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Doctoral Thesis in Economics

Improving the Efficiency of Public Procurement

Empirical evidence using micro-level contract data

IVAN RIDDERSTEDT

Stockholm, Sweden 2023

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Abstract

Among OECD countries, close to one-third of government expenditure is allocated using public procurement. This implies that the skill of public authorities in handling the procurement format has a significant impact on how much the public sector accomplish in relation to their goals and responsibilities. The aim of this thesis is to provide new insights into how public procurers can achieve more for the money by improving the design of their auctions and contracts. Specifically, the thesis examines how the efficiency can be influenced by the following three aspects: the method of bid evaluation (the award mechanism), whether items are procured separately or grouped into larger contracts, and variations among procurers in the activities and quantities they specify in a given case.

The thesis includes four essays that analyze detailed contract information from Swedish procurements of road reinvestments and public bus services. For a comprehensive sample of the examined contracts, information has been collected from procurement documents and compiled into rich microdata sets. The use of microdata has enabled detailed reviews of how the procurements have been designed as well as statistical analysis of associations between the procurer's choices and the outcome. While the essays primarily focus on results and implications regarding their respective research questions, the kappa provides a more general discussion about quantitative microanalysis in the field of procurement. This reflects a complementary aim of the thesis, which is to contribute to well-informed decisions regarding whether and how contracting authorities should facilitate analyses of this kind.

Two of the essays investigate to what extent and how the Swedish national infrastructure manager Trafikverket can improve its efficiency in procurements of highway pavement replacement. Trafikverket spends approximately EUR 200 million on these works annually. Hence, if better procurement methods could lower the cost by 5% without reducing the quality, about EUR 10 million would be freed up annually for additional road maintenance or other uses. Both essays indicate that even greater efficiency gains can be achieved through improved dissemination of best practices. The results support Trafikverket's policy to bundle similar and adjacent road work but imply that the contracts are generally not large enough to fully benefit from the economies of scale. A conclusion is that it is motivated for Trafikverket to consider the scope for efficient bundling when deciding on the timing of these pavement replacement measures.

The other two essays examine how the Swedish regional Public Transport Authorities (PTAs) have implemented the *scoring rule award mechanism* and its efficiency. This alternative to the *lowest price* and *quality-only* mechanisms is promoted within the EU procurement directive and is dominant in many countries. However, the literature on how well public agencies implement this policy is scarce and fragmented. One of the essays shows that scoring rules are common in Swedish procurements of public bus services, but also that there are significant differences between the PTAs in whether and how they have applied this award mechanism. Several implementations have unsound and likely unintended properties, in the light of economic theory. The findings suggest that best practices are not spread effectively between the organizations. The second essay on this theme exploits the property that one PTA alternated between lowest price and a performance focused variant of scoring rules and, equally

important, could provide data on a relevant and reliable outcome measure. Based on 30 months of observations on monitored punctuality, performance is not found to be better in contracts awarded using scoring rules. The results suggest that the promotion of scoring rules is not accompanied with adequate guidance on when and how to implement it efficiently.

The kappa highlights how microdata at the contract level enable research that considers both the ‘uniqueness’ of each procurement and random variation. In the analyses of road reinvestments, the detailed data allows us to consider several important characteristics of the contracts and the treated road segments. Similarly, the analysis of bus punctuality considers several aspects of the traffic assignment. In this way, quantitative microanalysis can provide reliable quantifications of how costs and quality are affected by both the procurer's actions, while considering the external conditions. Many of these associations are too complex to be reliably assessed by an individual civil servant, even if it is highly knowledgeable and experienced. However, the thesis emphasizes that even quantitative analysis can yield misleading results if the data material is not good enough, for example, if the sample is too small or relevant aspects are not captured.

A central argument in the thesis is that the standardized and rigid procurement process creates particularly excellent conditions for collecting useful procurement data. However, the potential for this has largely remained untapped by the public agencies themselves. Instead, these data have primarily been compiled within individual research projects, where even the collection of tendering documents has been a notorious obstacle. In Sweden, Trafikverket's information management and cost control have repeatedly been criticized. However, Trafikverket is far from the ‘worst in class’ in these matters, and the criticism mainly reflects the agency's position as one of Sweden's largest procurers. An overall conclusion of the thesis is that public agencies in general should take a more active role in improving how procurement data are collected and managed. Of particular importance is the establishment of well-structured archiving processes for procurement documents, along with systems to track changes in both costs and content after a contract is awarded. For smaller authorities, it is reasonable that this development is coordinated or driven by a centralized function, whereas Trafikverket is well positioned to take a leading role in finding and disseminating best practices. Ultimately, the responsibility for instructing and overseeing improvements in this area lies with the governing bodies of the public agencies, given that the agencies do not set their own agendas.

