (Eisenhardt, 1989). It facilitates an understanding of participants' experiences, ideas, and perceptions. Typically, it encompasses six stages (Yin, 2018): familiarisation with data, generating initial codes, identifying potential themes, refining themes, defining and naming themes, and the final analysis and report. The analysis used a deductive (top-down) approach (Sarker et al., 2000) to analyse the data based on different tags regarding the themes. This approach facilitated understanding the procurement system with data that could not be fully captured through quantitative data alone (Flyvbjerg, 2006). Paper IV used partial least squares structural equation modelling (PLS-SEM) to analyse the data. PLS-SEM is a multivariate statistical analysis technique used to analyse structural relationships and combines factor analysis and multiple regression analysis (Musil et al., 1998).

Table 7 describes the method, data collection, and analysis in each of the four papers.

Table 7 Summary of methods, data collection, and analysis

Paper	Methods	Data collection	Data analysis
Paper I	Combination of quantitative and qualitative	Literature search in databases including Scopus, Web of Science, and Lens. Used data from Lens of 335 papers from the *Journal of Public Procurement* from the period 2001–2021	Scientometric, document analysis, and gap analysis for new model development
Paper II	Quantitative	Secondary survey data collected from procurement officials by the Agency for Public and Financial Management in 2022 including 578 respondents, with 529 respondents answering our target variable. Respondents across municipalities, state enterprises, counties, and municipality and state companies	Descriptive statistics, correlation analysis, and hypothesis testing
Paper III	Qualitative	Literature review and 12 qualitative semi-structured interviews, and government documents	Qualitative analysis using coding and thematic analysis techniques

Paper IV	Quantitative	Secondary survey data collected from procurement officials by the Agency for Public and Financial Management in 2018, including 196 respondents across 74 municipalities, 69 state enterprises, 8 counties, and 45 municipality and state companies	Structural equation modelling

3.5 Reliability and validity

Validity and reliability are two fundamental concepts in any research project (Yin, 2009). Validity indicates how accurately the study's results represent the phenomenon under investigation. On the other hand, reliability refers to the degree to which these results remain consistent over time and when replicated by researchers or in further studies. A prevalent concern when employing a case study methodology is the issue of generalisation (Riege, 2003). Yin (1994) proposed that the outcomes of case research could be generalised to a theory, a concept he terms 'analytic generalisation', as opposed to 'statistical generalisation'. Yin (1994, p. 30) explains that '[s]tatistical generalisation involves making an inference about a population (or universe) based on empirical data gathered from a sample'. Conversely, 'in analytic generalisation, the researcher aims to extend a specific set of results to a broader theory' (Yin, 1994, p. 36). Yin (2009) suggests several ways of improving the validity and reliability of case study research, such as using multiple sources of evidence, involving participants in the interpretation of findings, and conducting the study multiple times.

In this study, multiple methods were used, and data were collected using four sources: scientometrics, document analysis, qualitative interviews, and secondary survey data. Each of these sources has its own level of reliability and validity. Scientometrics is a form of data analysis used to measure the impact of scientific research. The data in scientific publications are reliable because they are based on open data and methods, but thet can be less valid because they do not consider the complex social and cultural context in which research is conducted. Document analysis, which is a form of data analysis that examines written documents such as reports and articles, is valid but can be less reliable because it may be influenced by researchers' interpretations when classifying topics. Qualitative interviews are a form of data collection that involves speaking directly to respondents to gain insight into a particular case. They are highly valid but can be less reliable because the results may be biased based on the researcher's understanding and previous knowledge. Utilising a management cybernetics perspective, this study recognises the second-order cybernetics and reflexivity inherent in the observer's role in qualitative data analysis, understanding that the view of the Norwegian public procurement system is influenced by the researcher's perspective and experiences (Von Foerster, 2003). Having operational experience at both the operational and policy levels, the researcher may exhibit bias; however, because of this is also well equipped to explore the system's complexities. Finally, the secondary survey data in both 2018 and 2022 were collected by a government agency. In Study II, with the data set from 2022 the reliability was challenged by the complexity and disorder within the data set, including non-responses and mixed data types, which may undermine the robustness of the results. Validity concerns arise from inconsistent coding and potential biases from self-reported data. In Paper IV, the survey's design and data quality was better and its administration to a well-defined cross section of Norway's public procurement personnel underpins the study's reliability. The diversity and scope of the respondents enhance the

validity and generalisability of the findings within the Norwegian public procurement context. Comments on various aspects of validity and reliability in this study are presented in Table 8 below.

Table 8 Validity and reliability of the study

Assessment features	Description, Yin (2009)	Implementation in this thesis
Construct validity	How well a test measures its intended construct. To establish construct validity, Yin recommends using multiple sources of evidence, such as interviews and documents.	The data collection used multiple sources of evidence to certify that the operational measures were correct – for example, in Paper I, document analysis, and in Paper III, interviews. Furthermore, Papers II and IV employ survey data to examine the adoption and performance of DDDM. Multiple sources help to ensure that the measures were accurate and comprehensive.
Internal validity	The extent to which a study is methodologically sound and free from bias, thus enabling justifiable conclusions about cause-and-effect relationships within the observed data.	The data analysis tested a range of factors with different methods to ensure that other mechanisms did not influence the causal relationship they were testing. Multiple sources of evidence helped to control for potential confounding variables. For example, Paper I used descriptive statistics and Paper II used descriptive statistics and correlation. Paper III used qualitative interviews and Paper IV used PLS-SEM analysis. In Study II, the internal validity of the study may be affected by data inconsistencies and non-responses, necessitating meticulous data cleaning to ensure accurate, reliable conclusions.
External validity	The extent to which the results can be generalised to other contexts.	The study's research design focuses specifically on the public procurement system in Norway, and a common concern is that the findings may not be statistically generalisable to other contexts. However, using multiple methods and sources of evidence helps to increase the analytic generalisation of the study. It is documented by, for example, the EU, the OECD, and the World Bank that the adoption of DDDM in public procurement is not yet accomplished in other countries. However, it would require further research to see how well the findings from this study correspond with adoption and performance in another context.
Reliability	The operations of the study being repeatable with the same results.	The individual papers provide a detailed description of the data collection methods used. The data in Papers I, II, and IV are publicly available, allowing the study to be repeated. In Paper II, the data set's reliability was compromised by inconsistencies like mixed data types and non-responses, necessitating standardised protocols. In general, using open data and multiple sources of evidence helped to increase the reliability of the study's findings.

In assessing the validity and reliability of the study based on Yin's (2009) criteria, the research demonstrates a robust approach to construct validity by employing multiple sources of evidence, including interviews and document analysis, across several papers. Internal validity is maintained through diverse methods that control for potential confounding variables, such as qualitative interviews and PLS-SEM. While the study's focus on Norway's public procurement system limits external validity and statistical generalisability, using multiple methods enhances the potential for analytic generalisability. The reliability of the study is ensured through detailed methodological descriptions and the public availability of data, allowing for potential replication. Even though the study used multiple methods and data sources, research limitations stemming from the research methodologies used in this study exist, which are addressed further under the limitations of the study in Chapter 5.

4 Findings

This chapter summarises the research papers' findings and their relevance to the overall research context and theme. In the following sections, each paper is introduced, and the primary objective, design, findings, and contributions are highlighted. The significance and implications of the findings are discussed in the following chapter. The papers are arranged coherently, ignoring publication dates, to enable an understanding of the research findings. Table 9, below, gives an overview of the papers, and the appendix contains the full text for reference.

Table 9 Overview of the papers

Paper	Name of paper and contributors	Status & publication outlet
1.	Langseth M., De Boer L., & Moe, H. T. (2023). Two decades of Journal of Public Procurement: Content Analysis and Theoretical Expansions of the Thai Model.	Submitted to the *Journal of Public Procurement*
2.	Langseth, M., & Haddara, M. (2023). Spend Analytics in Norwegian Public Procurement: Adoption Status and Influencing Factors.	Under review at *International Journal of Information Systems and Project Management*
3.	Langseth, M., & Moe, H. T. (2022). Driving through dense fog: a study of the effects and control of sustainable public procurement of electric cars.	Published in *Environment Systems and Decisions*, 1–14. https://doi.org/10.1007/s10669-022-09854-2
4.	Similiä J.O., Mwesiumo D., Langseth M., & Haddara M. (2023). Antecedents and implications of data-driven decision-making.	Accepted by the *International Journal of Procurement Management* (IJPM)

4.1 Paper I: Two decades of Journal of Public Procurement

Objective: The objective of the paper is to review the state of the art in public procurement literature by examining the production, impact, and research topics of the JoPP from 2001 to 2021. The paper specifically focuses on JoPP, as this is the only international peer-reviewed journal fully and exclusively dedicated to public procurement research. To categorise the topics, the paper uses Thai's (2001) model of the public procurement system to compare the topics in the journal with the categories in the model. This is done to see how well the foundational model of the system corresponded with the research conducted in the last two decades and to develop a new version of the model.

Design/methodology/approach: The authors conducted a two-step analysis of the scholarly papers published by JoPP from its 2001 inception through to 2021. First, a quantitative scientometric

analysis of the articles was conducted to see the trends in production, impact, and topics, followed by a qualitative document analysis to compare the identified topics with the categories in the themes in Thai's (2001) model. All research articles published by JoPP between 2001 and 2021 (335 papers) were included in the analyses; editorials, symposium introductions, US government reprints, and book reviews were excluded.

Findings: The findings indicate that JoPP has increased production, but the journal shows a decreasing tendency in terms of impact. Clustering and document analysis revealed that the journal's content focuses mostly on policymaking, management, and procurement functions in operations elements, with less research interest in law, authorisation, and feedback in the public procurement system. The main findings reveal an imbalanced distribution of research, with limited attention given to feedback and DDDM topics. Of 335 articles, nine were related to feedback and DDDM, and none of these were from Norway. Key findings from these papers emphasise the significance of well-crafted performance metrics (Randall et al., 2004), value assessment tools (Schiele, 2005; Apte et al., 2019), the value of competitive dialogue for feedback (Buccino et al., 2020), accuracy in cost estimates (Ryan et al., 2012), contract performance monitoring (Smirnova et al., 2016), and effective sourcing strategies. Flynn (2018) studies the EU Commission's procurement performance measures, Mehrbod et al. (2018) semantic product matching in public procurement, and Thai (2001) the importance of feedback in a public procurement system. This also led to a suggestion for an expansion of the Thai model with procurement intelligence as a new feature that serves to scan the system's environment and derive implications for necessary renewal and change.

Contribution: This is the first analysis to categorise the published articles with Thai's (2001) model. The findings highlight areas needing further research, particularly appropriation, authorisation, and feedback mechanisms. The research also showed that Thai's (2001) model did not cover all topics within public procurement research, which underscored the need to develop a refined model of the public procurement system. Our refined model could provide a robust analytic tool for identifying system weaknesses and improving public procurement processes at various levels. The limited studies on feedback and DDDM in public procurement systems demonstrate the need to look further into these topics.

4.2   Paper II: Spend Analytics in Norwegian Public Procurement

Objective: Paper II investigates the adoption of spend analytics in the Norwegian public procurement system. It aligns with a technology adoption view, utilising the TOE framework to examine factors influencing the adoption of DDDM.

Design/methodology/approach: The study utilises data from a 2022 survey by the Norwegian Agency for Public and Financial Management, with 578 responses from a diverse array of public organisations where the survey's 51% response rate provides a solid foundation for analysis using descriptive and correlation statistics. A total of 528 respondents answered the question on our target variable, 'the use of spend analytics'. The paper examines determinants for the adoption of spend analytics and addresses 15 core factors identified in preceding research and tests related to hypotheses using the TOE framework.

Findings: The analysis highlights some new insights. The findings show a lack of DDDM adoption, with 61% of surveyed entities not employing spend analytics, and adoption rates varying distinctly among different public entity types. The study reveals a positive correlation between procurement analytics expertise and the adoption of analytics and finds that larger procurement volumes and the centralisation of procurement processes are positively correlated with higher rates of adoption of DDDM.

Contribution: This paper extends the preliminary findings from Paper I, which highlighted the scarcity of research into the adoption of feedback and DDDM within public procurement. The findings reveal that a substantial 61% of Norwegian public entities have not adopted spend analytics, underscoring the scarcity of DDDM practices. By applying the TOE framework, it systematically investigates how specific factors influence DDDM adoption, discovering that entities with established procurement analytics expertise and larger procurement operations are more likely to adopt such practices. These findings enhance the paper's contribution by not only addressing research gaps but also by providing targeted recommendations for practitioners and charting a strategic path for continued academic exploration in public procurement's data-driven landscape.

4.3   Paper III: Driving through dense fog

Objective: This paper aims to gain a deeper understanding of the mechanisms of the adoption of DDDM with the use of the procurement of electric vehicles (EVs) as an example. This was done by looking closer at how stakeholders at various levels in the public procurement system identify and evaluate the sustainability effects of public procurement. Sustainability effects were used as an example because governments are large purchasers of vehicles that contribute to pollution. To address this issue, policies in Norway have been established to replace government-owned fossil fuel cars with electric cars, utilising public procurement as a strategic tool to foster the transition towards sustainability (Ministry of Climate and Environment, 2021). However, the number of studies examining how stakeholders at various levels identify and evaluate the sustainability effects of these changes is limited. This limited knowledge is particularly relevant given the findings from Papers I and II, which underscore the importance of feedback mechanisms and DDDM in public procurement systems. Paper III applies De Leeuw's (1976) control paradigm and seeks to explore the adoption and performance of DDDM by examining the interconnectedness of various elements in the public procurement system, such as feedback mechanisms and alignment of the policy–operational levels in the system.

Design/methodology/approach: The paper employs an exploratory research design with a view to understanding various perspectives on DDDM. The paper conducted 12 interviews with stakeholders from different levels of the public procurement system. Data collection was conducted between January and May 2021, and the paper's sample included informants from government agencies, public procurement officers, car suppliers, and EV users. The data were analysed using a qualitative thematic analysis approach.

Findings: The findings reveal two key insights. First, the research highlights limited adoption of DDDM and missing vertical and horizontal feedback loops in aligning the evaluation of

sustainability effects. Second, because of missing standardised measurement methods, the perceived effects of SPP are based on the stakeholders' perspectives, leading to an inconsistent understanding of the results. The limited adoption of DDDM in the Norwegian public procurement system creates a divide between policymaking and practical operations, which can potentially influence sustainability performance.

Contribution: The contribution of this paper is a broader understanding of the mechanisms for the adoption of DDDM and the importance of vertical and horizontal feedback loops. Paper III complements the findings of Papers I and II and contributes to an enhanced understanding of the mechanisms related to the adoption and performance of DDDM through the lens of De Leeuw's (1976) perspective. This analysis underscores the need to look further at the structural relationships between mechanisms associated with the adoption of DDDM within public procurement and determine whether DDDM has an impact on public procurement performance.

4.4   Paper IV: Antecedents and implications of data-driven decision-making

Objective: Despite the growing interest in DDDM in public procurement by international organisations such as the EU, the World Bank, and the OECD, there remains a lack of research on the mechanisms for adoption, as identified in Papers I, II, and III. Paper IV seeks to contribute to the understanding of DDDM in the public procurement system at an operational level. Building on the results from Papers II and III, the paper highlights the importance of considering specific mechanisms to be more data driven.

Design/methodology/approach: The research methodology employed in Paper IV is survey-based hypothesis testing that utilises data collected by the Norwegian Agency for Public Management and eGovernment in 2018. This data set contains 196 observations. The paper develops a conceptual model where the hypothesis is tested using PLS-SEM (Hair et al., 2019).

Findings: The findings reveal an interplay of factors that influence the adoption of DDDM in public procurement organisations. The paper confirms all four hypotheses, supporting the argument that the path that predicts adoption is that digital motivation positively influences the development of specific goals for digitalisation in public procurement. The definition of clear goals for digitalisation then has a positive effect on the development of the organisational structure, which lays the foundation for DDDM. In the paper, DDDM also exhibits a positive effect on organisational performance.

Contribution: Paper IV contributes to the body of knowledge on the adoption of DDDM and performance in the public procurement system by identifying the causal links between motivation and goal setting in combination with business intelligence tools for DDDM adoption. The paper contributes to the theory of public procurement performance by determining the necessary processes underlying the link between motivation in digitalisation and performance in terms of effectiveness gains and inefficiency reduction. Paper IV supplements and expands the insights from Papers I, II, and III.

Collectively, these papers encourage an approach that emphasises the importance of DDDM, feedback mechanisms, and policy–operational alignment in enhancing public procurement performance and achieving broader societal objectives. The primary findings are summarised in Table 10 below.

Table 10 Summary of primary findings

Paper	Primary findings
Paper I	The findings imply that the *Journal of Public Procurement* has enhanced its output, although its influence appears to decline. The paper finds that the topics covered in the articles reveal that the journals primarily concentrate on policy formulation/management and procurement roles within operational aspects as per Thai's (2001) model. There is comparatively less focus on feedback within the public procurement system. Of 335 articles, nine were associated with feedback and DDDM, with none of the nine coming from Norway. The nine articles in JoPP focus primarily on technical aspects of DDDM adoption and exploring strategies and tools related to value assessment and contract monitoring,
Paper II	The analysis underscores a significant shortage in the application of DDDM, with 61% of surveyed entities not employing spend analytics. The study reveals a correlation between procurement expertise and the adoption of analytics, with adoption rates varying distinctly among different public entity types. Furthermore, it reveals that larger procurement volumes and the centralisation of procurement processes are positively correlated with higher rates of adoption of DDDM.
Paper III	The findings reveal two key insights. Primarily, the lack of adoption of DDDM within the Norwegian public procurement system culminates in an inconsistency in perceived effects between policy and operational levels. The impact of sustainable public procurement is subject to variation depending on the perspectives of stakeholders. Secondly, the study emphasises the absence of vertical and horizontal feedback processes for linking the evaluation of sustainability outcomes.
Paper IV	The findings reveal an interplay of factors that influence the adoption of DDDM in public procurement organisations. The paper finds that digital motivation increases the likelihood of setting specific goals for digitalisation. These goals, in turn, affect the use of business intelligence systems, which leads to the adoption of DDDM. Secondly, the findings show that the organisations that adopted DDDM show improved performance, with the largest effect on reduction in prices paid and better control of the use of allocated funds.

In the discussion, the emphasis shifts from what has been observed to what it could mean within the field's broader scope. The results are interpreted and contextualised, connecting them to broader academic conversations and real-world implications.

5   Discussion

The objective of this thesis has been to study the adoption of DDDM and its impact on performance in the public procurement system. This chapter begins by discussing the three research questions related to the findings in the four research papers, before summarising the findings to discuss the primary research question. The chapter then expands and shows how the results contribute to the existing body of literature and give grounds for several important implications. Lastly, the limitations of the study are considered and discussed.

5.1   Research questions and findings

This section first presents the central findings from the study with the research questions. The first question draws insights from literature and survey results with a view to understanding the current state of DDDM in the public procurement system.

5.1.1   *RQ1: What is the state of the art in research and practice on the adoption of DDDM within public procurement systems?*

To answer the research question, this discussion integrates findings from two sources: the scientometric review and document analysis of JoPP in Paper I and the quantitative study of the adoption of spend analytics in public procurement in Norway in Paper II. The insights from these papers are examined using the theoretical framework (Figure 10) presented in Chapter 2. The first research question focuses on DDDM adoption in research and in public procurement systems. Systems theory helps understand the levels in the system and management cybernetics aids in understanding the connections between feedback and performance. Decision-making theory connects to the DDDM aspect and technology adoption relates to mechanisms for adoption.

The findings show that within the academic discussion on public procurement, an apparent variation exists in the research focus distribution. As revealed in the examination of JoPP in Paper I – and supported by broader academic literature (Lange et al., 2014; Moretto et al., 2017) – an overemphasis on the operational aspects of public procurement exists, with research on procedures, policymaking, and management. In contrast, the examination of procurement feedback mechanisms and DDDM within procurement systems is under-represented. This lack of research contrasts with the recommendations by leading organisations such as the EU Commission (2017), the OECD (2021), and the World Bank (2022), which emphasise the significance of DDDM for improved performance in public procurement systems. There is limited research in the public procurement context related to DDDM and performance, and Halsbenning and Niemann (2019) argue that insufficient data leads to inadequate information management in the public procurement system. Outside the public procurement context, several studies, such as that by Brynjolfsson et al. (2011), show a positive impact of DDDM on performance. Public procurement has a massive effect on the economy, and minor changes in performance could have considerable consequences on a larger

scale. The findings also show that even as the public procurement system generates large volumes of data via digital tools, translating these data into valuable insights for informed decision-making is limited in practice, as shown by the low level of adoption of spend analytics in Paper II. The study reveals that 61% of government entities don't conduct spend analysis, thereby exemplifying the low DDDM adoption. The literature suggests that low adoption is due to various factors (Choi et al., 2021; Halsbenning & Niemann, 2019; Storm & Borgman, 2020). The findings show that employee expertise in analytics predicts spend analytics adoption, while using digital tools may not be enough. Organisational scale and structure are also significant factors, with larger – in the form of procurement amount – and more centralised procurement units showing a greater tendency to adopt analytics. The interplay with environmental considerations is complex, indicating a need for strategies that integrate sustainability goals with data-driven procurement practices. Based on the limited research, apparent limitations in the literature, and a need for a better understanding of mechanisms for adoption, the following questions seek to discover what stimulates and suppresses adoption.

5.1.2   *RQ2: Which mechanisms within the public procurement system of Norway stimulate or suppress the adoption of DDDM?*

The study on the mechanisms within Norway's public procurement system that either stimulate or suppress the adoption of DDDM sheds light on a collection of interconnected factors linked to adoption. The study relates to the theoretical framework (Figure 10) via decision-making theory, exploring how DDDM can be more data driven in public procurement. Additionally, it investigates technology adoption theory, analysing mechanisms influencing DDDM adoption within the Norwegian public procurement system, emphasising organisational structure and policy alignment. Lastly, the study illustrates management cybernetics, underscoring feedback mechanisms in relation to adoption.

The study started with a review of existing literature, as described in Paper I and Chapter 2. The literature explored various sides of adoption. These included the utilisation of digital tools, the presence of skilled labour, organisational size, leadership engagement, and the influence of regulations (Choi et al., 2021; Halsbenning & Niemann, 2019; Storm & Borgman, 2020), alongside the TOE framework (Tornatzky & Fleischer, 1990). Paper II's findings support these earlier studies, establishing a link between the adoption of spend analytics and the presence of analytical skills. It further identifies a positive significant correlation between adoption and factors such as procurement centralisation and volume, resonating with the insights of Merhi and Bregu (2020) and Zhang et al. (2022). Paper III contributes by illuminating the disconnect between policy and operational levels, thus affirming Halsbenning and Niemann's (2019) claim regarding the critical need for structural alignment in the adoption of DDDM. The paper reveals inherent challenges within the Norwegian public procurement system, including the absence of uniform data structures and standardised measurement guidelines. This lack of both vertical and horizontal feedback mechanisms complicates the monitoring and evaluation of outcomes. In line with Gelderman et al.'s (2015) findings, we suggest that adopting a structural alignment perspective that is receptive to DDDM could enhance the system's performance. This aligns with the new model in Paper I, suggesting that procurement intelligence should be a part of the public procurement system.

Continuing with Paper IV, we further explore the interconnection of DDDM adoption, studying the interplay of several influential factors from Paper III. In line with Choi et al. (2021), the findings show that a comprehensive approach is needed to the adoption of DDDM. The adoption is related to the role of digital motivation in shaping clear digitalisation objectives. Clear goals that incorporate business intelligence stimulate the adoption of DDDM, and the adoption of DDDM further improves the effectiveness of activities in the procurement process, which in turn leads to an improvement in procurement performance.

In conclusion, this study argues that the integration of DDDM within Norway's public procurement system centres on the interplay of digital motivation, analytical skills, the centralisation of procurement units, clear digitalisation objectives, and the use of business intelligence systems. Obstacles, such as the lack of uniform data structures and standardised measurement guidelines and the disconnection between policymaking and operational levels (Figure 13), as shown in Paper III, present mechanisms that suppress adoption. Furthermore, cultivating a structure that encourages digital motivation and cultivating feedback processes stimulates DDDM adoption. Our findings suggest that the successful integration of DDDM in the Norwegian public procurement system lies in understanding and navigating these diverse and interconnected mechanisms (Figure 13).
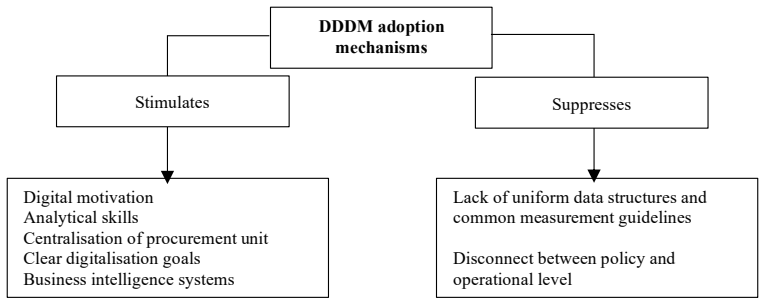
Figure 13 Mechanisms influencing the adoption of DDDM

In understanding the adoption of DDDM within Norway's public procurement system, a theoretical framework inspired by systems theory, management cybernetics, decision theory, and a technology adoption perspective proves helpful. The public procurement system, being a complex entity, necessitates information and feedback flow for optimal functioning. The TOE framework (Tornatzky & Fleischer, 1990) and previous research (Handfield et al., 2019) suggest mechanisms influencing DDDM adoption, such as user skills and management support. Our findings also suggest that the adoption of DDDM is linked to centralisation, and size. In addition, we find that a condition for connecting between policy and operational levels is the development of uniform data structures and standardised measurement guidelines. The findings also show that to stimulate DDDM adoption, it is important to foster digital motivation, establish clear digitalisation objectives, and utilise business intelligence systems, as well as refining feedback processes and ensuring structural alignment. This synthesis shows that a multi-sided theoretical approach is needed for understanding the mechanisms that either stimulate or suppress DDDM adoption in Norway's public procurement system.