Keywords: Public procurement, public sector efficiency, auction design, award mechanisms, bundling, transport infrastructure, public transport.

Sammanfattning

Bland OECD-länder allokeras nära en tredjedel av offentliga sektorns utgifter genom offentlig upphandling. Detta innebär att offentliga myndigheters förmåga att hantera upphandlingsformatet har en betydande påverkan på hur mycket de, och den offentliga sektorn i stort, uppnår i relation till sina mål och ansvarsområden. Denna avhandling syftar till att ge nya insikter om hur offentliga upphandlare kan uppnå mer för pengarna genom förbättringar av hur de utformar sina kontrakt och auktioner. I synnerhet undersöks hur effektiviteten kan påverkas av följande tre aspekter: metoden för anbudsutvärdering (tilldelningsmekanismen), om objekt upphandlas separat eller är grupperade till större kontrakt, samt skillnader i hur olika upphandlare specificerar aktiviteter och mängder i ett givet fall.

I avhandlingen ingår fyra artiklar som analyserar detaljerad kontraktsinformation från svenska upphandlingar av vägreinvesteringar och kollektiv busstrafik. Denna information har samlats in från förfrågningsunderlag för ett stort antal kontrakt inom respektive verksamhet. Det sammanställda mikrodatamaterialet har möjliggjort såväl detaljerade kartläggningar av hur upphandlingarna har utformats som statistisk analys av samband mellan upphandlarens agerande och utfallet. Medan artiklarna främst är fokuserade på resultat och implikationer angående deras respektive forskningsfråga, förs i avhandlingens kappa en mer generell diskussion om kvantitativ mikroanalys inom upphandlingsområdet. Detta svarar mot ett kompletterande syfte med avhandlingen, vilket är att bidra till välinformerade beslut angående om och hur upphandlande myndigheter bör främja analyser av detta slag.

Två av artiklarna undersöker i vilken utsträckning och hur Trafikverket kan förbättra sin effektivitet i sin upphandling av vägreinvesteringar, efter att prioriteringen av objekt redan är gjord. Trafikverket upphandlar årligen dessa arbeten för omkring 2 miljarder kronor. Om bättre upphandlingsmetoder skulle innebära att samma arbeten kan upphandlas för 5% lägre kostnad, skulle cirka 100 miljoner kronor årligen frigöras för ytterligare åtgärder. Artiklarna indikerar att effektiviseringspotentialen är större än så. Resultaten stödjer Trafikverkets policy att gruppera liknande och närliggande åtgärder men implicerar att kontrakten generellt inte är tillräckligt stora för att fullt ut dra nytta av stordriftsfördelarna. En slutsats är att det är motiverat för Trafikverket att i högre grad beakta förutsättningarna för effektiv gruppering av åtgärder vid beslutet om när en åtgärd genomförs.

De andra två artiklarna undersöker hur de regionala kollektivtrafikmyndigheterna (RKM) har implementerat tilldelningsmekanismen *bästa förhållande mellan pris och kvalitet* (BPK) samt dess effektivitet. Detta alternativ till *lägsta pris* och *högsta kvalitet* förespråkas inom EU:s upphandlingslagstiftning och är dominerande i många länder. Forskningslitteraturen som undersöker hur väl myndigheter implementerar BPK är dock begränsad i omfattning och mycket fragmenterad. Den ena artikeln visar att BPK är vanligt förekommande i svenska upphandlingar av kollektiv busstrafik men också att det är stora skillnader mellan olika RKM vad gäller om och hur de har tillämpat denna tilldelningsmekanism. Utifrån ekonomisk teori har flera tillämpningar har icke-fördelaktiga och troligtvis ej avsedda egenskaper. Den andra artikeln på detta tema utnyttjar att en RKM varierat mellan prestationsfokuserad BPK och lägsta pris över tid, och dessutom kunde tillhandahålla data på ett relevant och tillförlitligt utfallsmått. Baserat på 30 månaders observationer på uppmätt punktlighet påvisas ingen skillnad i

utförarens prestation mellan lägsta pris och en BPK. Slutsatsen är att förespråkandet av BPK inte i tillräckligt hög grad ackompanjeras av vägledning om när och hur denna mekanism bör användas.

Avhandlingens kappa belyser hur mikrodata på kontraktsnivå möjliggör för analyser som beaktar skillnader i förutsättningar mellan olika upphandlingar och slumpmässig variation. I analyserna av vägreinvesteringar beaktas kontraktens och de åtgärdade vägsegmentens karaktär, och i analysen av busstrafikens punktlighet beaktas flertalet aspekter av det specifika trafikuppdraget. På så vis kan kvantitativ mikroanalys ge tillförlitliga kvantifieringar av hur kostnader och kvalitet påverkas av upphandlarens agerande, med hänsyn tagen till de externa förutsättningarna. Många av dessa samband kan antas vara alltför komplexa för att en individuell bedömning ska vara tillförlitlig, även om den individen är mycket kunnig och erfaren. Avhandlingen understryker dock att även kvantitativ analys kan ge vilseledande resultat om datamaterialet inte är tillräckligt bra, exempelvis om urvalet är för litet eller relevanta aspekter inte fångas.

En central poäng i avhandlingen är att det standardiserade och rigida upphandlingsförfarandet skapar goda förutsättningar för insamling av användbara upphandlingsdata. Potentialen för detta har dock i stort förblivit outnyttjad av myndigheterna själva. I stället har dessa data främst sammanställts inom enskilda forsknings- och utredningsprojekt, där till och med insamlingen av förfrågningsunderlag varit ett påtagligt hinder. I Sverige har Trafikverkets informationshantering och kostnadskontroll fått återkommande kritik. Trafikverket är dock långt ifrån värst i klassen i dessa frågor, utan kritiken speglar främst myndighetens position som en av Sveriges största upphandlare. En övergripande slutsats i avhandlingen är att myndigheter bör ta en mer aktiv roll i arbetet med att förbättra hur upphandlingsdata på kontraktsnivå samlas in och hanteras. Särskilt behövs välstrukturerad arkivering av förfrågningsunderlag samt system för att följa hur kontraktens kostnader och innehåll förändras efter att de har tilldelats. För mindre myndigheter är det rimligt att denna utveckling samordnas eller drivs av en centraliserad funktion. Trafikverket, å andra sidan, har goda förutsättningar för att ta en ledande roll i att finna och sprida framgångsrika arbetssätt inom detta område. I slutändan är det myndigheternas styrande organ som har ansvaret att instruera och följa upp förbättringar inom detta område, eftersom myndigheter inte sätter sina egna agendor.

Nyckelord: Offentlig upphandling, effektivitet i offentlig sektor, auktionsdesign, utvärderingsmodeller, uppdelning av kontrakt, transportinfrastruktur, kollektivtrafik.

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Ivan
Stockholm, August 2023

List of essays

Essay 1
Ridderstedt, I., & Nilsson, J. E. (2023). Economies of Scale versus the Costs of Bundling: Evidence from procurements of highway pavement replacement. *Transportation Research Part A: Policy and Practice, 173*, 103701.

Essay 2
Smith, A. S., Nilsson, J. E., Ridderstedt, I., & Johansson, O. (2023). Efficiency Measurement in the Tendering of Road Surface Renewal Contracts. *Journal of Productivity Analysis*, 1-14.

Essay 3
Ridderstedt, & Pyddoke, R. Evaluating Bids on Price and Quality: The impact on the performance of Swedish public bus services. Accepted for publication in *Journal of Transport Economics and Policy.*

Essay 4
Ridderstedt, I. The Wild West of Public Procurement: A review of award mechanisms used for Swedish public bus services. Not submitted.