5.1.3 *RQ3: How can DDDM adoption potentially impact organisational performance in Norway's public procurement system?*

To answer this research question, this section uses insights presented in Papers III and IV, while simultaneously considering the theoretical framework (Figure 10) and academic literature. The theoretical framework is linked to this research question through systems theory and management cybernetics, illustrating the systemic understanding and the importance of feedback mechanisms in the system. Additionally, decision-making theory and technology adoption underline the potential improvements in procurement decision-making and technology integration with DDDM adoption.

Research in the past has emphasised the role of measurement methodologies and tools in shaping the performance of public procurement systems (Flynn, 2018; Schiele, 2005). Additionally, Duguay et al. (2022) highlight the transformative power of open procurement data on government contracts, urging a more transparent bidding process. In terms of data quality, Futia et al. (2017) also claim that the use of integrated data can strengthen information consistency. This proposition is further documented by preceding literature recommending performance measurement in public procurement (Randall et al., 2004; Schiele, 2005; Smirnova et al., 2016). Supporting this, Halsbenning and Niemann (2019) emphasise the role of DDDM in enabling sound decision-making in public procurement. These findings suggest that the implementation of DDDM could enhance performance in the public procurement system.

Paper III highlights the undervalued importance of structural alignment and feedback loops within the public procurement system. The paper reveals limited DDDM adoption within the Norwegian context, pointing towards an inconsistency between policy and operational perspectives, due to missing alignment for feedback processes. These findings emphasise the need for a systemic modification of the system. In line with systems theory and management cybernetics (Figure 10), without feedback, stakeholders in the system are left with limited control over it. Following this line of thought, Paper IV shows how DDDM adoption can enhance organisational performance in public procurement. The findings in Paper IV show improvements in efficiency gains, cost and time reductions, improved cost control, and enhanced communication with suppliers. These observations align with research from the private sector conducted by Brynjolfsson et al. (2011) and Brynjolfsson & McElheran (2016) that shows a positive correlation between DDDM adoption and heightened performance. This also aligns with the findings of Chatterjee et al. (2021), who demonstrate how a data-driven culture can stimulate product and process innovation, which is regarded important in public procurement systems.

To summarise, the incorporation of DDDM into Norway's public procurement systems can potentially improve organisational performance in terms of both efficiency and effectiveness. This shift, driven by DDDM adoption, could improve alignment, communication, and control between policy and operational levels. Drawing from the current study and the theoretical framework, it is suggested that DDDM can be an element in enhancing the performance of Norway's public procurement system. In summary, Figure 14 illustrates the influence of DDDM on performance at the operational level, including alignment with the policy level that stimulates adoption of DDDM. The organisational performance effects in bold show the variables with the highest correlation to performance from Study IV.
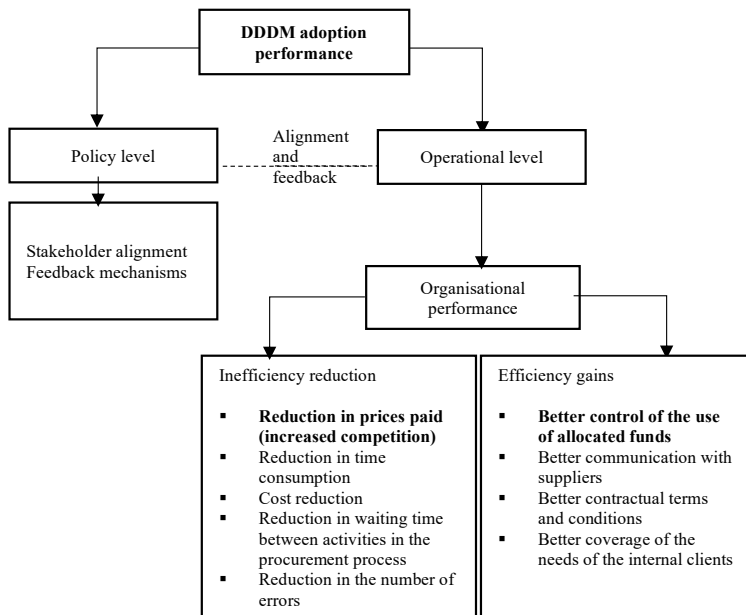
Figure 14 DDDM's influence on performance

The theoretical framework offers an understanding of how DDDM impacts performance in Norway's public procurement system. Systems theory underscores the stakeholders in the system, emphasising the need for information flow and feedback for optimal functioning. Decision theory acknowledges the influence of information processing on decision-making, with limited information often leading to less rational decision-making. DDDM, in this context, can enhance procurement decisions by providing data-driven support. The theoretical framework helps in explaining the potential of DDDM to improve organisational performance, by aligning technology adoption in feedback mechanisms and decision-making processes.

5.2   Mechanisms that drive adoption of DDDM and DDDM influence on performance

The primary research question investigates mechanisms driving the adoption of DDDM and DDDM influence on performance. The theoretical framework's (Figure 10) systems theory aspect addresses this, highlighting interactions within the public procurement system. Management cybernetics theory underscores the role of feedback loops in monitoring this process. Decision-making theory draws attention to procurement decision-making, suggesting its enhancement through DDDM. Lastly, technology adoption theory underscores mechanisms encouraging or suppressing DDDM, framing it within the technology, organisation, and environment context. To answer the primary research question, a central finding is the limited research on DDDM and feedback mechanisms within public procurement systems, as emphasised in Papers I and II. These unaddressed issues are

particularly relevant for further research when considering the insights from Papers III and IV, which highlight the importance of DDDM for performance.

Paper II reveals that less than half (39%) of public procurement officers use spend analytics during decision-making. This finding is noteworthy compared to Paper IV, which demonstrates that data-driven public organisations achieve better performance. The contrast emphasises the potential benefits of decision-making in the public procurement system being more data driven. The limited feedback mechanisms affect how policymakers and management perceive potential regulatory or authorisation developments. Similarly, limited feedback impacts procurement professionals' and managers' understanding of potential adjustments or improvements in procurement operations. The need for uniform data structures and central guidelines or indicators for consistent measurement of public procurement effects, highlighted in Paper III, aligns with the findings from Paper I and the theory of the importance of feedback mechanisms for a viable system (Beer, 1984; Thai, 2001). Developing the adoption of DDDM and effective feedback mechanisms can facilitate better communication and alignment among stakeholders, thereby improving procurement performance. Moreover, the central guidelines and goals discussed in Paper III could help address the limited use of DDDM identified in Paper II, by providing clear directives and incentives for organisations to adopt DDDM.

While Paper IV highlights the importance of specific mechanisms for adopting a data-driven approach in public procurement organisations, it also complements the insights from Papers I and III on the need for feedback systems and common procedures. By addressing the challenges and leveraging the potential opportunities discussed across the four papers, public organisations can improve their performance and contribute to achieving broader societal objectives, such as sustainability and innovation. Figure 15 summarises the findings of the main research question and presents a proposed framework for DDDM in the public procurement system of Norway.
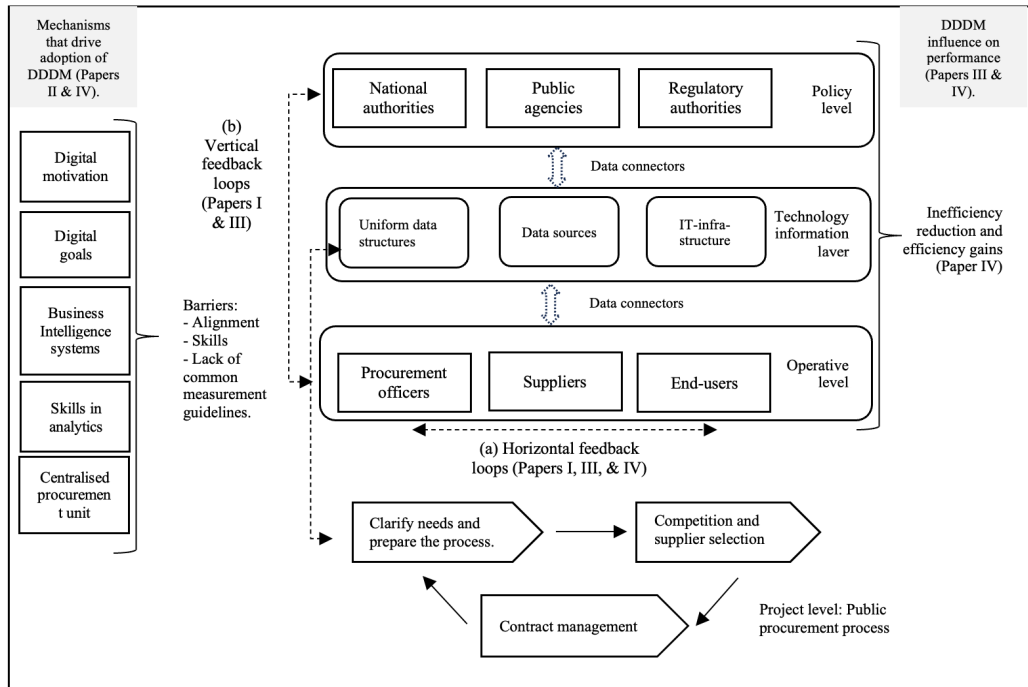
Figure 15 Proposed framework for DDDM in the public procurement system of Norway

The framework in Figure 15 illustrates a systemic change in the Norwegian public procurement system, where the interaction between internal organisational structures at the operational level and communication with higher-level policy systems affect the procurement process. The framework emphasises the presence of two primary feedback mechanisms within this procurement system, designed to enhance communication both internally and across varying levels. Horizontal feedback loops, as marked by the symbol (a) in the figure, are focused on the operational level, which is the level of direct interaction and execution. These loops encourage a cooperative environment amongst procurement officers, suppliers, and end users. Horizontal feedback loops are vital to fostering an understanding of collective performance from multiple perspectives. These loops promote a dialogue wherein each party shares information on performance, providing an evaluation of effects of the procurement process. This shared information aids in identifying issues, implementing necessary changes, and ultimately streamlining the procurement process. Vertical feedback loops, marked by (b), promote communication between different hierarchical levels, namely the policy level and the operational level. This vertical channel enables monitoring and feedback from the operational level to inform and adjust policy directives. This mechanism fosters an environment wherein policy modifications can be driven by practical insights from the operational level. This vertical feedback loop is key in bringing about policy changes that are aligned to the realities of the operational environment, thereby enhancing overall system performance.

The framework also highlights the factors influencing the adoption of DDDM and introduces an addition in the form of a 'technology information layer', located midway between the operational and policy levels. The technology layer serves as a channel that effectively leverages data and analytics to strengthen the feedback loops, thus contributing to better, more data-informed decisions. Furthermore, the procurement process stages are illustrated in a circular model, taking inspiration from Schotanus (2022). This circular illustration is intended to highlight the cyclical nature of the public procurement process. It emphasises the feedback from each contract feeding into the next, constantly improving and refining the process. The technology layer serves as the hub of information in this circular process, providing valuable data to inform the next cycle of the procurement process. In sum, the feedback loops and the central technology information layer facilitate a responsive and evolving public procurement system, as supported by the theoretical framework.

5.3   Contributions to existing literature and theory

The study findings contribute to the limited academic literature on DDDM in public procurement by addressing some of the missing aspects identified in the literature review and Paper I. Paper II responds to the need for more research on feedback and the adoption of DDDM in public procurement described in Paper I. The descriptive and correlation findings in Paper II highlight the mechanisms for adoption factors described in the TOE framework (Tornatzky & Fleischer, 1990), such as employee competence in analytics, size in the form of procurement amount, and a centralised procurement unit (Verma & Chaurasia, 2019).

Paper III broadens the understanding by examining how SPP effects are assessed among stakeholders at policy and operational levels. Paper III also contributes to understanding the public procurement system by drawing on systems theory, specifically De Leeuw's framework of levels of control. This theoretical perspective supplements the literature's limited focus on the adoption of DDDM within procurement systems, as noted in the literature review and findings in Paper I. Paper IV further shows that motivation, goals, and business intelligence systems are factors that influence adoption in the Norwegian public procurement system. The findings in Paper IV show that DDDM can stimulate improved organisational performance, which supports Brynjolfsson et al.'s (2011) argument. In summary, the research findings in this study enrich the academic literature on DDDM in public procurement systems by addressing this research shortage, exploring different stakeholder perspectives, and examining mechanisms for DDDM adoption and impact on performance. The research findings contribute to understanding DDDM in public procurement systems from multiple theoretical perspectives, and the proposed framework (see Figure 15) demonstrates the value of integrating these theoretical perspectives to effectively investigate and address the challenges and opportunities associated with the adoption of DDDM in public procurement (Thai, 2001).

The contribution to the theory lies in the combination of perspectives from cybernetics, decision-making, and technology adoption. The combination of perspectives enriches the understanding in the TOE framework of how organisational context factors such as how individual context factors such as motivation and goals stimulate adoption. In regard to decision-making theory, the study shows that by employing innovative technology and data analytics, the constraints of bounded rationality can potentially be improved by a collaboration between man and machine. DDDM

systems can serve as an 'additional intelligence' capable of processing data and finding patterns that exceed the capacity of human cognition (Simon, 1979, 2013). In this way, technology can supplement cognitive capacity, enabling public procurement decision-makers to tackle complex procurement challenges. Within the paradigm of data-driven public procurement, the principles of management cybernetics (Beer, 2002) underscore the significance of feedback loops. The identified need for horizontal and vertical feedback loops supports Beer's (1984) viable system model by emphasising the significance of bidirectional information flow within an organisation. By combining the principles of systems theory, management cybernetics, decision-making, and technology adoption, the initial framework of the public procurement system (Thai, 2001) can be expanded.

This research introduces new insights into DDDM within Norway's public procurement system by illustrating unexplored areas like feedback mechanisms and decision-making analytics. Findings highlight a contrast between current practices and potential performance improvements through data-driven approaches. The proposed framework, with its focus on horizontal and vertical feedback loops and a new technology information layer, offers a comprehensive model for enhancing the public procurement system. This innovative approach underlines the significance of integrating operational and policy levels with technology, pushing for systemic change and improved procurement outcomes. In summary, the research findings contribute to the management of cybernetics, decision-making, and technology adoption theories by offering an integrated understanding of the mechanisms that influence the adoption and implementation of DDDM in public procurement systems.

5.4   Implications for policy, practice, and current research

The present case study shows significant implications for policy and practice in Norway's public procurement system. On a policy level, Papers II, III, and IV emphasise the importance of leveraging data analytics within a systematic framework to evaluate and monitor the effects of procurement decisions. Moreover, a need exists for policy-level stakeholders to invest in infrastructural technology elements, as suggested by Paper IV. This investment would promote data-driven public procurement decision-making and strengthen organisational performance.

On an operational level, the importance of DDDM is influential. Procurement officers' decision-making relates to maintaining a balance between multiple objectives, such as cost efficiency, legal compliance, environmental protection, and the promotion of societal goals such as innovation and sustainability (Grandia et al., 2023). The introduction of feedback loops and data analytics as decision aids, as recommended in Papers II and III, enables procurement officers to make more informed decisions about how to prioritise and reach these goals, as detailed in Papers II and IV. As indicated in Paper II, analytical skills, a centralised procurement unit, and procurement amount show positive correlation with adoption. Paper IV supplements this picture by showing how digital motivation and goals, paired with investment in business intelligence, can enable procurement officers to employ analytical tools for better organisational performance. Better organisational performance in more public procurement entities within the Norwegian system has the potential to improve the performance of the system overall. The study puts forth a suggested framework, as depicted in Figure 15, which is intended to guide stakeholders within the public procurement

system. This tool provides guidance for the development of necessary structures and the achievement of improved performance outcomes, thereby transitioning from administrative manual procurement decisions to digitalised DDDM. An overview of the implications and recommendations for policy and operational levels is provided in Table 11 below.

Table 11 Implications and recommendations on policy and operational level

Stakeholder level	Implications	Key recommendations
Policy level	Need to leverage data analytics in policy decision-making and monitoring public procurement effects. Understand where horizontal and vertical feedback loops are needed.	Develop a systematic framework with uniform data structures and standardised measurement guidelines to evaluate and monitor procurement metrics and effects. Invest in technological infrastructure for DDDM.
Operational level	DDDM role in balancing multiple objectives. Using feedback loops from suppliers and end users for informed decisions. Transition to DDDM for enhanced performance.	Introduce feedback loops and decision aids in the procurement process. Invest in business intelligence and analytical tools. Create framework for structural development and performance improvement.

The adoption of DDDM into the public procurement structure holds considerable transformative potential. This proposition was underlined in Paper I, which highlighted the lack of research in this domain. Paper III further elaborates on this point, calling for the establishment of a policy framework that leverages data analytics to study the repercussions of procurement choices. Contemporary research should be more focused on exploring the role of data analytics and feedback mechanisms in enabling procurement officers to control the distribution of public funds more effectively.

5.5   Limitations and generalisations of findings

Acknowledging the study's limits can provide valuable context for interpreting the findings. This study's first limitation relates to the research paper's scope. In the first paper, the study focuses exclusively on JoPP. Focusing on a single journal in a literature review might limit the breadth of perspectives and depth of understanding. It risks excluding diverse methodologies, findings, and theoretical contributions from various scholars published in different journals, thereby narrowing the research scope. However, JoPP is the journal with the highest production of research papers and still the only international peer-reviewed journal fully and exclusively dedicated to public procurement. A second limitation is the environmental context of Papers II, III, and IV, which

concentrate on Norway as a specific geographical region. This may overlook the diversity of international contexts, creating bias and potentially limiting the statistical generalisability of the findings, as the outcomes may not be universally applicable in other contexts.

A third limitation is the limited focus on the technical side of DDDM in the public procurement system, such as data quality. Although data quality is a critical aspect of DDDM, it is equally important to consider other mechanisms, such as stakeholder engagement and governance structures (Mergel et al., 2019). However, the author acknowledges that technical oversight is important for a comprehensive understanding of DDDM's adoption. Fourth, the research methods used in the study could also present limitations. Papers I and III rely on qualitative data, which could be subjective and open to interpretation. In Papers II and IV, the methodological approach relies on the analysis of quantitative data obtained from a government-issued survey. The inherent limitation of this approach lies in the fact that the survey was constructed with predetermined questions and potential responses. Consequently, the scope of the obtained information might be restricted to these prespecified inquiries and options, possibly excluding other relevant insights. The construct of performance is also related to organisational performance and not the performance of the whole system. This represents a limitation in our approach, as we have not examined system-wide performance dynamics. Lastly, the research papers discussed in this text are based on quantitative data from 2018 and 2022 and qualitative data from 2020 until September 2021. As a result, any developments, policy changes, or technological advancements that have occurred since then may not be reflected in the findings. This temporal limitation could affect the relevance and applicability of the research outcomes in the current context. In conclusion, while the research papers discussed in this text offer valuable insights into the role of DDDM in the public procurement system, it is necessary to recognise the study's limitations. Acknowledging these limitations provides context for understanding the findings and opportunities for further research.

6   Conclusions and further research opportunities

This study has aimed to investigate the adoption of DDDM in the Norwegian public procurement system and assess its impact on performance. The study has raised three research questions to achieve its aim: identifying the current state of DDDM adoption, recognising the mechanisms that stimulate and suppress the adoption of DDDM, and understanding the effects of DDDM on organisational performance. A synthesis of the insights gained through exploring these questions produces an image of DDDM as a transformative stimulus for performance in the public procurement system.

The structure of the thesis includes this as Part I and four research articles as an appendix in Part II. The purpose of Part I has been to combine the separate pieces of work, provide an overall discussion and explanation of how they are connected, and address the primary research objectives. Part I has been structured into six chapters, unfolding as follows: Chapter 1 began with a broad view of public procurement, illustrating the need to concentrate on the adoption and performance of DDDM within the public procurement system. Chapter 2 identified past literature on DDDM within public procurement systems and presented the theoretical framework applied in the study. Chapter 3 introduced the research context and considered the philosophical orientation of the thesis. Following that was a description of the methodology, including data collection and analysis in the study. Chapter 4 summarised the findings from the four research papers included in the appendices, before Chapter 5 discussed the findings and introduced a new suggested framework for DDDM in the public procurement system. The chapter also reflected on the contributions and implications of the research and considered its limitations. To sum it all up, the conclusions in this chapter present the primary message of the thesis. Finally, recommendations for further research are offered.

6.1   Conclusions

The insights acquired from this study carry significant implications for the future of public procurement in Norway, and the findings could potentially lay the groundwork for comparable developments in public procurement systems on a global scale. The study reveals that the adoption of DDDM is fundamentally influenced by analytical skills and the recognition of DDDM's potential to enhance decision-making processes. This recognition plays a vital role in shaping motivation and setting goals. Additionally, the size of procurement amounts, and the centralisation of procurement units emerge as significant factors in the adoption process. The implementation of business intelligence systems is shown to facilitate efficient information exchange, thereby promoting collaboration and enhancing operational performance. The research further discusses how DDDM augments the effectiveness of activities within the procurement process, subsequently leading to improvements in procurement performance. Intriguingly, the study uncovers a discordance between policy intentions and operational realities within the Norwegian system. This mismatch may be attributed to the limited adoption of DDDM and the absence of robust feedback loops. A more pronounced focus on the utilisation of both horizontal and vertical feedback mechanisms could

cultivate a more collaborative environment. Such an approach would bridge the identified gap, enabling better alignment between policy oversight and operational execution. Considering the second component of the primary research question, this research also emphasises the impact of DDDM on organisational performance. The study finds a positive correlation between the digitalisation of public procurement, the implementation of DDDM, and improved performance. With the assistance of DDDM, a responsive procurement system can be developed that can adapt to changes in procurement objectives, such as sustainability and innovation. This implies that a more wide-ranging adoption of DDDM could contribute to achieving broader societal objectives, making a convincing case for the continual adoption of DDDM. The effectiveness of DDDM's adoption will, however, depend on an understanding of the mechanisms that stimulate and suppress its adoption, as explained above.

In summary, the primary message of this study is that the opportunity for public procurement to be seen as a strategic tool in achieving societal objectives is fundamentally tied to the successful implementation of DDDM within the public procurement system. Given the value of DDDM within the public procurement system, it seems appropriate to raise the proverb 'Knowledge is power'. This old saying captures the fundamental essence of DDDM. In this context, the 'knowledge' represents the evidence-informed information that DDDM utilises to enhance decision-making processes. Possessing this 'power' in the realm of public procurement allows for more effective strategies and practices, enabling the system to reach its full potential as an instrument of societal value. Consequently, the more knowledge we harness and utilise correctly within the public procurement system, the more powerful and effective our decision-making capabilities can become, thereby increasing the overall societal benefits.

6.2   Further research opportunities

The results and recognised constraints of this study suggest multiple prospects for further enquiry, which I shall outline below.

Research direction 1: In line with the initial discussion, the potential exists to explore the technical aspects of DDDM in the public procurement system more deeply. Future research should investigate the transformative opportunities of emerging technologies such as AI, blockchain, and the Internet of Things in enhancing data collection and decision-making practices. Moreover, the potential of AI and machine learning in automating data processing and extracting insights from the public procurement system presents a promising area for investigation. The adoption of new technologies requires the expansion of existing databases and the creation of more comprehensive ones for public procurement data. New data sources could serve dual purposes: first, facilitating data exchange; and second, enhancing cross-level collaborations in the public procurement system. Scholars could explore best practices for data governance, confidentiality, and security in this context, thereby ensuring the integrity and safety of procurement data.

Research direction 2: This study is based on quantitative data from 2018, 2021, and 2022 and qualitative data from 2021. Future research could investigate the development of decision-making practices over time with newer data or a longitudinal approach. This could enable an understanding of the evolution of DDDM in the public procurement system. Studying this evolution could generate

analytical insights into trends and the influence of external factors on the performance of the public procurement system.

Research direction 3: The environmental context in this study has been the public procurement system in Norway. It could also be valuable to do a geographical expansion of the study. In another external environment, there could be other mechanisms that either facilitate or hinder the adoption of DDDM. Consequently, future research should investigate the mechanisms for the adoption of DDDM practices in various countries or regions. Such comparative studies could clarify the influence of motivation, goals, and business intelligence systems on DDDM adoption and performance within the public procurement system.

Research direction 4: Future research could conduct a more thorough investigation into the human and organisational dimensions of DDDM within public procurement systems. For instance, studies could explore the types of mechanisms that impact performance orientation in public procurement systems. Potential research questions might encompass aspects such as the factors that encourage performance orientation in these systems, and whether there is a difference between having a business intelligence system and actively utilising its functionalities.

Research direction 5: Future research could also investigate the concepts of 'feedforward vs feedback control' and 'single- and double-loop learning' in relation to DDDM. These concepts could provide a lens for understanding how organisations learn and adapt their DDDM practices over time. For instance, feedback–feedforward control could be used to study how policymakers look at the best way to manage and control performance in public procurement. A perspective that looks at single- and double-loop learning could examine how the adoption of DDDM could potentially change their strategies in response to the insights gained from DDDM.

In conclusion, this thesis has shown a variety of opportunities for future research, from exploring emerging technologies in DDDM to examining human and organisational dynamics in public procurement. As we proceed forward in this field, let us strive to encourage more research and better knowledge of our public procurement systems. A better understanding of public procurement systems will benefit us all.

7   Literature

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Part II Content – The papers

Paper I – Appendix I
Langseth, M., De Boer, L, & Moe, H. T. (2023). Two decades of Journal of Public Procurement: Content Analysis and Theoretical Expansions of the Thai Model. Submitted to the *Journal of Public Procurement*.

Paper II – Appendix II
Langseth, M., & Haddara, M. (2023). Spend Analytics in Norwegian Public Procurement: Adoption Status and Influencing Factors. Under review in *International Journal of Information Systems and Project Management*.

Paper III – Appendix III
Langseth, M., & Moe, H. T. (2022). Driving through dense fog: a study of the effects and control of sustainable public procurement of electric cars. Published in *Environment Systems and Decisions*.

Paper IV – Appendix IV
Similiä, J. O., Mwesiumo, D., Langseth, M., & Haddara, M. (2023). Antecedents and implications of data-driven decision-making in public procurement. Accepted in *International Journal of Procurement Management*.

Two decades of Journal of Public Procurement:
Content Analysis and Theoretical Expansions of the Thai Model

Marius Langseth
Luitzen de Boer
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This paper is awaiting publication and is not included in NTNU Open

Paper I

review version

Spend Analytics in Norwegian Public Procurement: Adoption Status and Influencing Factors

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Abstract:
Public procurement accounts for a substantial part of Norway's economy. Using the technology-organization-environment (TOE) framework, this study explores the adoption of spend analytics within Norwegian public procurement organizations with descriptive and correlation analyses of responses from 529 different entities in Norway. The findings and analyses are based on a survey conducted by the Norwegian Agency for Public and Financial Management. Our descriptive results reveal that 61% of the entities lack spend analytics, with variations in adoption across different public entity types. The findings also suggest a positive correlation between procurement analysis expertise and the adoption of spend analytics, affirming the importance of analytical skills in procurement. In addition, organizational factors such as procurement volume and centralized purchasing showcase a positive influence. However, the size and role of procurement teams and perceived management barriers show a more nuanced impact. The environmental context also presents a mixed effect, where functionality barriers encourage spend analytics adoption, yet focus on sustainability and competency barriers may discourage it. This research supports a systems approach to enhancing data-driven public procurement by integrating technological ability, strategic organizational structures, and supporting external conditions.

1. Introduction

Public procurement is a significant economic force in the economic health of nations. In the European Union (EU), public procurement represents 14% of GDP, amounting to €2 trillion. The Norwegian public sector spent 63 billion euros in 2022 [1]. According to the EU Commission [2], the public sector should use public contracts strategically to achieve positive social outcomes and reduce environmental impact. This substantial investment through public procurement underscores the need for an overview of where and how all the money is being used. Spend analytics is defined as methods and tools that provide enterprises or countries knowledge about how much is spent on what goods and services, who are the buyers, and who are the suppliers, thereby identifying opportunities to be more strategic. According to the US Government Accountability Office [3], taking a strategic approach to procurement involves using "spend analytics" to understand better how the government is devoting its resources. In addition, the use of analytics in public procurement to analyze spending is also recommended by the World Bank [4]. Spend analytics is essential in strategic procurement, integrating with the digital transformation of public procurement [5].

The digitalization of public sectors globally and in Norway is a trend that has also gained momentum in the public procurement domain [6, 7]. According to Pandit and Marmanis [5], spend analytics is the way to strategic sourcing, and the shift toward data-driven approaches in public procurement is driven by the dual forces of an expanding data universe and the decreasing cost of managing data. Together, these forces drive greater efficiency and productivity in the public sector [8]. Despite the clear recommendations, the research on adopting data and spending analytics in public procurement is limited [9]. Patrucco, Luzzini and Ronchi [10] report a lack of research focusing on the use and impact of advanced tools and procedures for supporting procurement activities, and Langseth and Similä [11] highlight the scarcity of studies on analytics adoption within a Norwegian (public) context. An OECD working paper by van Ooijen, Ubaldi and Welby [12] argues that the reduction in data storage and processing costs requires the government to adopt data analytics and data-driven decision-making (DDDM) for evidence-led policy making and data-backed service design [13]. The opportunities for public procurement to be more strategic are comprehensive if a DDDM ecosystem is incorporated. The procurement function can access data from internal transactions, suppliers, environmental footprint, and more. This wealth of data has stimulated the adoption of DDDM in other government operations, like healthcare [14]. The drive for DDDM in public procurement is to capitalize on the benefits of big data analytics, thereby transforming public procurement into a data-driven function within the government [15]. DDDM as a paradigm helps extract actionable insights from data. It encapsulates foundational theories, methodologies, and techniques for interpreting complex phenomena, trends, and patterns [16]. In a data-rich environment, the symbiosis between domain knowledge and data analysis is more crucial than ever for accommodating informed decisions [17]. Provost and Fawcett [16] map out the DDDM ecosystem (see Figure 1), charting the evolution from intuitive to data-driven enterprise decision-making. Combining data analysis and experiential knowledge can lead to more informed decisions. The positive impact of DDDM on performance has been validated across various sectors [18], confirming the value of a data-driven approach.

Historically, the public sector has provided limited resources for data analysis, and according to a study by [19], limited adoption of data analytics in the public sector was connected to the lack of top management and organizational support, and the lack of proper information and data management [20]. Despite Norway's recognition of technological advancements and its public sector digitalization efforts, challenges in adopting data analytics in the public sector persist. The national Norwegian white paper on public procurement highlights the underuse of data in procurement decision-making and calls for an environment that encourages DDDM to improve decision-making quality [21]. The limited use of data for decision-making is also supported by an assessment of the Norwegian public procurement system [22], which states that there is a lack of monitoring systems to measure the effects of public procurement decisions.
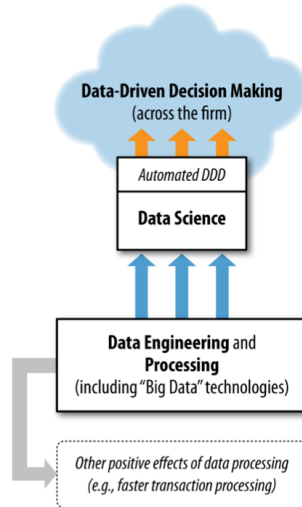
Figure 1. DDDM ecosystem

To address the research gaps, this study examines the adoption of analytics among public procurement professionals in Norway, particularly spending analytics, and the determinants influencing its use. The primary research question being addressed is: *What is the status of spend analytics adoption in public procurement in Norway, and what technological, organizational, and environmental factors influence the adoption?* In addressing this question, the study also explores the interplay between technological readiness, organizational capabilities, and the external environment. By focusing on spend analytics, this study not only contributes to the academic discourse on public procurement but also provides practical insights for stakeholders in the public sector aiming to improve the adoption.

The rest of the paper is organized as follows: in the next section, we provide an overview of the related research and discuss the theoretical framework for this study. In Section 3, we present the research design and methodology adopted. The findings are presented in Section 4, followed by a discussion of the research findings, implications, and limitations in Section 5. Finally, a conclusion is provided in Section 6.

2. Related research and theoretical background

Since Gutenberg's printing press in the fifteenth century, the accumulation of information and data has increased twice every 50 years. In contemporary times, the rate of data generation has surged dramatically. As conceived by McKinsey and Company, there is an annual data volume growth rate of about 50% [23]. The dropping data storage costs further strengthen this data accumulation trend, aligning with the premise that potential value exists in data, making it a worthy asset for analytics pursuits [24].

2.1. Related research

In public procurement, data analytics and spend analytics are often called procurement analytics. Interestingly, while DDDM adoption is well-researched in private sector areas like marketing, its exploration in public procurement remains

limited [25]. Some studies have examined its dynamics, challenges, and applications. Langseth & Haddara [26] studied data analytics adoption in public procurement in Norway and highlighted the influence of organizational factors, such as employee competence and top-management support, on its adoption. However, they noted that no factors were found to have significant effects.

Ghosh [27] investigated cloud-based big data analytics, emphasizing the facilitating role of information technology (IT) infrastructure, internal capabilities, and vendor support. In contrast, the study also identified barriers, including a lack of an analytics culture and top management support. Merhi & Bregu [28] stressed the significance of technological advancements in effectively using big data analytics in the public sector. Weng [29] inquired into the relationship between business strategies and the adoption of big data analytics. They found that a strategic framework heavily influences intentions to adopt. Farshchian et al. [30] discussed challenges in technology adoption related to public procurement innovation. Rada et al. [31] highlighted the merits of software applications in public procurement, particularly for time efficiency and the adoption of big data analytics. Handfield et al. [32] raised concerns about the global low adoption rate of advanced procurement analytics, pointing to data quality issues. They argued that standardized data collection protocols foster a culture of DDDM within organizations. Other research has indicated the power of data analytics in streamlining procurement processes and identifying fraud [33]. Finally, LaValle et al. [34] and van Ooijen et al. [12] emphasize the potential of DDDM in the public sector, from supporting citizen trust to enhancing service quality. A summary of the present research and the main findings is provided in Table 1.

Table 1. Summary of related research and findings

Publication	Main findings
[26]	The study highlighted the influence of organizational factors, such as employee competence and top management support of adoption. No elements were found to have significant effects.
[27]	IT infrastructure, internal capabilities, and vendor support facilitate cloud-based analytics adoption; lack of analytics culture and management are barriers.
[28]	Technological advancements, data security, and transparency is vital for successful big data analytics adoption.
[29]	Business strategies, especially strategic typologies, impact the adoption of big data analytics.
[30]	Challenges include evolving procurer roles, procurement methods, and collaboration, which are hurdles that impact technology adoption.
[31]	Software in public procurement offers time efficiency benefits and emphasizes the role of Big data.
[32]	The low global adoption rate of procurement analytics is due to data quality issues, the importance of standard data protocols, and DDDM culture.
[25]	Limited exploration of DDDM in public procurement compared to other sectors.
[34]	DDDM in the public sector can boost citizen trust, enhance service quality, and serve sustainability goals.
[12]	The adoption of data analytics has the potential for better decision-making.
[10]	There is a lack of research that explores the use and impact of advanced tools and procedures for supporting procurement activities
[33]	Predictive algorithms enhance budgetary and spending estimations in public agencies.

According to the literature review, the adoption of spend analytics in public procurement is influenced by organizational, technological, and strategic factors. Key enablers include top-management support, IT infrastructure, and standardized data protocols, while challenges span from analytics culture to data quality. Its potential for enhancing efficiency, trust, and service quality is acknowledged.

2.2. Theoretical background

Public procurement, as a critical component of the public sector, requires efficient and strategic use of Information Systems (IS) and IT to ensure transparency, fairness, and value for money. Adopting these technologies within the procurement landscape shapes how governments and public entities purchase goods and services [35]. Several theoretical models have been proposed to illustrate and aid in identifying and managing the complexities of IS/IT adoption. Among these models, the *technology acceptance model* (TAM) [36], the *theory of planned behavior* (TPB) [37], the *diffusion of innovations* (DOI) [38], and the *technology-organization-environment* (TOE) framework [39] are of particular significance. While TAM and TPB primarily focus on individual-level analysis, the DOI and TOE, especially relevant to public organizations, emphasize organizational-level dynamics [40].

In choosing to incorporate the TOE framework into public procurement, we picture public procurement as a dynamic system with numerous interrelated components [41]. In this context, data analytics can be perceived as a tool and part of a system. As a tool, it aids procurement officers in making informed decisions by analyzing datasets related to suppliers, market trends, and historical purchasing data [42]. As part of a system, it acts as a feedback mechanism, continuously refining the procurement system. Insights collected from data analytics can highlight inefficiencies, detect abnormalities that might suggest fraud, and predict future procurement needs. When looped back into the public procurement system, this feedback leads to iterative improvements, ensuring the procurement process remains transparent and adaptive to changing circumstances [43]. Feedback loops in systems theory and management cybernetics emphasize the importance of monitoring and adapting a system based on the system's outputs [44]. In the public procurement domain, these loops become necessary to play a strategic role. For instance, after analyzing a series of tenders, spend analytics might suggest that a specific product or service's environmental footprint is higher than the market average. When fed back into the system, this insight can lead to revised procurement strategies or a re-evaluation of the specifications to ensure sustainability [45].

The TOE framework [39] is a conceptual model used to analyze the factors influencing the adoption of technological innovations in organizations (see Figure 2). It considers three main dimensions: technological (technological readiness and features), organizational (size, structure, and resources), and environmental (industry characteristics, market competition, and regulatory environment). This framework aids researchers and practitioners in understanding and predicting technology adoption behaviors. The adoption of the TOE framework provides a broad lens to dissect how organizational setting influences the adoption of technological innovations. Using the TOE framework in past studies examining data analytics adoption in private, e.g., [46] and public enterprises, e.g., [47] highlights its robustness and relevance.
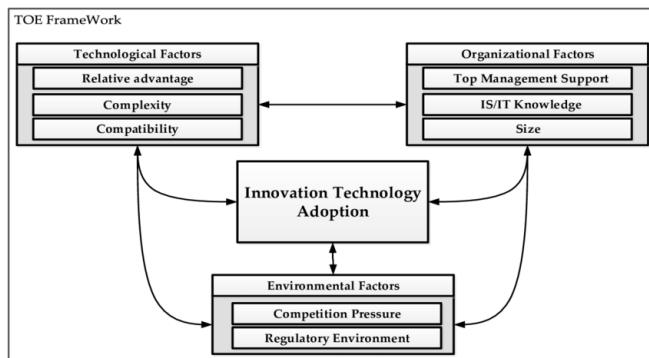

Figure 2. The TOE framework [39]

2.2.1. Technological aspects

The theoretical framework emphasizes the role of existing technological infrastructure and the presence of digital resources in assessing an organization's digital transformation readiness. According to Trenerry, Chng, Wang, Suhaila, Lim, Lu and Oh [48], evaluation of an organization's technological readiness should be a factor in variables related to analytics adoption. They argue that the degree to which an organization utilizes digital tools reflects its adaptability to new technology trends. Within this context, Handfield, Jeong and Choi [32] argue that it's also essential to analyze the influence of procurement analysis expertise, as it significantly contributes to the uptake of spend analytics, underlining the importance of procurement process know-how The skillset available within the organization shapes its capacity to deploy and maximize the benefits from spend analytics, making it a vital factor for adoption. The interaction between the use of digital tools utilization and their potential negative relationship with analytics uptake also merits investigation; this may suggest a preference for these tools that could hinder the strategic application of analytics [49]. Integrating a digital procurement strategy into this analysis reflects the strategic planning in technology use, which supports spend analytics integration [50]. Additionally, proficiency in digital tools warrants inclusion in a thorough examination of spend analytics adoption [51]. The following hypothesis captures the relationship between technological aspects and spend analytics adoption:

H1: Use of digital tools in various aspects of the procurement process and employees' expertise in analytics positively correlate with adopting spend analytics.

2.2.2. Organizational aspects

In exploring organizational factors influencing technology adoption, it is crucial to investigate how various characteristics may affect the uptake of spend analytics in public procurement. According to studies by Liberatore, Pollack-Johnson and Clain [52], organizational size should be a key consideration, as previous research suggests larger organizations have more complex operations and thus may be more likely to invest in data analytics. In addition, related to studies by Yao, Xu, Liu and Lu [53], a central purchasing unit is another variable that warrants attention, as centralized procurement functions can influence the extent and effectiveness of spend analytics adoption, based on the argument that centralization could streamline procurement practices and enhance analytical capabilities A study by Borkovich, Skovira and Breese-Vitelli [54] suggest that organizational roles and the number of procurement employees also merit inclusion in the analysis. The diverse roles within a business can provide insight into the differing impacts on technology adoption, given that some roles may prioritize spend analytics differently. Finally, Chong and Olesen [55] suggest that the perceptions of management as a barrier to technology adoption are essential to consider. The management's stance towards innovation can significantly influence the organizational culture and readiness for change, making it a potential factor in successfully implementing spend analytics. These features—organizational size, centralization, role in business, procurement employee numbers, and management's role as a barrier—compose a framework for analyzing the organizational readiness and potential for spend analytics adoption. This framework aligns with the many-sided nature of organizational dimensions in the TOE framework, which include culture, leadership, and resource allocation. It is crucial for understanding and predicting technology adoption patterns in public procurement. Hence, to investigate the impact of the organization-related factors on spend analytics, the following hypothesis was formulated:

H2: The size of the organization and the centralization of the procurement unit positively correlate with the extent of spend analytics adoption in public procurement.

2.2.3. Environmental Aspects

According to the TOE framework, the environmental dimensions include industry structure, regulatory environment, and public funding. The choice to include zero/low-emission solutions in this analysis stems from the observation by, for example, Bellucci, Bini and Giunta [56] that environmental sustainability initiatives often intersect with organizational

technology strategies. Researchers can distinguish how environmental strategies impact spending analytics prioritization by emphasizing zero or low-emission solutions.

Functionality barriers provide a lens to understand organizations' specific challenges in technology implementation. The perceived efficacy of digital tools is a critical component of an organization's environment, influencing both the perceived need for and potential resistance to spend analytics. As organizations struggle with functional challenges, they may be more motivated to adopt advanced analytical tools to navigate and mitigate these barriers [57]. Procurement collaboration is another environmental factor that reflects on the external business practices influencing an organization's technology adoption. This aspect of the environmental context captures the trends and pressures of inter-organizational cooperation, which can make arenas for the exchange of best practices, including the application of spend analytics [58]. Competence barriers reflect the human resource dimension of the external environment, where the general competence level may serve as a promoter or a barrier to analytics adoption [59]. Lastly, established routines within organizations can signify both stability and stagnation. Investigating these routines is vital to understanding how missing established processes may challenge the implementation of spend analytics. Analyzing these routines within the environmental context can reveal the degree of flexibility and readiness for organizational change, which is crucial for technological adaptation and integration [60].

The regulatory environment can also enable or hinder technology adoption, depending on its alignment with data governance standards. Competitive landscape and inter-organizational collaborations further promote or hinder technology adoption. Therefore, the following hypothesis was formulated to investigate the environmental dimension:

H3: The broader environmental context, encapsulating external policies and the accessibility of technology, serves as a positive catalyst for the adoption of spend analytics.

The overarching objective of this study is to investigate the status of spend analytics in Norwegian public procurement and explore how spend analytics adoption is influenced by organizations and practitioners for DDDM within the public procurement domain in Norway. As the existing literature suggests, a range of factors affect the adoption of data analytics and DDDM in public organizations. Figure 5 provides an overview of the factors identified in the literature.
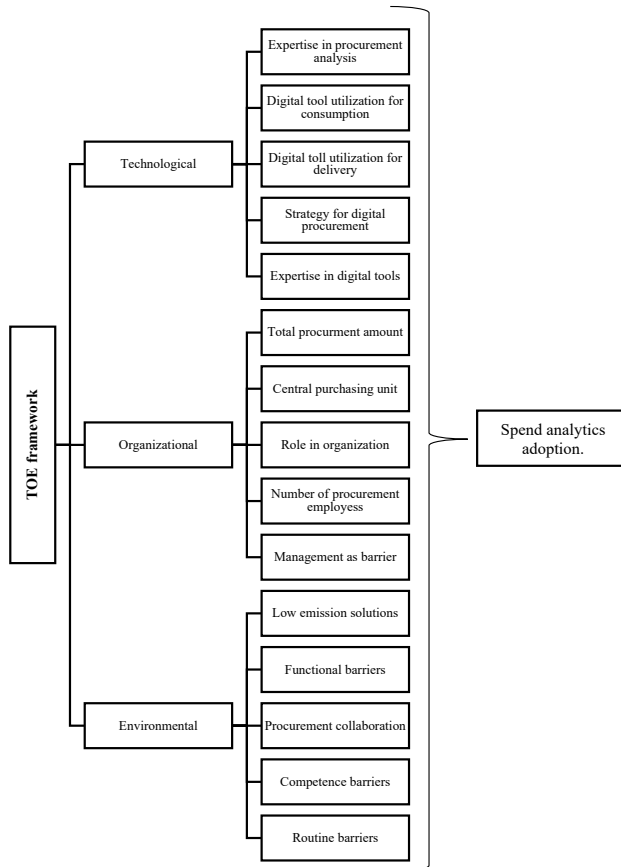
Figure 3. TOE factors affecting data science and analytics adoption in public organizations.

3. Research method

This section outlines the methodological approach adopted in this research to explore the elements influencing the adoption of spend analytics in procurement planning. The methodology drives the research design, data collection, and data processing and analysis procedures.

3.1. Research design

The research adopted a quantitative cross-sectional survey design based on secondary government data from 2022 in Norway. The design captured a specific moment in time [61], providing insights into the current practices, perceptions, and barriers associated with adopting spending analytics within public procurement entities in Norway. Utilizing a quantitative methodology, the study was structured to statistically evaluate the relationships between various factors categorized within the TOE framework and their impact on adopting spend analytics. The survey included a wide-ranging

set of variables with a total of 276 variables. Based on the literature, this study looked closer at 15 factors (see Figure 3) to reflect aspects critical to adopting procurement analytics. This structured approach facilitated the measurement of the extent to which public procurement entities have adopted spend analytics into their operations and allowed for exploring the strength and nature of the associations between adopting spend analytics and the potential determinants identified in the TOE framework. While offering valuable insights into the factors influencing the adoption of spend analytics, the study's nature implies a limitation in establishing causality. Nevertheless, the correlations provide a foundation for understanding the current landscape of adoption of spend analytics within public procurement in Norway, serving as a springboard for further studies that could track changes over time and potentially reveal causal relationships [62].

3.2. Data collection

The survey was conducted by *The Norwegian Agency for Public and Financial Management*. The Agency operates a biannual survey, which is a broad effort to understand the current state of public procurement in Norway. Targeting procurement managers from a wide array of public entities, including state enterprises, counties, and municipalities, the survey focused on individuals directly involved in public procurement to ensure the quality and relevance of the collected data. In 2022, the survey was distributed electronically, allowing efficient participation and adherence to data integrity principles. This strategy led to 578 out of 1132 public companies in Norway responding. A response rate of approximately 51%, thus offering a rich and diverse dataset for analysis. The responses were spread across public organizations. As seen in Table 2, out of the 578 respondents, 42 % came from Norwegian municipalities.

Table 2. Overview of responses from procurement government type.

Type of public entity	Percentage of respondents
Municipality	42 %
Public enterprise and company	29 %
State enterprise	28 %
County	1 %

The survey aimed to provide a comprehensive overview of public procurement, focusing on governance, operation of the public procurement process, competence, time and resources, sustainability, innovation, and digitalization. Our target variable was stated as the question, "What surveys and analyses are carried out in connection with planning the total purchasing portfolio?" where spend analysis was one of the alternatives (sl_an_spend). This structured data collection approach, the wide range of variables, and the survey question explicitly asking about spend analytics were crucial for insights into adopting spend analytics in Norway's public procurement. The resulting dataset was therefore positioned to support a many-sided analysis, offering valuable perspectives on the technological, organizational, and environmental influences on spend analytics adoption.