Contents

1. Introduction

The study of how decision-makers can achieve the best possible outcome with limited resources has always been at the heart of economics, and a key determinant for our well-being throughout human history. Even in prehistoric societies, the allocation of members to various activities, such as hunting and gathering tasks, played a crucial role in determining living conditions and chances of survival. Later, with the agricultural revolution, societies gained an increasing ability to control not only how manpower was allocated but also the allocation of natural resources, in terms of how the available land was cultivated. Whereas the fundamental matter of survival likely exerted significant influence on the actions of early societies, the societal goals and concerns have become more diverse over time. Today, many societies consider outcomes such as equality, freedom, and environmental sustainability, when deciding on how their resources are to be allocated. Moreover, as the world has become more interconnected and with an accumulating knowledge about the long-term effects of actions made today, societies increasingly account for how their action affects the outcomes of others and future generations.[1] Even with economic growth, the resources available for achieving these outcomes do, however, remain limited.

This thesis deals with the issue of how public authorities can achieve the most, in terms of their often wide-ranging objectives, given their budget limitations. The scope is confined to public authorities that mainly provide their public services through procurement of external suppliers. Many public services are ultimately provided in this way, not least following the global wave of privatization during the late 20th century (Bortolotti and Faccio, 2009). Among OECD countries, public procurement amounts to about one-third of the total government expenditure (OECD, 2021). Hence, the public authorities' performance in allocating and using resources within the procurement format is important for the overall performance of the public sector. This issue can be particularly pressing with the current surge of inflation, eroding the budgets for public services if no or little extra funding is provided. Moreover, the demand for many public services changed during and following the Covid-19 pandemic. For the public procurers of these services, adjusting to this shift in demand while also fulfilling long-term contracts and commitments has exacerbated the current cost crisis.

The overall aim of this thesis is to contribute towards more efficient procurement policies in the public sector, thereby facilitating the provision of more and better public services with limited public funds. Correspondingly, the thesis comprises four empirical essays on the scope and ways for a public procurer to improve its costs and outcomes through the design and specification of the auctions and contracts. Based on new collections of micro-level contract data, these essays contribute novel and detailed insights into the effects of the following decisions: the choice and design of the award mechanism, whether and how multiple objects are procured and contracted separately or as larger bundles, and what activities and quantities are specified under given circumstances. All these decisions are present in most, if not all, procurements. While the findings and implications presented in this thesis are not perfectly

[1] Human history also provides many examples of societies prioritizing less altruistic outcomes, for instance stability for the ruling elite, ethnic homogeneity, negative impacts on other societies during and after conflicts.

generalizable to all kind of procurements, they do shed new light on the importance of the examined decisions and how a public procurer can approach them strategically.

The studied contracts are for road infrastructure work (highway pavement replacement) and public bus services, procured by the Swedish national Infrastructure Manager (IM) Trafikverket and the regional Public Transport Authorities (PTAs), respectively. The findings relate to a procurement framework that is common within the European Union, which is an important contribution since the literature is predominantly based on US data, particularly regarding public procurement of road infrastructure work. This thesis describes how the IM and the PTAs have experienced a period of considerable cost increases, beyond the general inflation-rate and the demand for traveling. Notably, the Covid-19 pandemic had a strong impact on the traveling on both the roads and railways, including the public transport ridership. For a sustainable use of public funds, it is important that these public agencies find ways to keep their costs down while upholding the level of public services they provide.

There are several terms for describing the relation between the outcomes achieved and the resources used. The term "value for money" is often used in the public sector when discussing this ratio, reflecting a view of the taxpayers. In this thesis, the more general term "efficiency" is preferred, as it allows for better comparisons and parallels with non-public organizations, and even beyond that. High efficiency implies that either a high output level and outcome is achieved with a given number of inputs (output-oriented efficiency), or that a given output level (and outcome) is achieved with few inputs (input-oriented efficiency). Several closely related concepts cover the steps between having a set of inputs and achieving certain outcomes, helping to distinguish between *doing things right* and *doing the right things*.

Figure 1 shows one way to informally define and separate the main sub-components of efficiency, which are often used interchangeably in everyday speech. Productivity is a term for how much of some intermediary output is achieved per input used, whereas effectiveness is a term for the extent to which an output contributes to the desired outcomes. The former captures *doing things right* and the latter captures *doing the right things*, and both are determinants of how much outcome is achieved per input, i.e., efficiency.