3.3. Data preparation and analysis

To ensure the integrity and robustness of the findings in this study, the data preparation and analysis were conducted with careful attention to detail, following established protocols in the field [63]. *The Norwegian Agency for Public and Financial Management* provided the dataset, which consisted of survey responses from various public procurement entities in Norway. The dataset exhibited several critical survey design and data management issues. Firstly, missing values in the dataset can skew results and limit the dataset's representativeness. Mixing integers and decimals in coding also introduces inconsistencies in data types, complicating data processing and analysis. The use of unusually large values (e.g., 400) can be problematic, potentially representing outliers or errors in data entry that can distort statistical findings. Moreover, the inclusion of 0 as a value, depending on the context, might represent either a legitimate data point or a placeholder for missing or unrecorded data, adding to the ambiguity. The dataset also exhibits unclear and inconsistent

coding practices, as evidenced by a feature containing an inconsistent array of values like 0, 1, 12, 400, 1.5, 40, and 150. Such a range suggests a lack of standardized data entry protocols or a misunderstanding of the data's nature, making it challenging to interpret or analyze these values meaningfully. Finally, using long attribute names poses technical challenges, as some data analysis libraries or software may have limitations on character length, leading to errors during data processing. This issue, while seemingly minor, can cause significant practical difficulties in data handling and analysis. Overall, these problems collectively undermine the dataset's reliability and validity, necessitating thorough cleaning and standardization of the dataset before any meaningful analysis can be conducted. Hence, a systematic data cleansing and preparation processes were employed to mitigate the risk of biases arising from incomplete or inconsistent data. Although the dataset had several design issues, nevertheless, the dataset contained a rich array of continuous and categorical variables. Out of a comprehensive collection of 276 variables, 15 were based on the literature study and selected to align with the TOE framework, which guided the analysis of factors influencing the adoption of spend analytics. These variables encompassed a spectrum, from technological tools and digital maturity to organizational characteristics and the wider business environment. The dataset also contained attributes with missing values and outliers, which warranted the use of imputation strategies tailored to their data types. For example, median values substituted missing entries in numeric columns as it is less sensitive to outliers [64]. In addition, to ensure the consistency in textual columns, all textual values were converted to lowercase to ensure consistency. Categorical variables, such as the type of public entity and the number of employees, were also converted into a binary matrix. This was necessary for subsequent regression analysis, enabling numerical techniques to process and analyze categorical data effectively [65]. As the features in the dataset had different ranges, hence, the preparation process also included min-max normalization, which is a technique that maintains the original distribution's shape while scaling the values to a specific range, typically 0 to 1. This technique can be particularly useful in ensuring that no single feature disproportionately dominates the others [66]. Following the data preparation, descriptive statistics were generated to provide an initial overview of the data's characteristics. This foundational step involved calculating the frequency distributions, percentages, means, and standard deviations of the variables under consideration. It allowed for identifying general patterns, trends, and potential anomalies within the dataset as an introduction to more complex analyses [65]. The study then progressed to a correlation analysis to explore the relationships between the selection of factors captured in the survey and the target variable 'sl_an_spend,' which denotes the adoption of spend analytics in procurement planning [67]. The correlation coefficients provided a measure of the strength and direction of the linear relationships between the variables. This analysis was central in identifying which factors showed the most substantial associations with the adoption of spend analytics, thus identifying potential areas of interest for deeper investigation. Hypothesis testing was conducted using chi-square tests of independence to validate the findings from the correlation analysis. These tests involve determining the significance of the relationships between variables and adopting spend analytics [68]. By determining the statistical significance of the observed associations, the study moved beyond exploratory data analysis to confirmatory data analysis, thus providing a better understanding of the factors influencing spend analytics adoption.

A commitment to methodological quality supported this multi-faceted approach to data analysis. Every step was executed carefully, from the *Norwegian Agency for Public and Financial Management's* initial survey design to the data analysis. This ensured that the conclusions drawn about the status and determinants of spend analytics adoption in Norwegian public procurement were based on empirical evidence and stood up to a thorough statistical study. Finally, even if the dataset had critical issues by following best practices in data handling and statistical analysis, the study provides a reliable and insightful examination of the factors contributing to adopting spend analytics in public procurement in Norway.

4. Findings

Exploring the data gathered from the survey, this section reveals the dynamics of spend analytics adoption within Norway's public procurement. The section first looks at descriptive findings before it goes deeper into the correlation analysis and hypothesis testing.

4.1. Descriptive findings

In this section, we explore the descriptive statistics that summarize the findings on using spend analytics in public procurement. Our dataset consisted of 578 responses, which are 529 valid responses on the adoption of spend analytics. A key measure of dispersion, the standard deviation, is 0.458. This indicates a moderate spread in the data, suggesting that while there may be some consensus on specific aspects of spend analytics, there is also significant diversity in how the respondents utilize and perceive it. This variance highlights the need to examine the factors contributing to this divergent adoption of spend analytics in procurement processes. Table 3 shows the distribution of roles among respondents who answered the 'sl_an_spend' question, stated in percentages.

Table 3. Respondent's roles.

Role	Percentage of respondents
Procurement Manager with Personnel Responsibility	29 %
Procurement Coordinator without Personnel Responsibility	29 %
Economic or Administrative Manager	19 %
Purchaser	7 %
Technical Specialist	5 %
Budget Owner	3%
Project Manager	1 %
Other Roles	7 %

The breakdown shows the roles of individuals who provided insights on analytics adoption within their organizations. Of these, approximately 39% of the respondent's report using spend analytics, while 61% do not use spend analytics in their procurement planning (see Figure 6).
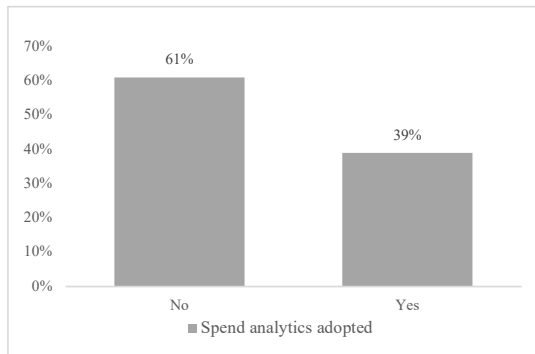
Figure 4. Adoption of spend analytics in procurement planning.

Table 4 displays the distribution of spend analytics usage among various public entities in Norway. It shows the percentages of entities within each category that do not use spend analytics. In state enterprises and public enterprise companies, the majority (66 % and 65 %) do not conduct spend analysis in their procurement planning. In municipalities, 56% do not conduct spend analytics. County municipalities report a higher adoption rate, with 38% not using spend analytics.

Table 4. Overview of entity type and percentage that do not conduct spend analytics.

Type of public entity	Do not conduct spend analytics in %
State enterprise	66 %
Public enterprise companies	65 %
Municipality	56 %
County	38 %

These descriptive findings give a foundational understanding of the analytics landscape in Norwegian public procurement. A correlation analysis of the identified factors based on the TOE framework was conducted to understand which factors influence the use of analytics in procurement planning. The correlation analysis findings are presented in the following section.

4.2. Correlation analysis

As discussed earlier, the technological, organizational, and environmental contexts identified in the literature could potentially affect public organizations' adoption and use of data analytics. Hence, our findings below are organized and presented according to the three main dimensions of the TOE framework.

4.2.1. Technological context

The technological background is vital in understanding the landscape of analytics adoption within public procurement. This relates to both the internal and external technologies relevant to the organization. It involves the technologies available to the firm, as well as the technologies currently in use. The heatmap (Figure 5) offers insights into the correlation between various technological dimensions and the adoption of analytics.
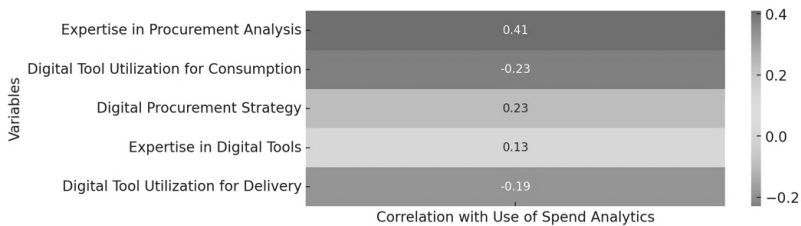
Figure 5. Correlations top five technological context variables.

The study finds that expertise in procurement analysis, with a correlation of 0.41, positively correlates with adopting spend analytics, highlighting the importance of analytics competence in adopting analytical tools. In contrast, a correlation of -0.23 for digital tool utilization for consumption indicates an inverse relationship. A digital procurement strategy correlates 0.23, showing a modest positive effect on the likelihood of spend analytics adoption. With a correlation of 0.13, expertise in digital tools has a slight positive impact on adopting spend analytics. Lastly, a -0.19 correlation for digital tool utilization for delivery suggests that prioritizing digital delivery tools has a low negative correlation with adopting spend analytics. These correlations demonstrate the roles that expertise in procurement analytics has in adopting spend analytics while also revealing the nuanced interplay with the practical use of digital tools in such adoptions.

4.2.2. Organizational context

The organization context, such as the organization's size and internal organization, has drawn significant attention. We conducted a correlation analysis to clarify the underpinning organizational factors influencing this adoption. The findings below are based on the correlation heatmap (Figure 6).
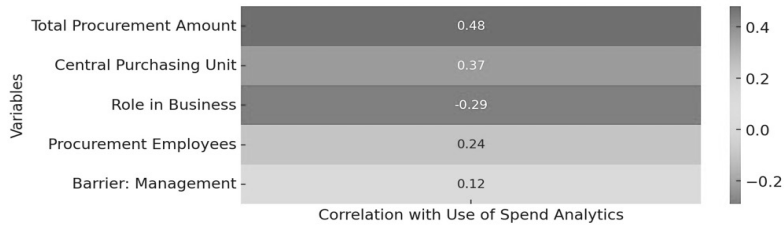
Figure 6. Correlations top five organizational context variables.

The heatmap for the organizational context describes the relationship between organizational characteristics and the adoption of spend analytics in public procurement.

The findings reveal that organizations with higher total procurement volumes show a positive correlation of 0.48 with adopting spend analytics. A correlation of 0.37 with having a central purchasing unit indicates that such organizational structures are more likely to implement spend analytics. The negative correlation of -0.29 associated with the role in business suggests that the specific organizational roles and priorities may negatively affect the adoption of spend analytics. The number of procurement employees has a moderate positive correlation of 0.24 with spend analytics adoption.

Moreover, a mild positive correlation of 0.12 with the perception of management as a barrier. These correlations reveal the influence of organizational structure and perceived barriers on the integration of spend analytics, with the size of procurement amount and centralization being facilitative factors. At the same time, the specific role in the business and management attitudes show a more subtle influence on this adoption trend.

4.2.3. Environmental context

In the environmental context we focused on the external business environment found in literature within the TOE framework's environmental context. The heatmap (figure 7) for the environmental context exposes the influence of environmental factors on the adoption of spend analytics in public procurement:
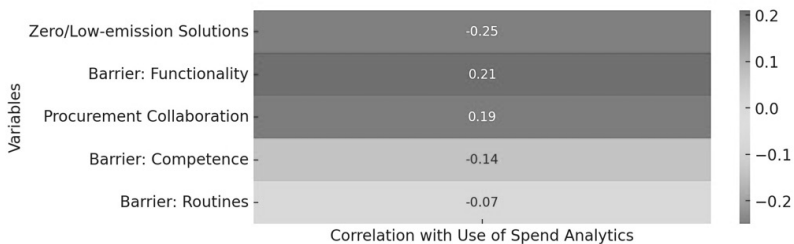
Figure 7. Correlations top five environmental context variables.

The findings show a moderate negative correlation of -0.25 with zero/low-emission solutions. A positive correlation of 0.21 with functionality barriers. Procurement collaboration had a mild positive correlation of 0.19. Competence barriers show a mild negative correlation of -0.14. Finally, a weak negative correlation of -0.07 for established routines indicates that established practices in organizations have a slight negative impact on adopting spend analytics. Although the correlations show some trends, all of them were weak and it was challenging to say something about the relationship between the environmental context and adoption. Based on the findings in the correlation test, we will further test the hypothesis constructed from the literature.

4.3. Hypothesis testing

The exploration of hypotheses in this study empirically tests the theoretical statements concerning the adoption of spend analytics in Norway's public procurement. By conducting hypothesis testing, we move from preliminary observations to a more, data-driven understanding of the factors influencing this adoption. The statistical validation process involves presenting the outcomes of regression analyses, supported by numerical evidence, to establish the validity of the proposed relationships. See Table 5.

Table 5. Results hypothesis testing

Hypothesis	Variable	Coefficient	P-value	Support
H1: Use of digital tools in various aspects of the procurement process and employees' expertise in analytics positively correlate with adopting spend analytics.	Analytics expertise among employees	0.41	< 0.001	Supported
	Use of digital tools	-0.23	0.045	Not supported
H2: The size of the organization and the centralization of the procurement unit positively correlate with the extent of spend analytics adoption in public procurement.	Organizational size	0.48	< 0.001	Supported
	Centralized procurement unit	0,37	< 0.001	Supported
H3: The broader environmental context, encapsulating external policies and the accessibility of technology, serves as a positive catalyst for the adoption of spend analytics.	Zero and low emissions solutions	-025	0,034	Not supported
	Functionality not being perceived as a barrier	0.21	0,060	Not supported

Hypothesis H1 is centered on the premise that the proficiency of employees in analytics and the use of digital tools are significant determinants of spend analytics adoption. The regression output provides a divided picture: while employee expertise in analytics emerges as a positive influence on adoption (evidenced by a coefficient of 0.41 and p-value below 0.001), the use of digital tools paradoxically presents a negative association but is not significant (with a coefficient of -0.23 and p-value of 0.045). The data lends robust support in testing Hypothesis H2, which relates organizational size and the presence of a centralized procurement unit to spend analytics adoption. A larger procurement amount positively correlates with adoption, as indicated by a coefficient of 0.48 and a significance level below 0.001. The centralization of procurement functions further supports H2, with a positive coefficient of 0.37 and a high significance level. Hypothesis H3 considers the broader environmental context, including external policies and technology accessibility, as a promoter for adoption. The regression analysis shows that while zero/low-emission solutions show a moderate negative correlation of -0.25 with a p-value of 0,034 and the non-perception of functionality as a barrier has a positive coefficient of 0.21, its

p-value is 0.060. Both fall short of established significance thresholds, thus not providing statistical evidence to support H3. This outcome suggests that while favorable environmental conditions are hypothesized to promote adoption, zero/low emission solutions and functionality as barriers do not have a statistically significant effect.

The results from this study illustrate that the adoption of spend analytics in public procurement is influenced by a collection of factors, competence in analytics, procurement amount and having a centralized procurement unit is supported to have a positive effect based on statistical verification. The findings partially support H1, show support for H2, and the non-support for H3. This underscores the many-sided nature of DDDM adoption in public procurement, which will be further discussed in the next section.

5. Discussion, research implications, and limitations

The discussion section of this research paper explores the many-sided adoption of spend analytics in Norwegian public procurement. This section translates the study's findings, drawing on the TOE framework to explain the current state and influence of various factors on the uptake of spend analytics. It evaluates the paradoxes and correlations revealed in the findings and examines the hypothesis testing outcomes. This section will also discuss the implications of these findings for policymakers, promoting a systemic adoption approach and calling for further research into complex influencing factors. The study's limitations are acknowledged, highlighting the challenges posed by the dataset and self-reporting biases.

5.1. Research question and main findings

This study investigated the following research question: What is the status of spend analytics adoption in public procurement in Norway, and what are the technological, organizational, and environmental factors influencing this adoption?

The findings of 529 responses from different public procurement entities suggest low adoption (39 %) of spend analytics with a mix of adoption among different types of government organizations. Within the technological context of Norway's public procurement system, our findings indicate that proficiency in procurement analytics positively correlates with adopting spend analytics, highlighting the significance of technological competence in enhancing operational efficiency. However, an unexpected negative relationship with the usage of digital tools emerges, suggesting that while these technologies are crucial, they may interfere with the strategic application of analytics. This apparent contradiction calls for a more nuanced investigation into how active technology can conflict with strategic analytics objectives.

From an organizational perspective, the analysis reveals a more direct relationship. Larger procurement volumes and centralized procurement structures are linked to higher adoption rates of analytics, suggesting that organizational scale and configuration are conducive to the use of analytics. Yet, a subtle negative correlation is observed between individual roles and management's perception of analytics adoption, which may indicate a disconnection between the day-to-day operational activities and the strategic benefits of analytics.

Regarding environmental factors, our research introduces an additional layer of complexity to the adoption situation. There is a negative correlation between the emphasis on low-emission solutions and the utilization of spend analytics. This finding is counterintuitive, as one would expect that analytics, by quantifying and revealing spending patterns, would support sustainability goals by identifying areas for emission reductions and more eco-friendly procurement practices. This observed tension might also reflect a scenario where procurement professionals are not adequately equipped to integrate analytics into their sustainability strategies or analytics tools are not sufficiently tailored to address sustainability metrics. Therefore, it is crucial to explore further how public procurement can resolve and align with sustainability requirements.

The hypotheses test shows that employees' expertise in analytics significantly promotes the adoption of spend analytics, affirming Hypothesis 1 (H1). This is evidenced by a positive coefficient and a p-value indicating statistical significance. Contrary to expectations, the use of digital tools does not stimulate spend analytics adoption as initially

hypothesized, with a negative coefficient and a p-value suggesting it is not statistically significant. For Hypothesis 2 (H2), both the size of the organization and the centralization of the procurement unit have a positively significant correlation with the adoption of spend analytics, reinforcing the notion that larger and more centralized structures encourage the adoption of spend analytics. Regarding Hypothesis 3 (H3), the broader environmental context presents a more complex influence. The negative correlation between the focus on low-emission solutions and the utilization of spend analytics indicates that environmental policies may hinder adopting spend analytics. Additionally, the functionality of digital tools not being perceived as a barrier shows a positive but less statistically significant relationship, suggesting that while technology accessibility is generally perceived as favorable, it does not strongly predict spend analytics adoption. However, none of the factors have a p-value indicating statistical significance.

In summary, employee expertise in analytics predicts spend analytics adoption, while using digital tools may not be enough. Organizational scale and structure are also significant factors, with larger and more centralized procurement units showing a greater propensity to adopt analytics. The interplay with environmental considerations is complex, indicating a need for strategies that integrate sustainability goals with data-driven procurement practices. The factors with the highest positive significant correlation with the adoption of spend analytics adoption in our data are presented in Figure 8 below.
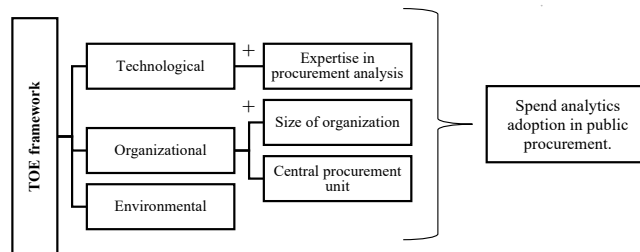
Figure 8. Factors positively related to adopting spend analytics in Norway's public procurement.

5.2. Spend analytics in Norwegian public procurement: adoption and impact.

The findings of our study regarding the adoption of spend analytics in Norwegian public procurement reveal the system's complexity where technology is not merely an infrastructural element but also a tool and feedback mechanism, as articulated by [41] and [42]. Consistent with systems theory [44], the adoption and impact of spend analytics are better understood as part of a dynamic system where data analytics enhances decision-making and simultaneously serves as a feedback loop, refining procurement processes over time [69].

Our research diverges from our earlier study by employing a newer survey dataset and focusing on another target variable [26]. The previous analysis did not find any significant relationships, but the findings in this study show that analytics skills, centralization of procurement, and size have significant effects. This reflects the complex connection between strategy, competence, digital tool usage, and analytics adoption and the unexpected negative impact of digital tool expertise on adoption rates, suggesting a misalignment that may stem from the systemic disconnect between operational and strategic IT use. In a feedback-oriented public procurement system where insights from analytics can iteratively improve procurement strategies, this insight supports the notion that analytics adoption is part of a more extensive feedback system where operational practices must be aligned with strategic goals to optimize the use of technology within the procurement system. Ghosh [27] emphasized the role of IT infrastructure and internal capabilities. Our findings partially support this, where procurement volumes and analytics competence positively correlate with analytics adoption. However, our study did not find the expected positive impact of digital tool usage. Our findings on the digital tool expertise negative impact conflict with Weng [29] study, which links business strategies with analytics

adoption intentions. This could imply that while strategy informs intention, operational tool use may not necessarily support the strategic deployment of analytics, indicating a potential misalignment between operational and strategic IT use in public procurement. While our study recognizes the critical role of technological advancements and standardized data protocols, as discussed by Merhi and Bregu [28] and Handfield, Jeong and Choi [32], the advanced technology's lack of direct influence on analytics adoption may suggest systemic barriers, such as data quality issues, resonating concerns that are integral to the feedback mechanism of the procurement system. In addition, the challenge of adopting spend analytics tied to evolving procurement roles, as highlighted by Farshchian, Sætertrø and Stålaker [30], points to systemic challenges within organizational change management and the need for clarity in defining new roles in the context of DDDM tools. This underscores the importance of feedback in role evolution and adapting processes within the procurement system. Finally, our findings support the findings by LaValle, Lesser, Shockley, Hopkins and Kruschwitz [34], van Ooijen, Ubaldi and Welby [12], and Westerski, Kanagasabai, Wong and Chang [33] that DDDM can enhance public trust and service quality, reflecting a structured approach to spend analytics as indicative of a mature public procurement system. This structured approach indicates recognizing the procurement function as part of an overarching system where spend analytics can lead to more informed decision-making and improved public trust. The contrast between the low adoption rate of procurement analytics and the potentials of DDDM highlighted by Moretto, Ronchi and Patrucco [25] and Patrucco, Luzzini and Ronchi [10] aligns with our study's findings of the underutilization of spend analytics in Norway, despite the country's technological advancement and digitalization.

In general, this research contributes to the dialogue initiated by previous studies by underscoring the multi-sided nature of adopting analytics in public procurement. It reveals the contradictions and complements existing theories, proposing that the relationship between technology use and analytics adoption is not linear. It may be mediated by factors such as size, organizational structure, and perhaps even competing priorities such as sustainability goals. The collective insights from our study advocate for recognizing public procurement as a complex system where spend analytics is a critical component. This system-oriented perspective suggests that future efforts to increase the adoption of spend analytics must consider the systemic interdependencies that shape public procurement.

5.3. Implications

Integrating spend analytics within Norway's public procurement systems represents a complex endeavor, but our findings show some starting points for adoption. Addressing the central question of how spend analytics is adopted, considering the TOE framework's determinants, this research enriches the academic debate and informs public entities on improving the public procurement system. Our analysis shows how incorporating spend analytics in Norway's public procurement enhances decision-making, reflecting the combined influence of analytical competencies, organizational traits, and external factors. For policymakers, the findings underscore the need to develop an analytics-centric organizational culture rather than solely concentrating on technological provision. Leadership is central, acting as stimuli for change by supporting and inserting analytics in the strategic core of public procurement operations. In addition, investment strategies should extend beyond acquiring tools to their incorporation into strategic processes to optimize public expenditure effectiveness as aligned with World Bank guidelines [4]. Moreover, personnel training to enhance analytics capabilities is critical to fully exploit technological investments and realize the potential of DDDM [16].

From an academic perspective, our results call for extended research into the complex factors shaping the adoption of spending analytics. Investigating the interplay among socio-technical systems, organizational behavior, and regulatory backgrounds can generate more comprehensive insights into the forces shaping analytics adoption in the Norwegian public procurement system. The difficulty in the Norwegian system with highly decentralized public procurement with many smaller entities [21, 22] demands strategic actions to address these challenges in light of our findings.

By addressing the primary question of spend analytics adoption and its determinants, this research contributes to scholarly discussion and provides public sector agencies with guidelines to harness the adoption of analytics. These insights can hopefully facilitate more informed decision-making and policy development in future public procurement.

5.4. Limitations

This study's investigation into the adoption of spend analytics among government entities in Norway offers a snapshot of the current practices but has limitations. Notably, the complexity and untidiness of the dataset pose challenges, as it includes instances of non-responses that may affect the robustness of the findings. In addition, the dataset presents multiple issues affecting its suitability for analysis, including mixed data types (integers and decimals), large and potentially erroneous values, and ambiguous use of zero. Additionally, inconsistent coding and long feature names create data interpretation and technical processing challenges. To address these issues in the future data collection and survey design, it's recommended to implement standardized data entry protocols, ensuring consistency in coding and data types. Handling missing values through imputation techniques or exclusion, depending on the context, can also improve data quality. However, missing data is a typical issues with surveys and frequently poses challenges for researchers analyzing surveys and various questionnaires, as respondents often leave some items unanswered [70]. This lack of responses complicates the execution of statistical analyses and the computation of scores for researchers [70]. Also, simplifying feature names and ensuring compatibility with analysis software will aid in efficient data processing. These steps are crucial for enhancing the dataset's reliability and validity for future statistical analysis and reducing the time and effort needed during the data cleaning and preparation phases. Moreover, the reliance on self-reported data could introduce biases, where the respondents' perceptions may not accurately reflect their organizations' realities, as they might be potentially influenced by social desirability or other subjective factors. These elements, while crucial to the adoption of spend analytics, were beyond the scope of the dataset and, as such, were not examined in this study.

The TOE framework adopted in this study may also posit limitations to the research. The framework has been criticized for being too generic and not fully accounting for the interplay between technology, organizational dynamics, and the broader environmental context. For instance, the TOE framework may oversimplify the many-sided nature of organizational change, which involves more than just aligning technological capabilities, organizational readiness, and external pressures. It may also neglect the influence of inter-organizational networks, industry standards, and the role of policy changes over time. Consequently, while the TOE model provides a structured approach to studying technology adoption, it may not capture the details and full range of factors influencing the implementation and utilization of spend analytics in public procurement.

6. Conclusions and further research

In the digital era's advance, the potential of data to transform public procurement operations into a strategic function within government remains a central theme. This study addressed the adoption of spend analytics within Norwegian public procurement, examining the interplay of technological, organizational, and environmental factors in its adoption. With only 39% of Norwegian public procurement entities adopting spend analytics, our findings highlight a sector on the edge of transformation yet still navigating the shift toward comprehensive data-driven practices. This reflects a scenario with public procurement at the beginning of embracing data analytics to enhance public procurement. This study illuminates the multifaceted nature of spend analytics adoption in Norway's public procurement, emphasizing the importance of technological competence, organizational scale, and strategic alignment. The significant positive impact of analytics expertise and organizational structure on adoption highlights the need for a strategic, analytics-centric culture. Contrarily, the surprising negative correlation of digital tool usage with analytics adoption indicates a potential strategic-operational misalignment. Addressing systemic barriers, such as prioritization conflicts and data quality issues, is critical. The findings suggest that public procurement should be recognized as a complex, feedback-oriented system where operational practices align with strategic goals. For policymakers, these insights advocate a systemic approach to adoption, integrating analytics into strategic processes and emphasizing the development of analytics capabilities.

Future research should aim to dissect the complexities of spend analytics adoption through a mixed-methods approach, employing both qualitative and quantitative analyses to address this research's shortcomings. Qualitative methods, such as in-depth interviews or focus groups, could provide richer, contextual insights into the motivations, barriers, and cultural

nuances that underpin analytics adoption in public procurement. Sector and country-specific investigations could further refine the understanding of these dynamics, allowing for more tailored and effective recommendations. Additionally, better-structured datasets, potentially through established and controlled data collection and management methods, would help clarify the long-term patterns in spend analytics adoption within this vital function of government.

Finally, Norway stands at a crossroads in realizing the full potential of data analytics in public procurement. This study provides insights for stakeholders to strategize effectively toward an analytic-centric procurement system. It underscores the many-sided nature of adoption, signaling that the journey towards spend analytics-empowered public procurement is ongoing and has opportunities for public procurement to develop as a strategic part of governments.

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Paper II

Driving through dense fog: a study of the effects and control of sustainable public procurement of electric cars

Marius Langseth[1,2] · Helene Tronstad Moe[1,3]

Abstract
Governments are large buyers of vehicles, thus contributing to pollution. To promote sustainability, policies have been shaped to replace government-owned fossil fuel cars with electric cars. Public procurement is seen as a strategic tool for the government to transition. This study identifies a research gap due to a lack of studies on how stakeholders at different levels identify and calculate the sustainability effects of public procurement of cars. Our approach uses a multilevel perspective to explore how various stakeholders perceive and assess the effects of sustainable public procurement. The data were obtained through a qualitative research design with documents and semi-structured interviews with stakeholders in Norway ranging from government agencies, public procurement officers, car suppliers, and end-users. (End-users in this setting are the ones who ultimately use the vehicles). The study's findings are two-fold. First, it contributes to understanding that perceived effects of sustainable public procurement vary from the stakeholders' perspectives and that public procurement initiatives perceive to have cultural effects in addition to innovation, environmental, economic, and social impacts. Second, it contributes to understanding the importance of feedback mechanisms in public procurement to align the assessment of the effects. A better understanding of how effects are identified, and improved feedback mechanisms could help government representatives control the procurement system and accomplish the intended effects.

Keywords Public procurement effects · Electric cars · Data-driven decisions · Sustainability

1 Introduction

While a well-functioning transport system is a prerequisite for achieving many of society's objectives, emissions from car transport must be drastically reduced to meet the Paris Agreement (2015) goals. In 2017, road transport accounted for 21% of the EU's total carbon dioxide emissions (2021) and 17% of the emissions in Norway (NEA, 2020). One suggested intervention is to replace fossil fuel cars with Electric Vehicles (EVs). To increase the number of EVs, Norway has introduced some of the most effective incentive schemes

globally (Aasness and Odeck, 2015). Some of the incentives are that EVs are exempt from value-added tax, cheaper road tax, and parking. The incentive schemes have contributed to a change in buyers' behaviour, and according to numbers by the Norwegian Road Federation (OFV, 2022), in 2021, 64.5% of new cars sold were electric. A large spender and owner of cars is the government itself. In Norway, the state, counties, and municipalities buy goods and services related to transport, amounting to approximately 1 billion EUR annually (Meld. St. 22, 2018–2019).

In this context, public procurement is often highlighted as a strategic instrument to stimulate sustainable consumption and cleaner production. Sustainable public procurement is high on the agenda of European policymakers, for example, reflected in the EU's 'Fit for 55' (2021) and the Norwegian government's climate plan 2021–2030 (Meld. St. 13, 2020). The climate plan argues that public procurement can play an essential role in reducing CO2 output and stimulating innovative green solutions. One action point is replacing fossil fuel cars with EVs by making it mandatory from 2022 for the public sector to buy EVs. The UN Sustainable Development

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Goals (SDGs) also reflect public procurement's sustainability potential, where SDG target 12.7 (2015) is connected to public procurement. An OECD assessment of the public procurement system in Norway showed that Norway had a solid legal and regulatory foundation for sustainable public procurement, which, however, was not well-implemented (OECD MAPS, 2020). The findings were also confirmed by a survey conducted by The Norwegian Agency for Public and Financial Management (2020), where the results showed that although 60% of the public procurement entities had an environmental procurement policy, lack of time, competence, and monitoring systems were the most significant barriers against implementation.

Earlier research has studied how procurement can drive the circular economy, e.g. (Alhola et al. 2019), the procurement of sustainable innovation, e.g. (Rolfstam 2015), and public procurement as an environmental policy mechanism, e.g. (Aldenius & Khan 2017). When looking at sustainability and effects, other studies have aimed to explore the relationships between environmental energy sustainability, low-carbon energy, and climate change mitigation, e.g. (Ionescu 2021a, b, c) and solve the practical problem on how to measure sustainability, e.g. (Neri et al. 2021). There is a research gap in studies on how the effects are perceived and assessed from different stakeholders' perspectives. Based on the introduction, the paper aims to answer two research questions: RQ1: How do government agencies, procurement officers, car suppliers, and end-users perceive the effects of sustainable public procurement of cars? RQ2: How do these stakeholders assess the effects of sustainable public procurement of cars?

The study proceeds as follows. Section two extends the introduction and lays the foundation for further work. Section three presents the research design and provides an overview of data collection and analysis. Further, Section four evaluates the findings, and Section five discusses the implications of the results, thus presenting the research limitations and suggestions for further research. Finally, Section six concludes the study.

1.1 Related research

Various theoretical frameworks have been used to investigate sustainability effects in general and public procurement of cars more specific. One of the first and widely used frameworks for exhibiting effects is The Triple Bottom Line (TBL), introduced by Elkington (1997). Elkington argues that organisations should see beyond the traditional economic bottom line and expand their reporting to include social and environmental factors. The TBL concept has since Elkington developed in many directions, and we will briefly go through the most influential ones. One of the frameworks that highlight sustainability effects is the Global Reporting

Initiative (GRI). GRI is an international independent standard that aims to help organisations communicate their impact on climate change and human rights issues. According to KPMG (2017), 67% of the largest 100 companies in 2020 used GRI for reporting.

TBL has also given birth to terms like Corporate Social Responsibility (CSR) and Environmental, Social, and Governance reporting. Porter and Kramer (2011) expanded the concept of CSR and introduced the concept of Creating Shared Value (CSV). One of the ideas behind CSV is that the success of a company and its suppliers are mutually dependent. Integrated Reporting, introduced by Gleeson-White (2015), is another framework influenced by TBL. In line with TBL, it emphasises that organisations should highlight the value it generates for society and the environment, but adds that this should be done along six capitals. In 2015, the United Nations presented the Sustainability Development Goals (SDG). These are a collection of 17 interlinked global goals to achieve a sustainable future; further, in 2017, the SDGs came with specific targets and indicators to measure progress. Countries report to the UN on their efforts, and Norway published a voluntary review in 2021 (VNR 2021). Lately, there has been discussion on whether the SDG goals are contradictory (Nilsen 2020), interlinked (Fonseca et al. 2020), or whether the environmental goals are a prerequisite for others (Singh et al. 2018). In a later article, Elkington (2018), who kick-started the reporting movement, proposes to recall the TBL framework. The main problem, he argues, is that organisations have smartly used the TBL to show how commendable they are. As Elkington (2018) explains, "Together with its subsequent variants, the TBL concept has been captured and diluted by accountants and reporting consultants".

1.2 Effects of public procurement of cars

Research connected to public procurement, sustainability, and cars has resulted in multifarious initiatives. Kemp and Rotmans (2004) suggest that transition into sustainable transport should be done in small steps. They call this transition management. Vergragt and Brown (2007) indicate a re-learning of society related to personal mobility, where the government plays a part in stimulating innovation. Michelsen and de Boer (2009) find that public procurement officers put sustainability demands in their calls for tenders. However, that lowest cost was often the actual selection criteria of the supplier. Whitmarsh and Köhler (2010) highlight the role of policy drivers in innovation in the supply and demand of cars and argue for greater attention to psychological, cultural, and infrastructural factors. Villareal (2011) describes what he calls an 'imitative rationality', wherein the market for EVs is a cognitive battle to define personal mobility. Brammer and Walker (2011) and Shepherd et al.

(2012) show a wide variation in involvement in implementing sustainable procurement when there is a demand for cars. However, notably, if the senior managers were supportive, the procurement team would be more likely to implement changes. Tran et al. (2013) find that financial benefits, rather than pro-environmental behaviour, were the most significant influence on adopting environment-friendly solutions. van Rijnsoever et al. (2013) show that the local Dutch governments were willing to pay between 25 and 50% extra for an alternative fuel vehicle without a severe loss of utility.

Nykvist and Nilsson (2015) studied what they called the EV paradox in Sweden. They observed that despite favourable conditions, the adoption of EVs was low. They explained that this was due to a regime favouring hybrid plugin vehicles. Palm and Backman (2017) also studied EVs in Sweden. They found that charging infrastructures and costs were barriers to diffusion. Ydersbond (2018) studied municipalities in Norway and found that the primary reasons to adopt EVs were political signals, economic benefits, and entrepreneurial employees who worked to promote electric cars. Significant barriers to adoption included the need for four-wheel drive, driving range, and structural conditions such as the length of leasing contracts. Mulligan (2021) points out new opportunities in smart city developments and argues that the Internet of Things and data analytics are instrumental for automated algorithmic decision-making processes. Finally, both reviews by Patrucco et al. (2017) and Sönnichsen and Clement (2020) show that the general scientific literature on sustainable public procurement is broad and growing. Literature related to public procurement of EVs involves leadership involvement, innovation, and adoption. However, there is a need to look further at how the effects are perceived based on the interest of various levels of stakeholders.

1.3 Calculations and assessment of procurement effects

Regarding the second research question on how the actors assess the effects, Thai (2001) argues that the feedback mechanisms are essential for a sound procurement system. Without a functioning feedback mechanism, it is difficult for policymakers and managers to see the consequences of their decisions. Van Thiel and Leeuw (2002) argue that the increase in performance assessment in the public sector could lead to lower performance because of a weak correlation between performance indicators and the performance itself. To counteract these consequences, they suggest multiple indicators reflecting the interests of different stakeholders and multidimensionality on various levels (micro, macro, and meso). Moe (2006) found that actors in the construction industry frame and calculate environmental-friendly houses differently.

Brynjolfsson et al. (2011) argue that organisations that use Data-Driven Decision Making show better performance. Sparrevik et al. (2018) studied the implementation of green public procurement in a building project. They found that data and co-creation between policymakers and regulators were critical for success. There is also existing literature that has been critical of the concept of sustainability measurement. For example, Boiral et al. (2020) show that sustainability performance is not a clear, measurable concept but an ambiguous phenomenon and that its rational appearance should be questioned. Lately, research has focussed on the relationship between advanced sustainability analytics, corporate social responsibility, and environmental sustainability. Keane (2020) explored the opportunities in self-driving cars. May et al. (2021) tested the inter-relationship between corporate social responsibility, employee green behaviour, and environmental sustainability. They argued that corporate social responsibility and employee green behaviour mediated by organisational trust and organisational identification positively affected environmental sustainability. The literature for adopting data-driven decision-making has explored the reasons for a mismatch between the simultaneous overproduction and underconsumption of data in government (Chen and Lee 2018). For instance, Langseth and Haddara (2021) found that even if public procurement officers used more digital tools and generated vast amounts of data, they were often unlikely to gather insights from these data and use it to make decisions.

The purpose of calculations in the sustainability field is to measure impact. Without calculations, representations cannot be designed or interpreted, and without measurement methods, one cannot estimate the extent to which criteria measure different sustainability aspects. Construction and management of representations, environmental criteria, and indicators require new calculations. The related research is summed up in the following table.

As presented, past studies have emphasised how leadership involvement and innovation are related to adoption and not distinguish the understanding of the effects of public procurement and EVs. The review shows various initiatives connected to assessing the impact, but these have concentrated on performance measurement and data-driven decisions. While studies in the past have studied discussed effects, there is a research gap in looking at the whole public procurement system and how the effects are perceived and assessed from different stakeholders' perspectives. This study endeavours to address this limitation of previous research by looking at public procurement decision-making through the theoretical lens of management control activity where the various stakeholders represent the procurement system. In the related research, there is a research gap related to a lack of studies on the perceived effects of public

Table 1 Summary of related research

Effects of public procurement of cars			Calculations and assessment of procurement effects	
Leadership involvement	Innovation	Adoption	Performance management	Data-driven decisions
Brammer and Walker (2011) Shepard (2012) Sparrevik et al. (2018)	Edler et al. (2005) Whitmarsh and Köhler (2010)	Vergragt and Brown (2007) Michelsen and DeBoer (2009) Villareal (2011) Palm and Beckman (2017) Ydersbond (2018)	Van Thiel and Leeuw (2002) Eccles et al. (2014)	Brynjolfsson (2011) Boiral et al. (2020) Keane (2020) May et al. (2021) Langseth and Haddara (2021) Mulligan (2021)

procurement policy from different stakeholders' perspectives. Table 1 summarises related research.

1.4 Public procurement decision-making as a management control activity

Schaltegger and Burritt (2010) describe sustainability assessment as a subset of accounting concerned with the methods, and systems used to assess and report economic, social, and environmental impacts and the relationships between these dimensions of sustainability. Sustainability assessment could then be considered a part of formal management control activities such as planning, evaluation, coordination, and procedure (Anthony et al. 2007). De Leeuw (1976) argues that management control activities should function as dual control relationships between an organisation and its environment (see Fig. 1). In his article, he argues that dual control belongs to the axiomatic branch of system theory. This branch defines the systems as a modelling box with abstract concepts and models filled with empirical content. The controller's objectives are two-fold; (1) Action: To control the system based on current system knowledge, (2) Investigation: To experiment with the system to learn about its behaviour to control it in the future better. These two objectives may be partly in conflict. If you, for example, are driving an EV and want to be in control to get to your destination smoothly, you also want to experiment with how far you can go before a recharge.

According to De Leeuw, the controller's ability to successfully control its system depends on the following five preconditions for adequate control.

1. The controller has an objective and an evaluation mechanism to check whether the goals are met.
2. The controller has a model of the controlled system to predict the effect of potential control actions.
3. The controller has information about the environment and the controlled system.
4. The controller has sufficient control actions to cope with the variability of the system.
5. The controller has sufficient information processing capacity to transform incoming information into practical control actions aligned with the objectives.

Central to De Leeuw's control paradigm is information for the controller both from the environment and the controlled system to monitor and make better decisions. Weber (2011) suggests that, due to technological developments, the role of the controller will increasingly focus on decision support in the form of data analytics. Data analytics offers the controller the opportunity to elevate its role within an organisation, thus adding value to the business. This paper examines the public procurement system as an abstract control system that we want to fill with empirical content. By taking a system theory approach, we wanted to understand better the stakeholder's perspectives associated with public procurement in the context of EVs. We will use this perspective further when discussing our results. A description and overview of the research design, data collection methods, and data analysis follow.
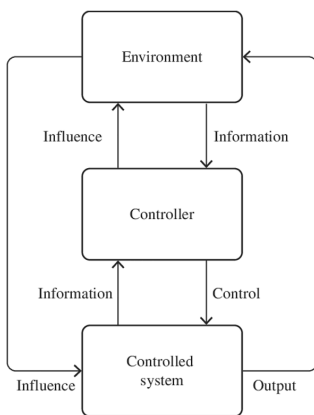

Fig. 1 De Leeuw control paradigm (De Leeuw, 1976)

2 Methods and data

2.1 Design

This study uses a grounded theory approach (Glaser and Strauss, 2017) for inductive theory-building to understand how stakeholders at different levels perceive and assess the effects of public procurement. An exploratory research design was chosen, and data were collected through a literature study, qualitative semi-structured interviews, and government documents. A qualitative method was selected to explore and understand how stakeholders perceive the sustainability effects. The qualitative approach is based on Eisenhardt (1989), who argues that the starting point for qualitative methods is that all phenomena comprise unique combinations of qualities that cannot be counted, measured, or weighed. We acknowledge qualitative research as a contextually situated practice.

Further, we recognise conceptualisation of qualitative research as research that is qualitative in both methods and values (Braun and Clarke 2013; Grant and Giddings 2002). As qualitative researchers, we understand contexts and qualitative researchers as contextually and temporally situated practitioners (Braun and Clarke 2021). Interview data are challenging to generalise but getting close to the informants gives us insight into the informant´s world of life (lebenswelt), which provides high validity. No qualitative research has much value without specific skills and practices as reflexivity, interpretation, and imagination (Gabriel 2018). Reflexivity can be understood as an "interpretation of interpretation" (Alvesson and Sköldberg 2009) and the extent to which reflexivity can corroborate the validity and enhance the value and contribution of an interpretation (Gabriel 2018). The goal was to understand and communicate how different stakeholders from various levels perceive reality related to sustainability. The grounded theory approach allows researchers "to make statements about how actors interpret reality" (Suddaby 2006). Therefore, the most crucial factor in collecting the data was gathering these stakeholders' perspectives. It is recommended that the sampling process in grounded theory studies should involve the recruitment of participants and organisations that are perceived as experts in the subject matter (Edmondson and McManus 2007; Makri and Neely 2021). Thus, in the research design, we invited experts in a government agency specialising in sustainable public procurement to suggest study participants and organisations.

2.2 Data collection

The project was reported to the Norwegian Centre for Research Data (NSD) before the data collection due to the data use privacy policy. As preparation for the interviews, document analyses regarding relevant government documents were conducted. The literature study collected data through Google Scholar searches using the following keywords: 'sustainable public procurement' AND 'public procurement' AND 'green' AND 'car transport', AND 'effects'. A total of 17 relevant contributions were found and categorised. The documents and literature content were used to form an interview guide. The primary data were collected through semi-structured in-depth interviews, which provide a balance between predefined and follow-up questions. According to Thagaard (2009) this is suitable to investigate the informant's perspectives. The informants were selected because they had been involved in the public procurement of EVs but were spread in terms of geographical location and type of activity. The sample, therefore, lent a strategic approach to our selection (Yin 2018). Questions were asked concerning the three primary areas of sustainability found in documents and literature (environmental, social, and economic), along with a wish to explore the understanding of sustainability and the participant's perception of the effects of public procurement.

The interviews were conducted between January and May 2021. The informants had different roles in the procurement system and worked as advisers in state agencies, public procurement officers, public sector car suppliers, and end-users of government cars. Government agencies are state-controlled organisations that act independently to conduct the government's policy on procurement. The agencies serve as the government's expert body and develop guidelines based on laws and regulations. Public procurement officers are responsible for the procurement of goods and services that will help achieve the goals set by the government. Generally, their work entails finding suppliers through public procurement competitions where the goal is to strike a balance between quality and cost, where sustainability factors could be part of quality. The car supplier participates in these competitions to make cars available for the public entity. This level contains commercial-based stakeholders. The end-users are the ones who ultimately use the vehicles. The interviews lasted approximately one hour each and were conducted as digital video meetings due to covid-19. We stopped collecting data or interviewing when we reached a data saturation state (Guest et al. 2006). Table 2 shows an overview of the informants. The study will use the informants' reference coding to present the results.

2.3 Data analysis

As preparation for analysis, the interviews were recorded and transcribed. The interviews were then classified using coding as the first step in the content analysis. To encode the data, we used open coding, gave keyword designations

Table 2 Informants

| Stakeholder	Role	Interview type	Reference
Government agency	Senior advisor	Digital	(A)
Government agency	Senior advisor	Digital	(B)
Government agency	Advisor	Digital	(C)
Municipality	Procurement officer	Digital	(D)
Municipality	Procurement officer	Digital	(E)
Health trust	Procurement officer	Digital	(F)
Car supplier	Car salesman	Digital	(G)
Car supplier	CEO	Digital	(H)
Car supplier	Manager	Digital	(I)
Inhabitant	End-user	Digital	(J)
Inhabitant	End-user	Digital	(K)
Inhabitant	End-user/patient	Digital	(L)
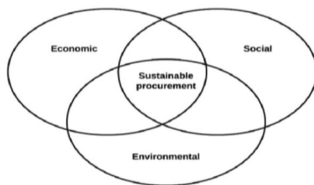
Fig. 2 Triple bottom line of sustainability (Elkington 1997)

to the various elements respondents had provided, and then grouped these with similar answers (Yin 2018). Data were then categorised with different tags in relation to the themes (Sarker, Lau and Sahay 2000). By finding unifying headlines and grouping the initial tags, we developed new categories. Through repeated, systematic reviews of the dataset considering our categories and codes, we gradually developed a set of themes that represented the content of our dataset. The themes will be exemplified and presented in tables and quotes from the stakeholders. The study uses the accepted Triple Bottom Line approach (Elkington 1997) to organise the findings (see Fig. 2). The Triple Bottom Line is a framework that combines three different dimensions of sustainability: environmental, social, and economical.

This framework incorporates ecological and social measures demanding to assign appropriate means of measurement (Liute and De Giacomo 2021; Pedroso et al. 2021; Rogers and Ryan 2001; Slaper and Hall 2011). The study used public procurement decision-making as a management control activity as a theoretical lens to discuss the results. We wanted to understand better the stakeholder's perspectives associated with public procurement in the context of

EVs. It was relevant to look closer at how the controllers, in this context government agencies and procurement officers, use data to manage and receive feedback in controlling the system considering the De Leeuw (1976) model.

3 Results

If we first start looking at the concept of sustainability, we find a significant variation in the informants' interpretation of the term. The government agencies emphasise the Triple Bottom Line approach from Elkington (1997). As stakeholder B said, "Simplistically speaking, sustainability is the environment, the society, and the economy, these three elements. It is a simplification of the 17 SDGs". When we look at the sustainability concept from the procurement officers' point of view, it is slightly more unclear. As stakeholder D said, "Sustainability includes the climate, the social perspective, and the circular economy. There is a lot in this concept. It means that we are doing something to better the livelihoods in our city".

The car suppliers have their interpretation of the concept of sustainability. One talks about sustainability as an innovation opportunity, but the other two talk about it as an economic problem. As stakeholder G said, "I see sustainability as an opportunity for innovation. I will give you one example: I met with the home care services at a municipality yesterday; they have 100 cars. That is because, between 8:00 a.m. and 2:00 p.m., they need 100 cars. Between 2 p.m. and 10 p.m., they might need 70 cars. Furthermore, on weekends, they need 50. So, I challenge municipalities to buy vehicles to cover their needs in the middle range and have other solutions for the peak hours. This is a new solution that we have developed". This is opposed to stakeholder I, who said, "If a tender is abnormally below the normal price, then there may be something wrong, it is not sustainable for car suppliers to provide a tender that is so low. And I guess I feel like we have done that, on the last tender".

Thus, the concept of sustainability varies in interpretations. Governments and car suppliers live in slightly different realities. In the next section, we look closer at what they think about the environmental effects.

3.1 Environmental effects

When it comes to the environmental effects of EVs, the opinions of the different stakeholders differ. In the interviews with the government agencies. Stakeholder A said, "What is the meaning of the term environmental is up to politics to define. The concept changes from time to time. However, right now, they are very concerned about zero-emission solutions. This is also reflected in the

government's climate plan for 2030. Our job as an agency is not to define political goals, but to take the political goals and turn them into action".

The public procurement officers shared the vision of the government agencies to contribute to zero-emission cars with the increased number of EVs in their community. They had various explanations as to why. One said it was part of a political strategy to be at the forefront of reducing greenhouse emissions, and another said it was part of a plan to have a fossil-free vehicle fleet by 2023. However, all of them mostly talked about the environmental effects pertaining to the reduction of CO_2 emissions. Stakeholder D explained, "The reason that this is an environmentally friendly project is that we get more electric cars, we get fewer fossil cars and less CO_2 in our city centre". None of the procurement officers brought up life cycle analysis or battery waste issues.

Car suppliers had different opinions. Two out of three did not agree with EVs having any environmental effects. As stakeholder G said, "I do not see any environmental effects of EVs. There are more factors to cars than just CO_2. Taking the whole life cycle from production until disposal is the environmental math here. In 2007 everyone was going to drive diesel cars. And then suddenly, a few years later, we found out that there was something called particles. Then suddenly, it is not that environmentally friendly after all. When I hear about the environmental accounting of electric cars, I do not know if it is good overall. However, in terms of emissions, I am sure it is. However, I guess when the government has chosen to buy EVs, they have probably done an investigation to find out that this is wise".