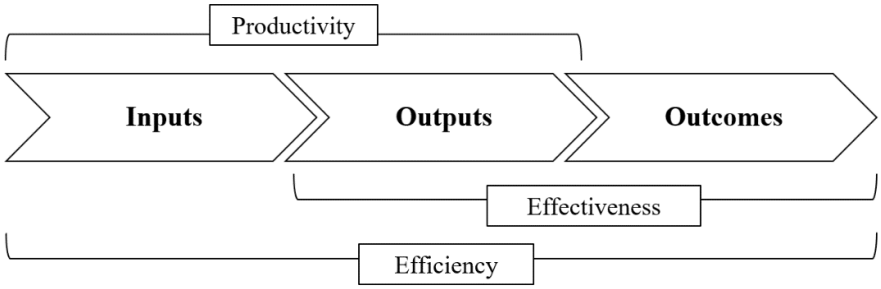

Figure 1. Definitions of efficiency and related concepts

In economic literature on efficiency, the standard case concerns a producer and issues like how much it produces (outputs) or profit (outcome) with its available labor and capital (inputs), and how well it sets the proportions of its inputs given the input prices (e.g., Coelli et al., 2005). In the case of a public procurer, the main issues are instead how much it can procure and achieve with the available budget, and how well it allocates its budget among the different outputs it

performs (public services), where the outputs contribute differently towards the desired outcomes. The scope of this thesis mainly corresponds the former of these issues, and more specifically on how a public procurer can minimize its payments once it has already decided what outputs to perform, through its skills as a procurer. By this, the focus is mainly on productivity and to what extent the public agencies are *doing things right* in the procurement phase.

The two essays on procurement of highway pavement replacement examine the scope and ways to reduce costs once the IM has decided what road segments are to be treated through the decision on how to bundle and specify the work. Similarly, the essays on procurements of public bus services examine the properties and effects of the PTAs' award mechanisms, which are determined once the main characteristics of the traffic assignments have been set. However, one key feature of the PTAs' award mechanism is that bids are evaluated based on both price and quality. In this case, the output is not completely fixed at the time of the procurement auction. Hence, the essays on this policy address how it can influence both the productivity and effectiveness of the procurers.

While it is not within the scope of this thesis to examine how efficiently public agencies (or their governing authorities) allocate their funds among different outputs, the essays contribute knowledge that is relevant also for this issue. This follows from the fact that the decisions on what outputs to prioritize, like which infrastructure projects to undertake or the departure frequencies of buses, are based on assessments of the costs and benefits of the different alternatives (e.g., Cost-Benefit Analyses). The accuracy of these assessments depends on the level of knowledge about cost structures and how output influences relevant outcomes. Micro-level analysis of historical procurements can be a valuable source of such knowledge.

This kappa summarizes and provides a general background to the four essays. The background includes descriptions of the examined public agencies and contracts, the general theoretical framework, and the methodological approach. Moreover, given that all essays are novel applications of micro-level efficiency analysis in research on public procurement, the kappa highlights insights gained regarding the merits and preconditions for this approach. This corresponds to the following complementary aim with the thesis: to facilitate informed decisions about whether and how to enable and conduct quantitative, micro-level efficiency assessments of procurement policies and entities. The inclusion of *whether* in this aim is to acknowledge the prevailing skepticism about what benefits can be achieved with this approach, apparent in both the public discourse and in some of my and colleagues' meetings with personnel at public agencies. Two reoccurring arguments are along the line of:

1. Every contract is unique in terms of both what is carried out and the preconditions.
2. The employees and managers already have relevant and in-depth experience and know-how for carrying out the procurement as well as possible.

I find that it is important to acknowledge these objections and not only preach to the already quantitatively oriented choir of economists. Hence, the kappa emphasizes how the quantitative methods applied in the essays handle the uniqueness of each contract and why even highly competent and experienced personnel may be biased in their assessment on the efficiency of policies and entities. Moreover, the kappa highlights the importance of a successful interplay between individual case-specific expertise and the use of quantitative methods.

A final note on the scope of this thesis is that it mainly considers public procurement in the format of competitive tendering, i.e., where a public agency procures services using an auction format. While procuring agencies may be allowed to use simpler, direct procedures to award contracts under some low threshold for contract value, competitive tendering is clearly the most common procurement mechanism within the European Union (Tender Electronic Daily, 2019). The empirical work presented in this study is based on cases of competitive tendering, however, most of the discussions on the role of data and statistical analysis should be relevant also to the less common variants, which may include additional stages of pre-selection, negotiation, and dialog.