When the end-users talked about effects, they saw EVs as a way of 'doing good' if it worked in their daily routine. They liked the experience of driving an EV and felt that they contributed to the government's overall goals. Informant J expressed it this way: "I like to use my fossil car as little as possible, at least for work purposes, where there are opportunities for me to use electric cars. Moreover, it is an effortless choice, and there is no obstacle". One interesting finding was that although most informants talked positively about the environmental effects of EVs, 7 out of the 12 did not own an EV themselves.

3.2 Social effects

When it came to the social effects, the stakeholders were interested in different things. On the agency level, they saw the social side but mainly talked about sustainability's environmental side. Stakeholder A said, "There are several municipalities with more cars than population. There is a high suspicion that some of these cars are used very little. Then it is more efficient with a pooling system. When you talk about a pooling system, you start to take in the social

perspective. However, I would say that the biggest push for us is to reduce greenhouse gas emissions related to transport. There is so much climate focus now".

On the other hand, the procurement officers talked enthusiastically about the social effects. As procurement officer, stakeholder D said, "Access to cars has a social perspective. It makes it possible for those who do not have a car to be part of the community. The possibilities could include visiting the grave of a late spouse or allowing their children to join sports teams. Access to cars has a social side because we saw that children who did not have parents with a car fell out of organised life earlier than others". The end-users in our material did not see the EVs having social effects. As stakeholder J said, "I do not see any social effects. Not in practice. I am so lucky that I have the alternative to use my own car". For government agencies, the environmental effects were most important. The procurement officers cared about the social impacts, and the end-user was mainly concerned with the EV's practical side.

3.3 Economic effects

Stakeholders also had differing opinions when it came to the economic effects of EVs. Government agencies were primarily concerned with making administrative solutions for financing the shift to EVs. As stakeholder A said, "One of the ways for a municipality to finance EVs can be loans. It is a barrier to investing in advance; the municipal budget rules do not like that. Another way is to subsidise, but promoting that can sometimes be complicated because the mechanism is incompatible with public procurement. You need to show that the funding itself will trigger an environmentally friendly solution to get subsidies. The problem for municipalities is that they often must make a procurement competition first. And then they cut themselves off from getting subsidies. So, it is like a catch 22 situation". When it comes to the procurement officers, they do not find the economic side of EVs that important. As stakeholder D said, "If you look specifically at electric cars, we have not put much emphasis on following up on the economic costs, because of the attitude towards it is that we are going to have zero-emission cars; It costs whatever it costs". From the supplier side, they were more concerned with the economic effects. "What you are left with economically with each car is very small. EVs do not need, for example, oil. The procurement officers drive us hard, and I sometimes wonder if they want us to survive. So financially, it is not good".

For government agencies, administrative solutions to cover political goals were most important. The procurement officers did not emphasise the cost. Some car suppliers worried about the economic impact, but others saw it as an opportunity for new business models. The end-users wanted solutions that worked their day-to-day life.

3.4 Cultural effects

Cultural effects of sustainable procurement relate to whether there is a cultural shift in how stakeholders and society address economic, social, and environmental issues. Thus, the culture related to sustainability refers to people changing their consumption patterns and adapting to EVs. Procurement officer E explained it as follows: "There are many employees who have never used electric cars, who are now forced to use electric cars. And some then see that it works. I am sure that this has had ripple effects in this community, and from that, more people have gained experience with other types of cars". The car suppliers look at the cultural aspect slightly different. As stakeholder, I said, "In the beginning, there were many who were sceptical, and there are still some who do not yet believe in electric cars. However, when you look at the number of electric cars sold in Norway, you notice that it has changed the entire car market in just a few years. Now the electric car is established in the minds of the entire staff. The attitude is that the electric car is here to stay, so we just have to deal with it". The procurement officers emphasised that their change in public procurement practices enables a cultural shift towards sustainability through positive experiences with EVs, thereby influencing consumption patterns for their employees and the attitude of car suppliers.

3.5 Innovation effects

Furthermore, we also find some innovation effects in our material. Government agencies put a strong emphasis on innovation. As it says in the white paper to the parliament, St. Meld. 22, 2019, "The Government wants the public sector as a customer to contribute to the use and development of new environmentally friendly technologies, products, and solutions. This is an important part of the policy for the green shift and for Norway to achieve our goals in the climate and environmental field. The public sector must adapt and solve its tasks in new ways".

A stakeholder from government agencies (B) explains innovation as follows: "Innovation is not one thing, but several things. To make it happen, you must have clear political signals and support from the management; you need a person who does that little extra in the organisation, can handle procurement appropriately and get a good dialogue with the supplier market. However, simultaneously, they also need to look internally and work with the organisation to adopt the new solution they buy. If all these things are in place, then it can become an inspiring and good solution". As we can see, sustainable innovation is an important goal for government agencies. The procurement officers are also aware that change requires innovation. However, innovation also comes with resistance from the rest of the organisation. As

stakeholder F explained, "I must emphasise that innovation is a long road from the time we started the process internally until we have the environmental focus we have now. It has been going on for years. So, gaining acceptance for it internally has been, perhaps, the biggest obstacle". Table 3 sums up the findings of RQ1 and shows the different stakeholders' perspectives.

The results show that the various stakeholders did not internalise the same elements of their calculations. They have different interests, ownership, backgrounds, and positions in the public procurement processes. Thus, there is an existence of various calculation practices rather than a uniform sustainability calculation process. The stakeholder's view of effects is inconsistent, and they have local interpretations of which effects are most important. The government agencies present the 'ideal version' of public procurement; the procurement officers present how they do it 'in practice', and the suppliers and end-users talk about the consequences of the government officials' decisions.

3.6 Assessment of effects

According to the Cambridge Dictionary, assessment is about deciding the amount, value, quality, or importance of something. We found that stakeholders act as calculation agents, framing and externalising various procurement elements when constructing calculations. Both quantitative and qualitative components are included in the calculations. Externalities were not calculated and are therefore without value. The different actors do not internalise the same elements in their calculations. Thus, there are many calculation practices rather than a uniform sustainability calculation procedure. When we talk with the informants, the government agencies consider it ideal to base their decisions on feedback mechanisms in the form of data. Stakeholder A said, "We had a meeting with a company that was very concerned with value creation. The first question asked, who should we create value for? The second question is, what value should we create? The third question is, how should we measure value creation? Furthermore, the answer to the last question is often lost in what we do. Still, I think it is crucial".

The public procurement officers do not have tools or systems to calculate the effects and find solutions that are 'good enough'. As stakeholder D said, "I am sure that this has ripple effects in this community and see that more people have gained experience with other types of cars, but we do not measure it". The car suppliers assess only the effects connected to their financial goals. As mentioned before, the supplier informants in our study differ in opinion. Some see EVs as an opportunity, and others see them as a threat. The end-users did not reflect on the assessment if the solutions worked in their daily routines.

Table 3 Effects from the stakeholders' perspective

Stakeholder/Effects	Environment	Social	Economic	Cultural/Innovation
Government agency	Wide scope of sustainability where environmental effects are defined as more than CO_2	Social effects are important, but environmental effects matter more in the current political climate	Economic effects are discussed, but they are more concerned with environmental effects; one stakeholder considers this a prerequisite for the others	High emphasis on innovation
Procurement officers	The procurement of new cars becomes almost exclusively electric cars and focus on reducing CO_2	Social effects are highlighted because the purchases give more user groups access to affordable car transport	Not so interested in economic effects; it is more an argument for change	High emphasis on cultural effects and ripple effects
Car suppliers	Different views on environmental effects, the life cycle of the car, and the total effect are discussed	See both positive and negative social effects—positive in terms of accessibility and negative in rural areas	Divided when it comes to economic factors, some see it as a loss, others as an opportunity	One sees this as an opportunity for innovation, but the two others are more reluctant to change; they all acknowledge that EVs have changed their culture
End-users	Enjoy the feeling of contributing to the environment when driving an EV	See the social aspect as an extra benefit	Thinks about the economic effect if it affects themselves	Some liked new opportunities, and others felt things should stay the same

In summary, it is the procurement officer's job to find the best solution to buy based on their interpretation of signals from the government agencies. However, they lack a feedback mechanism in the form of data to investigate and control if the goals are met. The procurement system has few organised data-driven channels for supplier or end-user input. There are no system or national guidelines for what should be included in sustainability assessment or which calculation methods should be used. Therefore, the different stakeholders do their own calculations in their evaluation on what to include and exclude. The government agencies' and procurement officers' decisions could therefore lead to sustainability effects but also sub-optimal solutions for suppliers and end-users. To sum up the findings on RQ2, Table 4 shows how the different stakeholders perceive the assessment of the effects.

4 Discussion

This study first aimed to investigate how government agencies, procurement officers, car suppliers, and end-users perceive the effects of public procurement of cars. The findings show that different stakeholders operate with varying definitions of sustainability, and the sustainable aspects from Elkington (1997) are perceived in different ways in their assessment. In government agencies, environmental and quantitative effects, such as CO_2 numbers, dominate over qualitative effects like user satisfaction. The public procurement officers and car suppliers emphasise the qualitative impact, and several stakeholders mention the social, innovation, and cultural elements. In sum, the results are in line with findings from Boiral et al. (2020), that sustainability is not a straightforward concept. The stakeholders do not internalise the same elements in their calculations, and there are many calculation practices rather than a uniform calculation process.

The second research question was related to how the stakeholders assess the effects of sustainable public procurement. When we look at our material in the light of De Leeuw's control paradigm model (1976) and the preconditions for adequate control, the controllers, in this context the government agencies and public procurement officers, lack an objective and an evaluation mechanism. This is also because the controllers lack a controlled system model and information. Owing to the shortage of feedback mechanisms, the government officials in our material make decisions but do not have ways to evaluate whether their goals are met. The possibility of controlling actions to cope with variability is not being used because of a lack of feedback loops. Therefore, as illustrated in Fig. 2, controlling the procurement system is like one stakeholder said, "driving through

Table 4 Assessment of effects

Agency	Procurement officer	Car supplier	End-user
Express that the procurement officers should follow-up on the government's ambitions It is ideal to have information and feedback in the form of data, but they are not there yet	Lack information systems and find solutions that are 'good enough' when calculating effects	Assess the effects connected to their financial goals but do not report data back to the procurement officers	Assess the effects for themselves but do not reflect on the assessment or feedback if the solutions work in their daily routines

a dense fog", and the government decision-makers are left in the dark.

The stakeholders in our material act as calculation agents and frame and externalise various elements of sustainability when they make and construct calculations. In this sense, stakeholders have a range of different calculation practices rather than a unified understanding of a sustainability calculation. The procurement officers who are active early in the planning phase will, for example, make different calculations compared to the supplier stakeholders who are responsible for delivery. The controllers, in this case, are the government agencies and the public procurement officers. From the government agencies, sustainable procurement decisions are expected to demonstrate high levels of environmental value. Like one stakeholder said, "what is the meaning of the term environmental is up to politics to define. However, right now, they are very concerned about zero-emission solutions". From the procurement officers' point of view, social effects are as important. As one representative said, "Access to cars has a social perspective. It makes it possible for those who do not have a car to be part of the community". This implied more driving which was not intended by the government's goals. From a practice and policy perspective achieving sustainable procurement will often involve balancing conflicting social and environmental values. Without common goals and understanding, it is difficult to achieve what De Leeuw (1976) calls an "evaluation mechanism to check whether the goals are met".

The findings of this study offer valuable insights with implications for theory, practice, and policy, as discussed below. In terms of theory, the overall results support DeLeeuw's (1976) model and the idea that public procurement decision-making can be seen as a management control activity where sustainability can be seen as an emergent property of the system (Lanhoso and Coelho 2020). Sustainability arises from the contributions made and conditions created in service of a shared reality. All the stakeholders' decisions and calculations impact the system and affect the controller's ability to control its system successfully. This confirmation is crucial because it affirms the relevance of this theory. Besides confirming the relevance of the management control theory, this study extends it by using it in a public procurement setting and showing that decision-making in sustainable public procurement should be seen as a non-linear process. The study indicates that there are many different calculation practices connected to the effects of public procurement. The effects are characterised by negotiations of reality by different stakeholders and therefore cannot be mandated from above. The government agencies and procurement staff make decisions but do not collect feedback from suppliers and end-users, and limited feedback loops exist. The finding supports the study by Michelsen and DeBoer (2009), which showed that problems

with understanding effects could result from a lack of vertical integration across system levels, not merely from deficiencies at any one level alone. This is in line with findings from Moe (2006) and Sparrevik et al. (2018), which showed that various actors put different meanings into the concept of environment-friendly housing, and co-understanding was critical for success.

The lack of vertical integration is caused, in part, by a lack of feedback mechanism between the different levels of the system. Stakeholders at one level, like government agencies, cannot see how their decisions interact with those made by actors at other levels. Like one of the representatives from the government agencies said, "how should we measure value creation? the answer to the question is often lost in what we do". When we look at the stakeholders, CO2 is calculated, but only the informants from the car suppliers mentioned indicators related to life cycle analyses or battery waste. The Life Cycle Analysis was externalised in the calculations for the procurement officers. When we compare the lack of feedback loops in

our findings with the model presented by De Leeuw, in an ideal setting, the controller's ability to successfully control its system depends on vertical integration where the government agencies and procurement officers have information about the environment and the controlled system. To be in control of the system, a start would be to have an objective and evaluation mechanism and draw an ideal model of the procurement system. As illustrated in Fig. 3, government agencies and procurement officers would have better control with better information flow between the levels and probably make better decisions (Fig. 4).

If we look towards policy implication, the findings presented fall within the broader debate about digital transformation in the public sector (Mergel et al. 2019). There is a need to create processes and structures that facilitate feedback mechanisms for decisions. Elucidating how decision-making within public procurement can become data-driven, thus providing a foundation for improving the quality of the decisions, represents an example of how policies can be

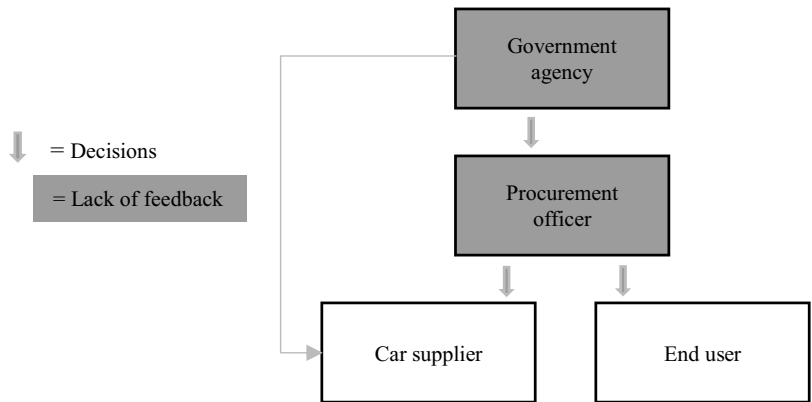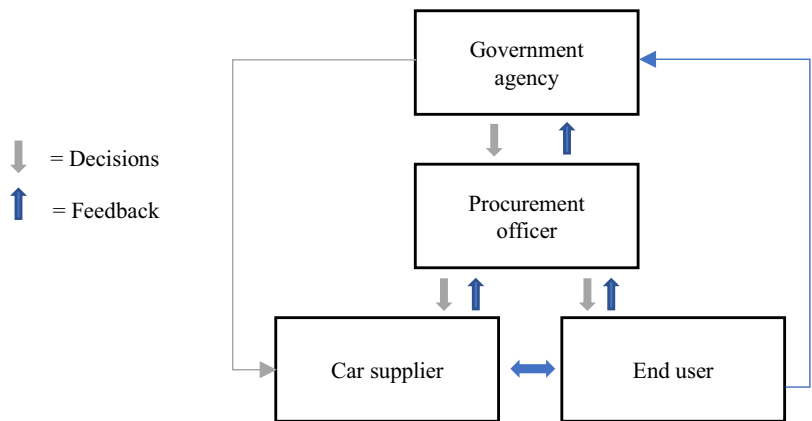**Fig. 3** Model of the procurement system based on our findings

Fig. 4 Model of control of public management of sustainability with feedback mechanisms for more informed decisions

strengthened towards better feedback mechanisms within sustainable public procurement.

4.1 Limitations

There are some limitations to this study. One of them is that the perceived effects can relate to a range of factors, such as organisational or political, and are often not directly related to public procurement itself. This is also seen in the results of our study. Another limitation could be in our strategic sample; by that, we mean the stakeholders selected as informants represented government entities that have paid attention to the procurement of EVs. This might not be representative of the larger population of public procurement entities. At the same time, from 2022, the public sector must buy EVs, and all public procurement entities will have to relate to these questions.

5 Conclusion and further research

The Paris agreement (2015) and other sustainability initiatives e.g. (fit for 55, 2021) consider car transport a significant problem for the climate. EVs are considered part of the solution, and public procurement has been seen as a tool to push this forward. Despite the growing body of literature on sustainable public procurement, there is still a need for understanding the concepts and the calculation practices of effects. This paper seeks to fill a gap in the current literature by examining how various stakeholders perceive the effects. The study contributed with an awareness of missing links in the procurement system where there is a lack of feedback mechanism and shared understanding of effects. Public procurement is part of a complex system with various stakeholders. The problem is that we do not know the effects of public procurement decisions and how different stakeholders calculate the impact. According to De Leeuw's (1976) control paradigm, the stakeholders need a model of the controlled system to evaluate and predict the effect of the decisions and actions. Therefore, the study visualised the current situation of the public procurement system and demonstrated a need for better vertical integration by using the De Leeuw model in a public procurement setting. The study intends to inspire the stakeholders to develop a practice to co-produce knowledge and use a data-driven feedback mechanism to contribute to more informed decisions within the public procurement context. For further research, there would be a need to expand the findings in a larger setting with quantitative methods to see if the perceived effects by our stakeholders are also represented in a larger sample. To better understand how knowledge is produced around sustainable public procurement, there would be interesting for further research to explore the co-creation process

thoroughly, especially the cultural effects mentioned by several stakeholders. A better understanding of the perceived effects by various stakeholders in the procurement system could help government agencies to shape policy for better feedback mechanisms and find the way out of the fog.

Declarations

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Paper III

Exploring the Antecedents and Implications of Data-Driven Decision-Making in Public Procurement

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Abstract

This paper investigates the structural relationships among factors associated with data-driven management decisions in public procurement and examines the impact of data-driven decision-making on procurement performance, through proposing and employing a conceptual theoretical framework grounded in literature and the strategy-structure-performance logic. The study tests four hypotheses based on data collected from 196 public procurement organizations in Norway, employing structural equation modelling for analysis. The findings support all four hypotheses, highlighting the positive influence of digital motivation on the formulation of specific digitalization goals in public procurement. In addition, the establishment of clear digitalization goals has a positive effect on the development of the organizational structure, which serves as a foundation for data-driven decision-making, ultimately enhancing organizational performance. This research contributes to the theory of public procurement performance by uncovering the fundamental processes that link motivation in digitalization to gains in effectiveness and reductions in inefficiency. The study's practical implications provide valuable insights for policymakers and procurement organizations seeking to cultivate data-driven practices, guiding managers in strategic planning and the implementation of effective tools for data-driven decision-making in public procurement, thus promoting a more strategic and efficient utilization of public resources.

Keywords: public procurement; data-driven decision-making; structural relationships; structural equation modelling; digital motivation; digitalisation goals; procurement performance; effectiveness; inefficiency reduction; resource utilisation; business intelligence.

1. Introduction

Making procurement decisions based on an analysis of historic procurement spending can be considered a value-adding approach to public procurement. Generally, public procurement represents a major economic activity for the government (Thai, 2001). For instance, member countries of the Organization for Economic Co-operation and Development (OECD) spend about 15% of their GDP on purchasing goods and services (OECD, 2021). Hence, it is of paramount importance that decisions are based on insights generated through data analysis rather than intuition or personal experience (Avila, 2018; Head, 2016). Although the digitalization of procurement has been made a top strategic priority (European Commission, 2017), the strategies from the OECD and EU appear to contrast with how decisions are often made in practice. The literature on the adoption of data-driven decision-making has explored the reasons for an existing mismatch between the simultaneous overproduction and underconsumption of data in government (Chen and Lee, 2018). For instance, Langseth and Haddara (2021) found that even though public procurement officers use more digital tools and generate vast amounts of data in Norwegian municipalities, they are unlikely to gather insights from these data and use them to make decisions. Government organizations that benefit from procurement analytics are the exception, and most still struggle to deploy more mature analytics capabilities to enhance their decisions and drive public impact.

The extant literature on becoming data-driven organizations and using data and analysis to drive decisions and actions mainly focuses on private sector organizations (Berndtsson et al., 2020; Hannila et al., 2022). In the private sector organizations literature, a range of barriers have been identified that need to be addressed to become data-driven organizations. These include resistance to change, skills, access to data, and a lack of strategy (Berndtsson et al., 2020; Halper & Stodder, 2017). Intriguingly, a lack of organizational alignment is noted as a top barrier to becoming a data-driven organization (Berndtsson et al., 2020). The underlying elements regarding the lack of organizational alignment include a lack of clear goals for becoming data-driven

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organizations and employees lacking incentives to adjust their daily work (Berndtsson et al., 2020). Public procurement plays a critical role in government operations and represents a significant economic activity (Thai, 2001). With member countries of the OECD spending approximately 15% of their GDP on procurement (OECD, 2021), it becomes imperative to ensure that procurement decisions are based on, and informed by, data analysis rather than relying solely on intuition or personal experience (Avila, 2018; Head, 2016). Despite the strategic priority placed on digitalization in procurement by global organizations such as the EU (European Commission, 2017), there exists a contrast between the recommended strategies and the actual decision-making practices in the sector. The literature on the adoption of data-driven decision-making in government highlights a mismatch between the abundance of data produced and their limited consumption (Chen and Lee, 2018). For example, Langseth and Haddara (2021) found that while public procurement officers generated vast amounts of data through the use of digital tools, they often failed to extract insights from these data and incorporate them into their decision-making processes. While some government organizations have successfully embraced procurement analytics, the majority still struggle to fully leverage mature analytics capabilities for driving public impact. Thus, the promotion of data-driven decision-making in public procurement organizations can be envisioned as a way of strategizing public procurement (Tan and Lee, 2015).

Despite the growing focus on data-driven decision-making in public procurement, there remains a scarcity of research directed toward public sector organizations in general (van Donge et al., 2020), and specifically studies examining the structural relationships among factors associated with data-driven management decisions within the public procurement context and their impact on procurement performance. Hence, this study aims to bridge this gap by exploring these relationships and shedding light on the processes underlying the link between data-driven decision-making and procurement performance in the public sector. By analysing data from 196 public procurement organizations in Norway and employing a conceptual theoretical framework based on the strategy-structure-performance logic and literature, this study seeks to contribute to the existing knowledge on the effectiveness of data-driven approaches in public procurement. In addition, discussing how a procurement organization can develop into a data-driven organization and how this can affect performance is a response to a call for research focusing on the performance of public procurement alongside the exploration of tools and procedures that can enhance procurement processes (Patrucco et al., 2017). Understanding these relationships and their implications can offer valuable insights for policymakers and procurement organizations striving to enhance their data-driven capabilities, ultimately leading to more efficient and impactful use of public resources. It is important to note that the definition of data-driven decision-making adopted in this study follows the definition of Provost and Fawcett (2013) as the practice where decisions are made on the foundation of data analysis rather than, say, intuition. The underlying rationale for increased attention to digitalization and data use suggests that collecting and analysing data before making decisions will have a positive impact on the quality of decisions, transparency, and efficient use of resources (Avila, 2018; Brynjolfsson et al., 2011; Chatterjee et al., 2021). Although public procurement is undergoing a digital transformation (Garcia, 2022), it still seems unclear how the goal of a data-driven culture within public procurement can be achieved and what is to be gained specifically (Mergel et al., 2016). This article contributes to the body of knowledge by exploring the antecedents and implications of data-driven decision-making in public procurement.

To fill the prevailing research gap, this research attempts to answer the following questions: *(1) How can public procurement organizations transition into data-driven decision-making entities? (2) How does the implementation of data-driven decision-making practices impact the performance and effectiveness of public organizations?*

As previously mentioned, to address these questions, a conceptual theoretical model is developed based on the strategy-structure-performance framework and literature and has been tested using partial least squares structural equation modelling (PLS-SEM).

The remainder of the article is structured as follows. The second section is devoted to related research and provides a background to, and an overview of, the proposed research hypotheses. The third section outlines the research methodology and the proposed conceptual theoretical framework, while the fourth section provides the data analysis and hypotheses testing results. The fifth section discusses the research findings. Section six provides a discussion on the external validity and generalizability of the research findings. Finally, the seventh section concludes the research by providing an overview of the research limitations and potential topics for future research.

2. Background research and research hypotheses

According to the OECD (2015), public procurement regulations establish procedures to ensure fairness and transparency in government spending. However, these regulations are often perceived as detailed and bureaucratic, leading to the perception that procurement is merely a necessary evil, a time-consuming process

that lacks value addition (Matthews, 2005; Patrucco et al., 2017). This perspective, however, overlooks the crucial fact that the efficiency and effectiveness of public spending depend on how the procurement process is executed.

To delve into the broader themes surrounding public procurement and the significance of structural alignment, the subsequent sections of this paper will attempt to identify, propose, and analyse key factors that exist in extant literature. These factors, along with inspirations from the strategy-structure-performance framework by Chandler (1962), will form the basis for developing and proposing a conceptual theoretical framework and establishing the research hypotheses of this study. By examining the relationships among these factors, we aim to gain a deeper understanding of the role of structural alignment logic in public procurement and its impact on organizations.

2.1 Data-driven public procurement

Data-driven public procurement refers to a procurement strategy that prioritizes the use of data in its processes and leverages insights derived from these data to drive the decision-making process (Moretto et al., 2017). Thus, the integration of data-driven decision-making in public procurement holds significant potential. Public buyers face numerous decision points, such as identifying internal needs, assessing market conditions, determining supplier requirements, evaluating award criteria, and selecting contract types. In these instances, data play a crucial role in providing the necessary information for making informed and valuable decisions that are efficient and effective (Langseth and Haddara, 2021). To professionalize the procurement processes, which often involves managing large volumes of data, information systems (IS) play a vital role (van Weele, 2018). These information systems facilitate the accurate and efficient processing of data, which enables the generation of relevant insights for decision-makers. The advent of the new digital government paradigm has also further emphasized the importance of data in public governance, as it enables the extraction of facts from various data sources to support managerial decision-making (Sanina et al., 2021). McAfee and Brynjolfsson (2012) assert that data-driven decisions tend to be superior, highlighting the potential benefits of leveraging data in decision-making processes. However, realizing the potential benefits of data-driven decision-making in public procurement lacks sufficient research and requires careful consideration (Charles et al., 2022). While information systems (e.g. data analytics/business intelligence packages) can analyse data in real-time and transform them into actionable insights, concerns regarding biases and the validity of machine analysis arise (Wagner, 2019). It is important to address these challenges and ensure that data analytics is complemented by human experience and expertise (Hannila et al., 2022). By combining the power of data analytics with human judgment, organizations can harness the strengths of both approaches to make more effective and contextually informed decisions.

Recent research also highlights the benefits of data-driven decision-making in public procurement. For example, studies have shown that data-driven approaches can enhance the detection of irregularities (e.g. fraud) (Lyra et al., 2022) and can improve efficiency, transparency, fairness, and accountability in the procurement processes (Kempeneer, 2021). Additionally, the utilization of data analytics and machine learning techniques in procurement has been found to improve supplier selection, risk management, and cost optimization (Cavalcante et al., 2019; Ni et al., 2022). These findings reinforce the argument that data-driven decision-making has the potential to yield substantial benefits in public procurement.

2.2 The impact of data-driven decision-making on public vs. private organizations

The impact of data-driven decision-making varies between private and public organizations. In private organizations, data-driven decision-making has been shown to provide numerous benefits, such as improved operational efficiency, enhanced customer insights, and increased profitability (Chen et al., 2012; Zhu et al., 2018). Data-driven approaches enable private organizations to gain competitive advantages by leveraging data analytics to identify patterns, trends, and opportunities for optimization. In addition, data-driven decision-making in the private sector is often driven by a profit-oriented mindset, where the focus is on maximizing financial outcomes (Kwon et al., 2014). On the other hand, the impact of data-driven decision-making in public organizations differs due to their unique characteristics and objectives. Public organizations aim to serve the public interest, deliver public services, and promote transparency and accountability (Robles and Mallinson, 2023). While data-driven approaches have the potential to enhance public service delivery, the impact is often influenced by factors such as governance structures, legal frameworks, budget constraints, and social and political considerations (Pencheva et al., 2020). Public organizations must navigate complex stakeholder dynamics, public expectations, and ethical considerations when applying data-driven decision-making (Mureddu et al., 2020). Therefore, the impact of data-driven decision-making on public organizations involves a broader set of outcomes, including improved service quality, citizen engagement, evidence-based policymaking, and efficient resource allocation (Starke and Lünich, 2020). Moreover, Troisi and Grimaldi (2022) discussed the role of data-driven orientation and open innovation in fostering resilience and social change. The study explored how contemporary resilient data-driven organizations can integrate technologies with human components to reframe

innovation emergence. The research emphasized the importance of restructuring, adaptation, and transformation in developing a resilient attitude in organizations, contributing to societal transformation.

By addressing the prerequisites for data-driven decision-making, fostering a data-driven culture, investing in technological infrastructure, and ensuring organizational alignment, public organizations can harness the full potential of data in their procurement processes. The adoption of data-driven decision-making practices has the potential to transform public procurement, leading to more informed and effective decision-making, improved performance outcomes, and ultimately better value for taxpayers' money. However, there is also a need to explain how an organization can reach a state where it is able and willing to take advantage of data-driven decision-making, how to align the organization so that procurement decisions can be data-driven, and what kind of effects data-driven decision-making can have on the organizational performance.

2.3 Motivation for digitalization as an antecedent for developing digitalization goals

Motivation is a multifaceted concept that has been extensively studied in various disciplines, including psychology, public management, marketing, sociology, education, and economics. While the classic approach focuses on the internal processes that drive specific behaviour (Reeve, 2016), Baumeister (2016) offers a more precise definition, emphasizing that motivation is about desiring change and seeking a desired transformation through the establishment and pursuit of specific goals. Research on motivation has primarily focused on individuals, such as consumer motivation in marketing (Britt, 1950; Shao et al., 2019) and public employee motivation in public management (e.g. Breaugh et al., 2018; Ritz et al., 2020). While not focused on public procurement organizations, however, several studies have explored both factors influencing motivation and variables influenced by it. For example, Corduneanu et al. (2020) investigated the role of performance-contingent rewards as antecedents of motivation, while van der Kolk et al. (2019) examined the effect of motivation on performance. These studies contribute to the understanding that motivation is strongly linked to behaviour. In addition, research in the field of motivation and organizational performance has yielded insightful findings. For instance, studies have demonstrated that motivated organizations exhibit higher levels of innovation, productivity, and employee satisfaction (Amabile et al., 1996; Kim and Mauborgne, 2004). Additionally, motivation has been linked to improved financial performance (Latham and Pinder, 2005) and organizational effectiveness (Locke and Latham, 2002).

In the context of organizational motivation, this study shifts the focus from individuals to organizations and explores the motivation of a public organization to adopt digital solutions and its impact on structural alignment. We argue that organizational motivation can drive positive actions toward realizing digital solutions, like how individual motivation influences behaviour. According to self-determination theory (SDT), motivation is effective when it aligns closely with goals (Deci et al., 2017). Simpson and Balsam (2016) also suggest that motivation energizes behaviour in pursuit of specific goals. In addition, Jahanger et al. (2022) presented a framework to facilitate digitalization in construction-phase information management by project owners. The study identified influencing factors and improvement aspects, providing a practical guide for public agencies to successfully implement digital solutions. Their research findings also emphasize the importance of motivation in driving positive actions toward realizing digital solutions (Jahanger et al., 2022). Consequently, we contend that organizations motivated to adopt new digital solutions in procurement processes will exhibit goal-oriented behaviour and are more likely to set specific goals for digitalization. This hypothesis is supported by the argument that suggests that organizational goals and policies often reflect the interests of the dominant coalition within the organization (Kotlar et al., 2018). Hence, the following hypothesis was formulated.

H1: Motivation to adopt new digital solutions in the procurement processes is positively associated with setting specific goals for digitalization.

2.4 Goals, business intelligence, and data-driven decision-making

Organizational goal setting plays a fundamental role in shaping the ability of an organization to achieve its desired objectives (Bergeron et al., 2004). For instance, if an organization aims to digitize its procurement process to enable data-driven decision-making, it becomes imperative to establish a structure that facilitates the provision of relevant information to the decision-makers. Business intelligence (BI) lies at the heart of making effective use of existing data to provide organizations with a competitive advantage (Larson and Chang, 2016). However, according to Larson and Chang (2016), the focus should be on the utilization of information rather than the software or hardware components of BI.

Over time, if the adoption of business intelligence demonstrates the ability to generate better decisions, the procurement organization may consider integrating a business intelligence system into its permanent organizational infrastructure (Ain et al., 2019; Trieu, 2017). BI enables organizations to make structured decisions based on internal data (Arnott et al., 2017) and enhances the decision-making process, enabling

effective actions (Ain et al., 2019). Such a BI system can serve as a managerial support system, enhancing the strategic orientations of the organization (Rouhani et al., 2016). For instance, several studies have highlighted the positive impact of BI on informed decision-making and organizational performance (Ain et al., 2019; Arnott et al., 2017; Niu et al., 2021; Shiau et al., 2022). In fact, Torres et al. (2018) emphasize that businesses see BI as a strategic priority, not only for achieving strategic objectives but also for benefits such as cost and time savings, improved information quality, better decision-making, and enhanced business processes (Rouhani et al., 2016; Wixom and Watson, 2010). In addition, Olszak et al. (2021) emphasize the importance of BI and big data in innovative and sustainable development and effective decision-making. The findings highlight the diverse ways of utilizing data to enhance various aspects of organizations, including sales, competition analysis, talent recruitment, forecasting, and brand protection. The paper also underscores the need for organizations to recognize the value of data and employ the necessary tools to harness their potential (Olszak et al., 2021). While the literature highlights the application of BI in public procurement to collect, extract, and analyse data in the decision-making process, however, the successful implementation of BI in public procurement requires attention to its critical success factors (Merhi, 2021).

Recently, the relationship between digitalization goals and the adoption of data-driven decision-making or analytics in private and public organizations has gained increasing attention in the literature. Digitalization goals refer to the strategic objectives set by organizations to leverage digital technologies and processes to enhance their operations and service delivery (Dremel et al., 2017). In general, digitalization goals involve the transformation of traditional processes into digital technologies, paving the way for enhanced efficiency, innovation, and opportunities for growth. These goals often encompass the utilization of data-driven decision-making and analytics to achieve digital transformation. Research has shown that the alignment between digitalization goals and the adoption of data-driven decision-making is crucial for successful digital transformation in organizations (Dremel et al., 2017). Specifically, organizations that articulate specific goals related to data-driven decision-making are more likely to invest in the necessary infrastructure, skills, and organizational culture to support data analytics initiatives (Tabesh et al., 2019). Moreover, organizations that establish digitalization goals aligned with data-driven decision-making are more likely to prioritize the collection, integration, and analysis of data as part of their digital transformation journey (Colombari et al., 2023). This alignment creates a favourable environment for the adoption of data-driven decision-making practices and the integration of analytics into organizational processes. A study by Tabesh et al. (2019) found that public organizations that explicitly set goals related to data-driven decision-making were more successful in implementing analytics initiatives and leveraging data for improved decision-making. It is important to note that the relationship between digitalization goals and the adoption of data-driven decision-making is a complex interplay of various factors, including organizational culture, leadership support, digitization, digitalization, data integration levels, and resource allocation (Colombari et al., 2023). However, by setting clear goals and recognizing the value of data-driven decision-making, organizations can create a foundation for the adoption of analytics and drive digital transformation.

To leverage data in procurement decision-making, thorough analysis and interpretation of the data are essential (Halsbenning and Niemann, 2019; Harrison and Pardo, 2020). Without a systematic approach to BI that generates relevant procurement data for analysis and subsequent decision-making, it becomes challenging for an organization to become a truly data-driven organization. Hence, we propose a logical two-step process where organizational objectives drive the development of organizational BI, leading to the generation of relevant procurement data and ultimately fostering data-driven decision-making. With this in mind, this research puts forward the following hypotheses:

H2: Setting specific goals for digitalization positively influences the utilization of business intelligence in public procurement.

H3: Increased utilization of business intelligence positively correlates with a higher level of data-driven decision-making in public procurement.

The application of BI in public procurement is aimed at harnessing the potential of data science to improve decision-making (Matheus et al., 2020). Hence, the utilization of organizational BI can directly impact the functional activities of the organization, particularly in terms of data-driven decision-making. Consequently, there is a need to explore the implementation of BI in public procurement and identify success factors associated with its adoption (Merhi, 2021).

In summary, achieving data-driven decision-making in public procurement requires a reasoned approach to BI that fosters the generation and analysis of relevant procurement data. Setting specific goals for digitalization positively influences the utilization of BI, thereby facilitating data-driven decision-making. By investigating the relationship between organizational goals, BI utilization, and data-driven decision-making, we can gain insights into the effectiveness of BI in enhancing procurement processes and outcomes.

2.5 Data-driven decisions as drivers of organizational performance

A seminal article by McAfee and Brynjolfsson (2012) highlights the fact that data-driven organizations exhibit higher productivity and profitability than their competitors. In the contemporary business landscape, an organization's commitment to a data-driven culture has a profound influence on both product and process innovation (Chatterjee et al., 2021). This alignment with data-driven principles has the potential to enhance organizational performance and strengthen its competitive edge, positioning the organization more favourably within the sector (Chatterjee et al., 2021). After conducting a comprehensive literature review, Reddy et al. (2022) contend that data-driven decision-making generates value in two distinct forms: functional and symbolic. The functional value pertains to economic performance, encompassing cost savings and profit generation. Furthermore, it can have strategic and competitive implications, as well as transformative effects on the organization's structure and capabilities. On the other hand, symbolic value is associated with factors such as reputation, ESG (environmental, social, and corporate governance), and CSR (corporate social responsibility) (Reddy et al., 2022). Given public procurement's mandate to fulfil socio-politically significant objectives while ensuring economic efficiency, both functional and symbolic values assume importance. To capitalize on a data-driven approach, Reddy et al. (2022) posit that organizations need a well-defined strategy and managers who are willing to embrace data-driven decision-making, which is also referred to as "top-management support". Based on this rationale, we assert that data-driven managerial decision-making enhances the efficacy of procurement activities, thereby leading to improved procurement performance. In light of this argument, we propose the following hypothesis:

H4: Data-driven managerial decision-making has a positive impact on procurement performance.

In summary, it is postulated that organizations can derive benefits from adopting a data-driven approach to decision-making in public procurement. However, this necessitates three key prerequisites: 1) a strong digital motivation within the organization; 2) well-defined digitalization goals; and 3) the establishment of a business intelligence system capable of generating pertinent decision data.

3. Research methodology and theoretical background

This section delineates the fundamental methodological decisions undertaken in this study and offers an overview of the proposed and employed conceptual model. It encompasses an illustration of the research setting, design, data collection methodology, operationalization of focal variables, and the techniques adopted for data analysis.

3.1 Research setting and context

This research was conducted using data collected from public sector organizations in Norway, a country that allocates a substantial amount of its budget to public procurement. With an annual expenditure exceeding ca. 60 billion euros, public procurement in Norway plays a vital role in addressing societal challenges and achieving value for money. Recognizing the significance of improving the procurement process, Norway has implemented various measures and initiatives to enhance efficiency.

One notable development in Norway's procurement landscape is the introduction of the Public Procurement Act (Anskaffelsesloven, 2017). This legislation highlights the importance of increasing efficiency in public procurement and optimizing outcomes. Furthermore, the government's recent recommendation to the parliament (Meld.St.22, 2018–2019) acknowledged the potential for streamlining public procurement and achieving lower transaction costs, improved pricing, and better coverage of requirements. However, it also recognized the challenges associated with conducting effective and efficient public procurement that delivers optimal results. To address these challenges, the government emphasized the need for increased investment in competence, improved management practices, and organizational enhancements. This context underscores the relevance of this study, as it seeks to uncover insights that can promote effective management and contribute to the advancement of efficient and successful public procurement practices in Norway.

3.2 Research design and data collection

The conceptual theoretical model developed in this study was empirically tested using survey data collected by the Agency for Public Management and eGovernment (Difi). The data collection process involved conducting a comprehensive survey in the autumn of 2018, targeting state, county, and municipal authorities in Norway. The primary objective of the survey was to assess the maturity of public procurement practices and build a knowledge base on the state of digital maturity in public procurement.

To ensure the relevance and accuracy of the data, the survey questionnaire was designed following the guidelines recommended by Kumar et al. (1993). The questionnaire was administered online as a self-administered survey,

allowing respondents to provide their insights and perspectives on various aspects of procurement directly. The respondents consisted of personnel who were directly involved in procurement activities within the target organizations, ensuring that the collected data reflected first-hand experiences and expertise in the field. A total of 196 usable observations were extracted and utilized for the analysis. These observations encompassed a diverse range of entities, including 69 state authorities, 13 state-owned companies, 32 municipality-owned companies, 8 county authorities, and 74 municipalities. The sample composition effectively represented the procuring entities identified in the Public Procurement Act, ensuring that the findings would be applicable to the broader context of public procurement in Norway. Although the number of responses from county authorities was comparatively lower (8 responses), it is important to note that this number was still adequate for analysis. Given that Norway had only 19 counties at the time of data collection, the response rate among the counties indicated a satisfactory representation, reaching 42%. Similar considerations apply to state-owned companies, where the number of obtained responses was sufficient for meaningful analysis. This robust and diverse sample, comprising various types of public sector entities, contributes to the extent of the generalizability and reliability of the findings within the Norwegian context. The comprehensive data collected through the survey provide valuable insights into the state of digital maturity in public procurement in Norway and serve as a foundation for testing the conceptual theoretical model proposed in this study.

3.3 Theoretical background – proposed conceptual theoretical framework.

To gain deeper insights into the process of public procurement organizations becoming data-driven, this study proposes a conceptual theoretical framework inspired by the strategy-structure-performance framework (Chandler, 1962). The strategy-structure-performance framework originated from Chandler's seminal work in 1962 and has since been further developed by various scholars (Amitabh and Gupta, 2010). Achieving improved organizational performance requires a fit between multiple organizational factors (Bergeron et al., 2004; Miles and Snow, 1984). The need for research on the alignment or fit between strategy, structure, and performance in public sector organizations has been emphasized by several studies (Boyne and Walker, 2010; Jacobsen and Johnsen, 2020; Walker, 2013).

Boyne and Walker (2010) define strategy in the public sector as a means to enhance performance and provide better services, diverging from the private sector's focus on outperforming competitors in a competitive market. In the context of public procurement, strategies and goals typically revolve around improving efficiency, effectiveness, and societal outcomes. Organizational structure pertains to managerial decisions on how to address the range of tasks faced by the organization to achieve strategic objectives (Mintzberg, 1983). In public procurement, where diverse goals are set through the Procurement Act and from within the procurement organization, a critical challenge lies in aligning these objectives with the organizational structure. Evaluating the attainment of defined objectives constitutes the organizational performance aspect (Pollitt, 2013; Talbot, 2008). In the realm of public procurement and the broader public sector, identifying relevant measures for performance evaluation remains a question (Van Thiel and Leeuw, 2002).

At the outset, our proposition suggests that digital motivation serves as an internal antecedent for the organization's formulation of specific goals or strategies. In line with the tenets of the strategy-structure-performance model, we hypothesize that organizational goals or strategies wield influence over their structural makeup. Furthermore, we posit that this organizational structure permeates the functional activities linked to generating data-driven managerial decisions, which subsequently ripple to affect overall organizational performance. Bolstering our proposed framework, we draw on pertinent academic literature. Studies spotlighting data-driven decision-making, encompassing public procurement, underline the need for aligning data capabilities with organizational strategies (He et al., 2020; Wamba et al., 2017). Additionally, research underscores the role of organizational structure in fostering data-driven practices (Chae, 2019; Kiron et al., 2017). By assimilating these insights into our depicted conceptual framework (Figure 1), we aim to enhance the explanatory power of our analysis and furnish a comprehensive grasp of the factors steering data-driven decision-making in public procurement, along with its reverberations for organizational performance. In Figure 1, H1 suggests that when there's a strong motivation to use new digital solutions in procurement, there's also a higher likelihood of setting specific digitalization goals. This idea fits well with the strategy-structure-performance framework, which emphasizes aligning internal drives with strategic aims. H2 proposes that by clearly setting digitalization targets, businesses are more likely to use business intelligence in their procurement. This ties back to the framework's principle of matching goals with the structural tools needed to achieve them. H3 draws a connection between the increased use of business intelligence and making more decisions based on data. This mirrors the framework's theme of how structural tools can facilitate data-driven actions. Finally, H4 states that decisions based on data enhance procurement performance. This underscores the strategy-structure-performance framework's core message, i.e. that strategic choices, the structures supporting them, and ultimate performance are all interconnected.
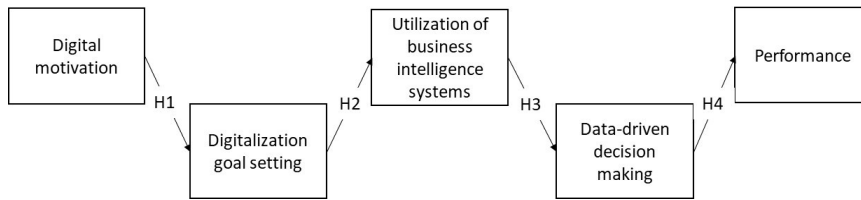
Figure 1: Conceptual theoretical framework.

3.4 Operationalization of constructs

As shown in Figure 1, the conceptual model tested in this study was based on relevant literature and the strategy-structure-performance logic/construct. It comprised six focal constructs: procurement performance, data-driven decision-making, utilization of business intelligence, setting of goals for digitalization, digital motivation, and digital goal setting. To accurately measure these constructs, a five-point Likert scale was utilized, allowing respondents to provide their assessment of each statement on a continuum ranging from 1 (very small extent) to 5 (very large extent).

The operationalization of each construct was as follows:

1. Procurement performance, data-driven decision-making, and utilization of business intelligence: These constructs were operationalized as multi-item measures, capturing various dimensions related to their respective concepts. The use of multiple items enhances the comprehensiveness and reliability of the measurements, allowing for a more robust assessment.

2. Digital motivation and digital goal setting: These constructs were measured using single items. The justification for employing single items lies in the fact that these constructs are sufficiently narrow and unambiguous, making them amenable to concise measurement (Bergkvist, 2016; Bergkvist and Rossiter, 2009). Digital motivation was operationalized as the desire to engage in digitalization practices and investments, while digital goal setting captured the extent to which organizations establish goals specifically related to digitalization.

3. Data-driven decision-making and utilization of business intelligence: Data-driven decision-making was operationalized using two formative indicators, showing that the construct is influenced by these indicators. On the other hand, the utilization of business intelligence was operationalized using four reflective indicators (see Table 1), suggesting that the indicators reflect the construct.

Additionally, procurement performance was operationalized as a reflective-formative second-order construct, incorporating two dimensions: inefficiency reduction and effectiveness gains. This approach enables a comprehensive understanding of procurement performance by considering its underlying dimensions and their interrelationships. Moreover, to account for potential variations in procurement performance, the utilization of business intelligence, digital motivation, and digital goal setting, the study included the size of the organization as a potential alternative explanation. It was assumed that larger organizations would possess more resources that could positively influence these variables. The number of employees served as a proxy for organization size.

By employing a combination of multi-item and single-item measures, as well as formative and reflective indicators, the study ensured a robust operationalization of the constructs included in the conceptual model. The inclusion of organization size as a control variable strengthened the analysis in considering its potential impact on the variables under investigation.

Table 1: Focal constructs and their respective measures.

Construct	Indicator
Data-driven management (DD)	DD1: To what extent do data from your organization's digital solutions support management decisions?
	DD2: To what extent has the use of digital solutions led to better support for management decision-making?

Digital motivation (DM)	To what extent do you find that your organization is motivated to adopt new digital solutions in the procurement area?
Digitalization goal setting (DS)	To what extent have specific goals been set for digitalizing the procurement process?
Utilization of business intelligence	BI1: To what extent are the organization's procurements carried out based on the use of consumption statistics? BI2: To what extent has an automated process for matching and checking purchase orders against item receipts and invoices been implemented? BI3: To what extent are the organization's invoices digitally checked against the contract concluded to check that the correct pricing conditions have been used? BI4: To what extent are invoices matched to orders based on an order number?
Inefficiency reduction	To what extent has the use of digital solutions led to the following: IR1: Reduction in time consumption IR2: Cost reduction IR3: Reduction in waiting time between activities in the procurement process IR4: Reduction in the number of errors IR5: Reduction in prices paid (increased competition)?
Effectiveness gains	To what extent has the use of digital solutions led to the following: EG1: Better contractual terms and conditions EG2: Better communication with suppliers EG3: Better control of the use of allocated funds EG4: Better coverage of the needs of internal clients EG5: Better suppliers?

4. Analysis and results

The hypotheses presented in Section 2 were empirically tested using partial least squares structural equation modelling. PLS-SEM has gained prominence across various disciplines, including public procurement (e.g. Mwesiumo et al., 2021) and information and communication technology (e.g. Purwanto et al., 2023)). Hence, this study employs PLS-SEM for several valid reasons. Firstly, the study is exploratory in nature, aligning with the suitability of PLS-SEM for such investigations, as recommended by Hair et al. (2022). Secondly, the measurement model utilized in this study incorporates a higher-order construct and formative indicators, which are usually best handled by PLS-SEM (Hair et al., 2019). Lastly, the model includes mediation effects, and according to Sarstedt et al. (2020), composite-based SEM methods like PLS-SEM are recommended for analysing such models, as they overcome the limitations of both regression- and factor-based SEM analyses.