The disposition of the thesis is as follows: Section 2 provides background information about the public agencies examined in the essays, including their objectives and the characteristics of what they procure. Section 3 describes the theoretical framework of the thesis, which mainly comprises auction and contract theory. Section 4 presents the quantitative micro-level methodology characterizing the empirical work in the thesis. This section covers both the prospects for collecting procurement data, based on the properties of the procurement format and the data collection for the essays, and the merits and limitations of quantitative methods for examining efficiency effects and levels. The essays are summarized in Section 5. Lastly, the conclusions are presented in Section 6, summarizing the thesis' contributions and suggestions on how to improve both the efficiency of public procurement and the preconditions for the quantitative micro-level analyses on these matters.

2. Background about the examined public agencies

2.1. The general objectives

When discussing the efficiency of an organization, it is natural to start by identifying their objectives and thereby the relevant outcomes. A lack of mutual understanding about these outcomes can lead to substantially different conclusions about what actions are efficient. For instance, the most efficient action in terms of one outcome may be inefficient when accounting for other relevant outcomes for that organization. What the relevant outcomes are varies with the type of organization. Owners of a public company are typically assumed to mainly consider profit maximization and increases in shareholder value, whereas a non-government (non-profit) organization may strive to maximize their impact on some particular issue. Regarding a public authority, its area of responsibility and instruction should indicate what outcomes are relevant to account for when discussing and analyzing efficiency.

Accessibility can be considered as *the* central outcome in transport, regardless of whether a public authority is responsible for transport infrastructure or public transport. Geurs and Wee (2004, p. 128) highlight four well-known definitions of accessibility, with reference to their origin:

- 'The potential of opportunities for interaction' (Hansen, 1959).
- 'The ease with which any land-use activity can be reached from a location using a particular transport system' (Dalvi and Martin, 1976).
- 'The freedom of individuals to decide whether or not to participate in different activities' (Burns, 1979)
- 'The benefits provided by a transportation/land use system' (Ben-Akiva and Lerman, 1979).

However, accessibility is typically only one of several factors covered by the objectives given to public authorities responsible for transport infrastructure or public transport. The additional objectives encompass a wide range of factors, including transport-specific concerns such as safety, comfort, and reliability, as well as broader societal goals such as environmental impact, distributional effects, and development of the supplier's market. Moreover, these objectives vary with respect to the level of government at which the public authority operates. Within one country, there are generally multiple public authorities responsible for the transport infrastructure, with either a national, regional, or local area of responsibility, and governed at the corresponding level.

In 2009, the Swedish parliament adopted a proposition outlining national transport policy goals (Gov. Bill 2008/09:93). These goals set out the long-term vision for the Swedish transport sector and wield significant influence over the public agencies responsible for transport infrastructure and public transport. The goals are:

- *The overall goal:* To ensure economically efficient and sustainable transport services for the general public and businesses throughout the country.
- *Functional goal:* The design, function, and use of the transport system should contribute to providing everyone with basic accessibility of good quality and usability, as well as contribute to the capacity for development throughout the country. The transport system should be gender-equal, meaning it should equally meet the transportation needs of women and men.
- *Consideration goal:* The design, function, and use of the transport system should be adapted to prevent any fatalities or serious injuries, contribute to achieving the overall environmental goal and environmental quality objectives, and promote increased health (Gov. Bill 2008/09:93; translated by the author).

2.2. Trafikverket

Two of the essays presented in this thesis examine the efficiency of procurements by the Swedish Transport Administration, Trafikverket, which is public agency. It was formed in 2010 following the merger of the previously separate authorities responsible for national road and railway network, and part of the Swedish Maritime Administration. Trafikverket is mainly financed by a yearly government grant (65.5% in 2022), or rather a set of grants ear-marked for

different areas within Trafikverket's responsibility. Additionally, it receives funds from loans, fees, and revenues from road, railway and maritime shipping user fees (Trafikverket, 2023). According to its instruction (SFS 2010:185), Trafikverket :

- is responsible for the long-term planning of the infrastructure for road and railway traffic, maritime shipping and aviation, and construction and operation of the state-owned roads and railways, using a comprehensive perspective across different transport modes;
- shall work towards fundamental accessibility in the inter-regional public transport;
- shall create conditions for an economically efficient, internationally competitive, and long-term sustainable transport system based on a perspective of societal development;;
- shall work to achieve the national transport policy goals (SFS 2010:185; translated by the author).