With regard to the criteria for conducting PLS-SEM, the sample size of 196 respondents used in this study surpasses the recommended threshold of 129, ensuring a statistical power of 80% (Hair et al., 2017). This sample size provides adequate statistical strength to examine the relationships between the constructs under investigation. In the subsequent subsections, the assessment of the measurement model and the estimation of the structural model are presented, elucidating the empirical analysis conducted to test the proposed hypotheses.

4.1 Assessment of the measurement model

Before proceeding with hypothesis testing, it was deemed crucial to assess the measurement model for internal consistency reliability, convergent validity, and discriminant validity of the multi-item constructs. In this research, we followed the two-stage approach suggested by Becker et al. (2012), where the latent scores for inefficiency reduction and effectiveness gains were first generated and then used as indicators for the procurement performance construct. The significance of the indicators for both constructs is evident from the results ($p < 0.01$) presented in Figure 2. Additionally, the variance inflated factors (VIFs) indicate an absence of collinearity problems, as they are well below the threshold of 3.
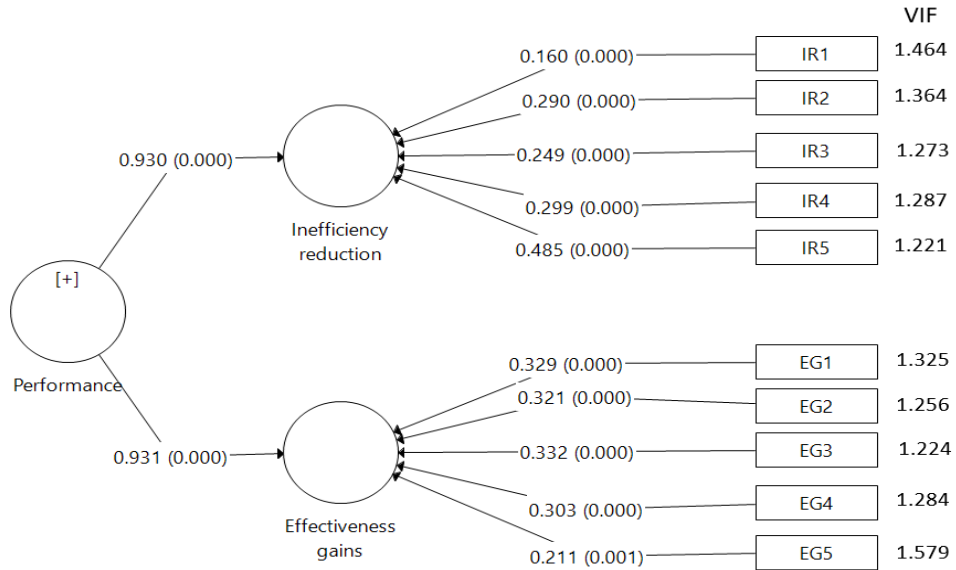
Figure 2: Generating latent scores for inefficiency reduction and effectiveness gains.

After generating the latent scores, they were then included in the data set to estimate the main measurement and structural models, which are presented in Figure 3. Following the recommendations of Zhao et al. (2010), our estimated model includes direct effects for each mediated effect. For instance, since the relationship between digital motivation and the utilization of business intelligence is conceptually mediated by goal setting, we also estimated the potential direct effect of digital motivation on the utilization of business intelligence. This approach allows us to explore the potential existence of other mediating factors, as suggested by Zhao et al. (2010).

Since digital motivation and digital goal setting were measured using single items, and data-driven decision-making was operationalized formatively, the assessment of internal consistency reliability and convergent validity focused on the utilization of business intelligence and procurement performance. To evaluate internal consistency reliability, we employed ρA (rho_A), a novel and more effective metric proposed by Dijkstra and Henseler (2015). As shown in Table 2, the internal consistency reliability for these constructs was established, as their rho_A values exceeded the recommended threshold of 0.708 (Hair et al., 2019). Reliability was also confirmed by considering the more stringent metric of Cronbach's alpha, which also exceeded the recommended threshold of 0.708.

Convergent validity was assessed by examining the average variance extracted (AVE). As displayed in Table 2, the convergent validity for the two variables (utilization of business intelligence and procurement performance) was established, as their corresponding AVE values surpassed the recommended minimum threshold of 0.5. Following the guidance of Hair et al. (2019), we evaluated discriminant validity using the heterotrait-monotrait ratio of correlations (HTMT), a superior metric compared to the conventional Fornell–Larcker criterion. The observed HTMT ratios, presented in Table 3, were well below the recommended threshold of 0.85, indicating satisfactory discriminant validity.

The measurement model for the construct data-driven decision-making was examined by assessing the significance of its outer weights and potential collinearity problems. The results demonstrated that both indicators were significant (p < 0.01), and there was no collinearity issue (the VIF value for effectiveness gains and inefficiency reduction was 2.223, well below 3). This suggests that the indicators adequately represent the construct, and that multicollinearity is not a concern.

In summary, the assessment of the measurement model in this study provides evidence of internal consistency reliability, convergent validity, and discriminant validity for the multi-item constructs. These results support the robustness of the measurement model and lay the foundation for further analysis and hypothesis testing.

Table 2: Internal consistency reliability and convergency validity.

Indicators	Loadings	Cronbach's alpha	rho_A	CR	AVE
BI1	0.641	0.754	0.771	0.845	0.581
BI2	0.867				
BI3	0.706				
BI4	0.814				
PP1 (Effectiveness gains)	0.941	0.852	0.860	0.931	0.871
PP2 (Inefficiency reduction)	0.925				

Table 3: Assessment of discriminant validity

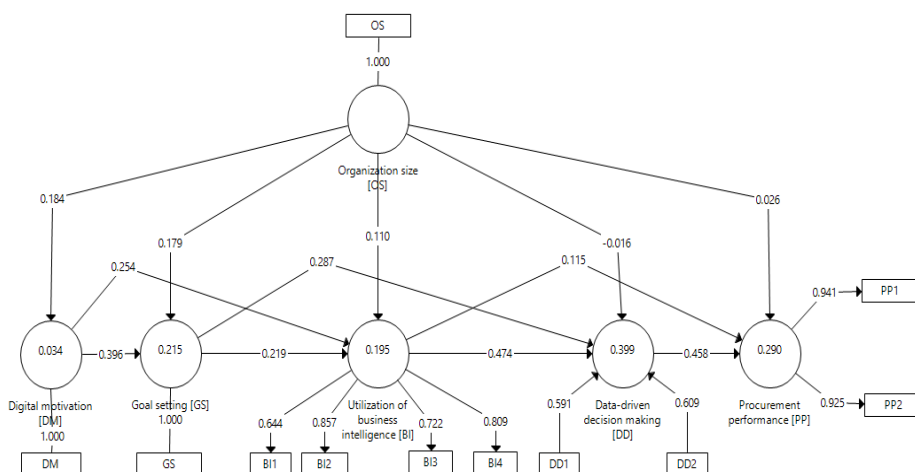|	Variables	1	2	3	4
1	Utilization of business intelligence systems				
2	Digital motivation	0.419			
3	Goal setting	0.395	0.429		
4	Organization size	0.235	0.184	0.252	
5	Procurement performance	0.475	0.296	0.404	0.135

Figure 3: Estimated mode.

4.2 Analysis of the structural model

After confirming the suitability of the measurement model, this section focuses on estimating the structural model to test the hypotheses. Several aspects of the structural model were assessed, including the path coefficients, R^2 values, potential multicollinearity, and internal predictive relevance.

The path coefficients, as depicted in Figure 2, exhibit absolute values ranging from 0.016 to 0.474, indicating the strength and direction of the relationships among the constructs. Effect sizes, ranging from 0.000 to 0.320, were also calculated, with the largest effect observed on the path between the utilization of business intelligence and data-driven decision-making. The R^2 value for the dependent variable is 0.290, suggesting that the model adequately explains 29% of the variance. These results provide insights into the significance and magnitude of the relationships proposed in the conceptual model.

To evaluate the internal predictive relevance of the model, Stone–Geisser's Q^2 value was calculated and found to be above zero, as shown in Table 4. This indicates that the model has internal predictive power, suggesting its usefulness for making predictions within the sample. In addition, all VIF values were examined to ensure the absence of multicollinearity issues, and the VIF values were found to be below the threshold of 3. This suggests that the estimated model does not suffer from severe multicollinearity problems, thereby enhancing the robustness of the results. To determine the significance of the structural paths, bootstrapping was also employed with 10,000 subsamples, following the recommendation of Hair et al. (2022). This resampling technique allows for the estimation of confidence intervals and p-values. Conducting bootstrapping ensures the reliability and accuracy of the inferential analysis, providing more robust evidence to support or reject the hypotheses.

Table 4: Results of the structural model estimation-

Path	Coefficient	STDEV	P Values	Effect size	VIF
DD → PP	0.458	0.076	0.000***	0.198	1.491
BI → DD	0.474	0.067	0.000***	0.320	1.166
BI → PP	0.115	0.086	0.178	0.012	1.523
GS → BI	0.219	0.074	0.003***	0.047	1.274
GS → DD	0.287	0.065	0.000***	0.116	1.189
DM → GS	0.396	0.068	0.000***	0.193	1.035
DM → BI	0.254	0.073	0.000***	0.065	1.235
OS → DD	-0.016	0.059	0.782	0.000	1.088
OS → DM	0.184	0.069	0.006***	0.035	1.000
OS → GS	0.179	0.066	0.007***	0.040	1.035
OS → PP	0.026	0.061	0.666	0.001	1.049
OS → BI	0.110	0.066	0.091*	0.014	1.076

R^2: Procurement performance [PP] = 0.290; Data-driven decision-making [DD] = 0.399

Adjusted R^2: Procurement performance [PP] = 0.279; Data-driven decision-making [DD] = 0.389

Q^2: Procurement performance [PP] = 0.235; Data-driven decision-making [DD] = 0.258

*** significant at $p < 0.01$; * significant at $p < 0.10$

4.3 Findings

This section provides an overview of the study's main findings, encompassing the relationships among digital motivation, goal setting, business intelligence, data-driven management, and procurement performance. This analysis offers valuable insights into the interconnections between these constructs and their impact on organizational dynamics in the context of public procurement.

The findings show that the path from digital motivation to goal setting and subsequently to business intelligence (DM -> GS -> BI) has a coefficient of 0.087, suggesting a positive association between digital motivation, goal setting, and the utilization of business intelligence. This association is statistically significant (p = 0.013**). Similarly, the path from digital motivation to goal setting and then to data-driven management (DM -> GS -> DD) indicates a positive relationship with a coefficient of 0.114, which is highly significant (p = 0.000***). The pathway from digital motivation to business intelligence and further to data-driven management (DM -> BI -> DD) also exhibits a positive and significant connection, with a coefficient of 0.120 (p = 0.003***). In the case of DM leading to BI and subsequently to procurement performance (DM -> BI -> PP), the coefficient is 0.029, and the association is not statistically significant (p = 0.214ns). The link from BI to DD and then to PP (BI -> DD -> PP) showcases a stronger and significant correlation with a coefficient of 0.217 (p = 0.000***). The relationship between goal setting, data-driven management, and procurement performance (GS -> DD -> PP) is also significant, with a coefficient of 0.132 (p = 0.001***). The path from GS to BI and subsequently to DD (GS -> BI -> DD) reveals a coefficient of 0.104, signifying a positive and significant relationship (p = 0.008***). However, the pathway from GS to BI and then to PP (GS -> BI -> PP) has a coefficient of 0.025 and is not statistically significant (p = 0.245 ns). The combined route from GS to BI, and further to DD, and then to PP (GS -> BI -> DD -> PP) exhibits a coefficient of 0.048 and is significant (p = 0.020**). Thus, the first hypothesis, which posited a positive association between digital motivation and setting goals for digitalization, is supported by the analysis. The path coefficient between these constructs is positive and statistically significant (p < 0.01), which indicates that higher levels of digital motivation within an organization are associated with an increased likelihood of setting goals for digitalization. Similarly, the second hypothesis testing suggests a significant and positive link between goal setting for digitalization and the utilization of business intelligence (p < 0.01). This finding suggests that organizations that set goals for digitalization are more likely to utilize business intelligence tools and techniques effectively. The third hypothesis proposed a positive relationship between the utilization of business intelligence and the management's use of data to support decision-making. The results provide support for this hypothesis, as the path coefficient is positive and statistically significant (p < 0.01). This finding implies that organizations that effectively utilize business intelligence are more likely to employ data-driven decision-making processes. Furthermore, the fourth hypothesis stated that data-driven managerial decision-making would have a positive effect on procurement performance. The analysis supports this hypothesis, as the path coefficient between data-driven decision-making and procurement performance is positive and statistically significant (p < 0.01). This suggests that organizations that prioritize data-driven decision-making in their procurement processes are more likely to achieve better procurement performance outcomes.

As regards the alternative explanation, the results indicate that organization size significantly affects digital motivation, goal setting, and utilization of business intelligence. Specifically, larger organizations tend to exhibit higher levels of digital motivation, engage in more extensive goal-setting for digitalization, and utilize business intelligence tools to a greater extent. However, the effect of organization size on procurement performance was not found to be statistically significant. In line with the findings, the study also assessed the indirect effects among the focal constructs, following the approach proposed by Zhao et al. (2010). The results confirm the occurrence of structural alignment, as the indirect effect of digital motivation on procurement performance through digitalization goal setting and utilization of business intelligence is positive and statistically significant (p < 0.05). This suggests that the positive impact of digital motivation on procurement performance is mediated by the establishment of digitalization goals and the effective utilization of business intelligence.

Notably, the analysis reveals that the paths leading to procurement performance without including data-driven decision-making (DM -> BI -> PP; GS -> BI -> PP; DM -> GS -> BI -> PP) are not statistically significant. This implies that digital motivation, digitalization goal setting, and utilization of business intelligence alone are insufficient to improve public procurement performance unless they are accompanied by data-driven decision-making practices.

Table 5: Specific indirect effects

Path	Coefficient	STDEV	P Values
DM -> GS -> BI	0.087	0.035	0.013**

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DM -> GS -> DD	0.114	0.032	0.000***
DM -> BI -> DD	0.120	0.041	0.003***
DM -> BI -> PP	0.029	0.024	0.214ns
BI -> DD -> PP	0.217	0.048	0.000***
GS -> DD -> PP	0.132	0.039	0.001***
GS -> BI -> DD	0.104	0.039	0.008***
GS -> BI -> PP	0.025	0.022	0.245 ns
GS -> BI -> DD -> PP	0.048	0.020	0.020**
DM -> GS -> BI -> DD	0.041	0.018	0.022**
DM -> BI -> DD -> PP	0.055	0.021	0.009***
DM -> GS -> BI -> PP	0.010	0.009	0.269 ns
DM -> GS -> DD -> PP	0.052	0.018	0.004***
DM -> GS -> BI -> DD -> PP	0.019	0.009	0.040**

*** significant at $p < 0.01$; ** significant at $p < 0.05$

5. Discussion

This study attempts to investigate the structural relationships among factors associated with data-driven management decisions within public procurement and their impact on procurement performance. The study fills a significant gap in the literature by providing valuable insights into the relatively unexplored topics of data-driven decision-making, BI, and data-driven organizations in the public sector domain (van Donge et al., 2022), particularly in the context of public procurement. By adopting a conceptual theoretical framework based on literature and the strategy-structure-performance logic, we obtained support for the core path defined by hypotheses H1, H2, H3, and H4.

The confirmation of hypothesis H1 supports the notion that digital motivation positively influences the development of specific goals for digitalization (Kotlar et al., 2018). While previous studies have primarily explored this concept at the individual level, this study demonstrates its applicability at the organizational level. The findings emphasize the importance of fostering a digital motivation culture within an organization as a driving force for developing it into a data-driven entity. The confirmation of hypothesis H2 suggests that defining organizational goals influences the development of the organizational structure, including the implementation of a BI system. This finding aligns with both the strategy-structure-performance logic and the principles of BI, highlighting the role of BI in goal development and its significance as a structural element in achieving those goals (Rouhani et al., 2016; Wixom and Watson, 2010). The presence of BI emerges as a critical factor in the journey towards becoming a data-driven organization. Similarly, the confirmation of hypothesis H3, indicating that the utilization of business intelligence positively influences data-driven decision-making, aligns with the strategy-structure-performance logic. The results underscore the importance of aligning the organizational structure with strategic goals and providing the necessary support for functional activities to enable effective data-driven decision-making (Bergeron et al., 2004). Moreover, the confirmation of hypothesis H4, suggesting that data-driven decision-making has a positive effect on procurement performance, is consistent with the literature highlighting the effects of data-driven decision-making on overall organizational performance (McAfee and Brynjolfsson, 2012; Reddy et al., 2022). Demonstrating positive effects on procurement performance within the context of public procurement is significant, as public procurement is expected to contribute to a wide range of societal goals. It also underscores the importance of investing resources in developing a data-driven culture, skills, and organizational structure.

The findings of this study highlight that there is no shortcut to improving public procurement performance through data-driven decision-making. Multiple actions need to be aligned to enhance data-driven decision-making, which, in turn, can lead to improved procurement performance. Therefore, organizational culture must be motivated and set goals to develop a data-driven organization. While a strong cultural foundation is important, it cannot substitute for the development of organizational structures that enable and support data-driven decision-making. In line with the goal of providing explanations for phenomena, this study identifies the mechanisms that link variables and contributes to the theory of public procurement performance. By uncovering

the fundamental processes underlying the link between digital motivation in digitalization and performance in terms of effectiveness gains and inefficiency reduction, the study enhances our understanding of these relationships. Additionally, the findings suggest that the presence of business intelligence has the most significant effect size in the estimated model. This finding indicates that having a robust business intelligence system is crucial for achieving a data-driven organization. It supports the argument that organizations must collect, analyse, and interpret data before making informed decisions (Halsbenning and Niemann, 2019; Harrison and Pardo, 2020). Hence, the presence of a well-designed business intelligence system becomes a necessary consideration when designing an organizational structure. Furthermore, the study establishes a significant association between organizational size and digital motivation, goal setting, and utilization of business intelligence. This finding is consistent with existing literature on the implementation of business intelligence in private sector companies, where organizational size was found to play a role (Ahmad et al., 2020; Bhatiasevi and Naglis, 2020; Rouhani et al., 2018). In the context of organizational performance, the relationship between organizational size and performance is complex. While economies of scale arguments suggest that larger organizations should outperform smaller ones, studies focusing on public sector organizations have found little or no effect of organizational size on performance (Carmeli and Tishler, 2004). The finding that becoming a data-driven organization has a significant impact on procurement performance, regardless of organizational size, reinforces the notion that data-driven practices can make a difference. It implies that smaller organizations can achieve better procurement performance than larger ones if the larger organizations primarily focus on seeking economies of scale.

The results provide valuable insights into the structural relationships between digital motivation, goal setting for digitalization, utilization of business intelligence, data-driven decision-making, and procurement performance in the public procurement context. The findings contribute to the literature on data-driven organizations and the use of business intelligence in public procurement. The study emphasizes the importance of developing a data-driven culture, aligning organizational goals and structure, and leveraging business intelligence to enhance procurement performance. These findings have implications for theory, practice, and policy and can guide organizations and policymakers in their efforts to improve public procurement outcomes through data-driven decision-making. From a managerial perspective, this study provides empirical evidence of the complexity involved in transitioning an organization towards effectively utilizing digital procurement data for data-driven decision-making. It highlights the importance of digital motivation as a foundational element for developing specific goals for digitalization. Additionally, the findings underscore the need to establish a business intelligence methodology that supports data-driven decision-making. The alignment of culture, digital motivation, organizational objectives, and structure is crucial for organizations to capitalize on the opportunities provided by technological solutions and become digitally mature entities (Rader, 2019). The implications for practice suggest that digital maturity can provide advantages for organizations, enabling them to utilize their resources more effectively than less mature organizations (Mergel et al., 2019). Developing a data-driven organization requires a holistic approach that encompasses culture, goal setting, and organizational structure. From a policy standpoint, the study contributes to the broader discourse on digital transformation in the public sector. Understanding how decision-making in public procurement can become data-driven and enhance the quality of decisions strengthens the case for policies aimed at promoting digitalization and data-driven decision-making in the public sector, particularly in the context of public procurement.

6. External validity and generalizability of the findings

It is essential to evaluate the external validity of the findings in the context of Norway and consider their broader applicability to other countries or regions. The specific characteristics of Norway's public procurement system and its organizational context may influence the effectiveness and prevalence of data-driven decision-making, potentially limiting the generalizability of the findings beyond this context.

Firstly, Norway's procurement regulations and practices may differ from those in other countries or regions, affecting the efficiency and data-driven nature of procurement processes. While the findings of this study shed light on the antecedents and implications of data-driven decision-making in public procurement, it is crucial to acknowledge that the effectiveness and level of data-driven practices may vary across different countries due to variations in legal frameworks, bureaucratic structures, and cultural factors (OECD, 2015; Thai, 2001). Additionally, factors such as the level of bureaucracy, remuneration, and motivation among public procurement professionals may differ between Norway and other countries. For instance, it has been suggested that bureaucrats in certain countries, such as southern and eastern European ones, may face unique challenges in terms of lower salaries and motivation levels (Bartolini et al., 2017; Takacs Haynes and Rašković, 2021). These factors can impact the adoption and effectiveness of data-driven decision-making in public procurement,

potentially limiting the generalizability of the findings to these contexts. Moreover, the digital infrastructure, technological readiness, and availability of resources for implementing data-driven practices may vary between countries. Norway is known for its advanced digital infrastructure and high technological readiness, which could facilitate the adoption and utilization of digital tools and business intelligence systems (EU-Commission, 2023). In contrast, countries with limited digital infrastructure or resource constraints may face challenges in achieving similar levels of data-driven decision-making in public procurement.

7. Conclusions and future research

This study provides valuable insights into the requirement for public sector organizations to harness the benefits of data-driven decision-making in procurement. Our findings highlight the advantage of strong digital motivations, which positively influence the development of specific digitalization goals in procurement. In addition, the establishment of business intelligence mechanisms plays a crucial role in data collection and analysis. The development of a conceptual theoretical framework inspired by the strategy-structure-performance logic has enabled a holistic understanding of the path towards data-driven decision-making in public procurement. The empirical results confirm the model's robustness and explanatory power, offering practical implications for government agencies and procurement professionals.

The practical implications of this study for the public sector and managers are multifaceted. From optimizing performance and efficiency to informed decision-making, the adoption of data-driven practices offers a transformative path forward. By aligning digitalization goals with broader strategies, fostering stakeholder trust, and securing top-management support, managers can harness the power of data-driven decision-making to propel the public sector toward greater operational excellence and societal impact. The findings also underscore the substantial impact of data-driven decisions on organizational performance. For public sector managers, this implies that fostering a culture of data-driven decision-making can lead to improved efficiency and efficacy across various operational domains. By leveraging data insights to guide procurement processes, managers can streamline workflows, reduce redundancy, and achieve greater cost-effectiveness. Public procurement managers are often confronted with complex choices that have far-reaching consequences. Embracing data-driven decision-making empowers these managers with factual insights, mitigating reliance on intuition alone. Access to data-driven insights equips managers to make informed judgments, resulting in more strategic and aligned decisions. The study's connection between the adoption of digital solutions, specific goals, business intelligence utilization, and data-driven decision-making holds crucial implications for strategic goal alignment. Hence, managers can strategically align their digitalization objectives with broader organizational goals, ensuring a coherent approach that drives performance improvements. The dynamic nature of DDDM mandates an attitude and environment of continuous learning and adaptation. Thus, public sector managers should invest in training and upskilling programmers to ensure that employees are equipped with the necessary competencies to derive maximum value from data-driven practices.

Building upon these findings, further research is warranted to deepen our understanding of data-driven decision-making in public procurement. This includes exploring the value derived from adopting data-driven practices, considering both functional and symbolic dimensions as suggested by Reddy et al. (2022). Investigating the impact of data-driven decision-making on societal goals, such as environmental sustainability and social equity, is crucial, given their increasing importance in public procurement (Sanina et al., 2021; van Weele, 2018). Moreover, future studies should delve into additional mediating factors that may influence the relationship between motivation, goal setting, and data-driven decision-making. Understanding these mechanisms will contribute to a more nuanced understanding of the processes underlying data-driven transformation in public procurement. It is important to acknowledge the limitations of this research, as it focused solely on public procurement organizations in Norway. To enhance the generalizability of the findings, future studies should consider conducting comparative research across multiple countries or regions, taking contextual factors into consideration. Examining variations in data-driven decision-making practices and their effects across different settings will provide a more comprehensive understanding of the factors influencing procurement performance. Finally, this study lays the foundation for further exploration of data-driven decision-making in public procurement. The identified antecedents and implications serve as a starting point for future research, guiding the advancement of theory and practice in this area. By addressing the research gaps and considering the practical implications, we can foster more effective and impactful data-driven decision-making in public procurement.

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