Table 1 shows how Trafikverket's budget for 2022, totaling about EUR 8.4 billion, was allocated among five broad categories of outputs, reflecting the breadth of its objectives. The majority of the budget is allocated to either investments (construction) or operation and maintenance. Within investments, 59% were for railway infrastructure, 40% for roads, and 1% for maritime and aviation projects. The budget for operation and maintenance was more evenly distributed between road (53%) and railway (47%). The third largest cost component is the handling of payments, which mainly consists of subsidies to private roads owners for maintaining and keeping their roads open for the public. In the fourth cost component, *expert support* refers to the provision of centralized support activities to the separate functions at Trafikverket responsible for carrying out and procuring the investment, operation, and maintenance work. The *exercise of authority* includes administering the Swedish driver tests and approving road and railway plans. The remaining categories encompass a range of services, including providing electricity and equipment to the railway operators, planning the transport system, deciding on investments and maintenance projects to undertake, administration, and financing research and innovation projects.

Table 1. The 2022 budget for Trafikverket by category. Exchange rate: EUR 1=SEK 10. Source: Trafikverket (2023).

Category	**EUR, million**	**Percent**
Investments	3 518	42%
Operation and maintenance	2 760	33%
Payments of subsidies and other supports	1 115	13%
Expert support and exercise of authority	300	4%
Commissioned services	300	4%
Planning	162	2%
Joint administration	142	2%
Research and innovation	72	1%
Sum	8 369	100%

While the allocation of Trafikverket's budget for 2022 is representative of its historical budgets, the level of the budget has increased considerably over time. Figure 2 shows the development of Trafikverket's budget, the Swedish construction-cost index, and the number of

vehicle kilometers on the Swedish roads and railway network between 2010 and 2022, using indices with 2010 as the base year (100). The budget for 2022 is 68% higher than that of 2010. Accounting for the 47% increase in the cost index, the budget has increased by about 20% in real terms. Over the same period, the number of vehicle kilometers on the roads and railways increased by 21% and 7%, respectively.

Overall, these developments suggest that the government and parliament have increased their ambitions within Trafikverket's area of responsibility in recent years, by more than compensating for inflation and the increase in traffic when considering both roads and railways. Possibly, one motivation for this is that the budget was decreasing in real terms during most of the proceeding period. However, as the public funds do not naturally increase in proportion to inflation, the current trend in Trafikverket's budget risks causing cannibalism on the budgets for other public services. This points to the importance of efficiency improvements, to handle (potential) maintenance and investment backlogs and to further increase the ambitions.

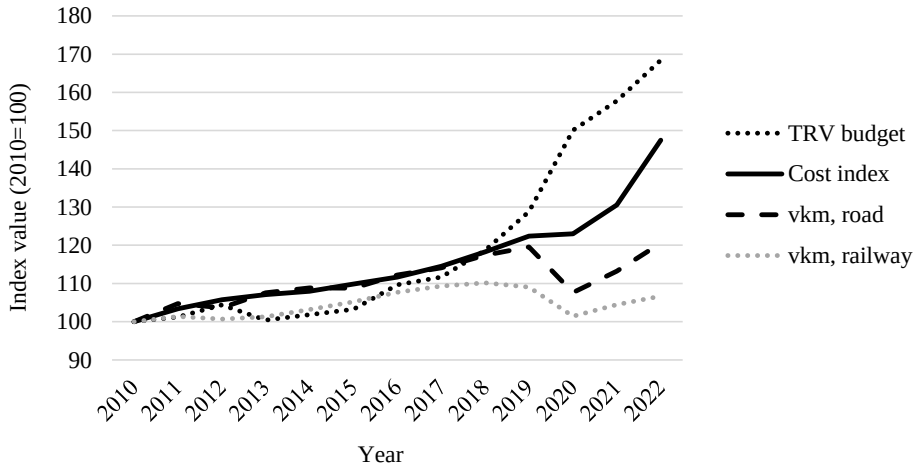

Figure 2. The development of Trafikverket's (TRV) budget level, the Swedish construction-cost index, and the vehicle kilometers (vkm) on Swedish roads and railway 2010-2022. Sources: Trafikverket (2013, 2016, 2018, 2021a, 2023), Statistiska Centralbyrån (2023), Trafikanalys (2023a)

It would be preferable to complement Figure 2 with some indications of how much and how well Trafikverket has performed over the period. However, in line with the motivations for the micro-level approach of this thesis, such aggregate measures risk being misleading by not accounting for important quality differences. This issue is amplified by the breadth of Trafikverket's responsibilities. Still, bearing this in mind, the development in some central outcomes can be mentioned. Between 2012 and 2022, the share of roads not meeting the set maintenance standard has been stable at about 3-5% for most road categories except for roads within the major cities (2% of the road network) and roads constituting larger corridors (18%). For these two categories, the share of roads that are not up to standard has increased to about 10% and 8%, respectively, between 2012 and 2022 (Trafikverket, 2023). Over about the same period, the yearly average punctuality of passenger trains has been stable at about 90-92%, with a high of 95% in 2020 during the pandemic, and the share of trains without disruptions has been

stable at about 99%. The yearly average number of deaths (excluding suicides) in road traffic accidents decreased from about 300 in 2010 to about 200 in the last couple of years (Trafikanalys, 2023c). In terms of sustainability, greenhouse gases emissions from the Swedish road traffic have decreased from approximately 19 to 13 million tons of CO2-equivalents between 2010 and 2022 (Trafikverket, 2023).

2.3. The regional public transport authorities

In Sweden, public transport is mainly the responsibility of the 21 regions and is organized either by regional departments or publicly owned companies. In this thesis, both the governing and organizing entity in a region are referred to as the regional Public Transport Authority (PTA), although this term formally only applies to the former[2]. These PTAs are the result of a reform in 2012 (SFS 2010:1065;), before which the municipalities were responsible for their public transport. The objectives of the PTAs are formulated in their regional Transport Supply Program (TSP), describing the regional needs and goals for public transport (SFS 2010:1065). When developing the provision programs, the PTAs are required to consult with neighboring regions, other relevant public authorities and organizations, public transport operators, representatives of the business sector, and travelers. This structure implies that the objectives of the PTAs are a negotiated distillation of the national transport policy objectives and the interests of many stakeholders. The organization and characteristics of this negotiation or collaboration process, including the influence of each stakeholder, varies between the PTAs (Davoudi and Johnson, 2022).

The goals set in the regional TSPs are rather cohesive, possibly as a result of the high level of collaboration between the stakeholders on the national level, or simply because of the similarities in the services provided. For instance, the PTAs in Skåne and Västra Götaland have their goals arranged under three similar themes:

- Development of the geographical accessibility; satisfied public transport users; and more of the region's inhabitants choosing public transport instead of other motorized means of transportation (Region Skåne, 2020).
- Good geographical accessibility (within and between all areas of the region); simple, safe and inclusive public transport; and low environmental impact (e.g., Västra Götalandregionen, 2021).

Until recently, the Swedish so-called 'Doubling Project' was highly influential for the goals set by the PTAs. This project was a collaborative effort by the public transport authorities, the regions and municipalities, and the suppliers. These stakeholders agreed on two goals: to double the public transport ridership between 2006 and 2020, and to double the market share of public transport between 2006 and 2030 (Swedish Doubling Project, 2009). Additionally, they established what was later termed the Partnership for Improved Public Transport (PIPT).[3] Under this collaboration format, the stakeholders have since developed and agreed on contract

[2] With this definition, which is used also in prior literature, (e.g.,Vigren, 2018; 2020), all the PTAs have the same responsibility and function. The differences in their organizational form are assumed to not be relevant for their preconditions as procurers.

[3] The partnership was initially termed Partnership for Doubled Public Transport

templates, guidelines, and standards for the procured transport services. While the stated intention was for this harmonization process to contribute towards the two doubling goals, it has likely contributed to reducing the transaction costs.

Figure 3 shows that the public transport ridership in Sweden increased by about 30 percent between 2010 and 2019, before the start of the Covid-19 pandemic in 2020. However, over the same period, the increase in the market share for public transport was only marginal, and the costs increased more than proportionally to the increase in ridership. It is worth noting that the customer satisfaction with public transport remained relatively constant over the period (Swedish Public Transport Association [SPTA], 2023a). These developments not only suggest that the goals of the doubling project were set unrealistically high but also indicate a possible deterioration of the PTAs' efficiency.

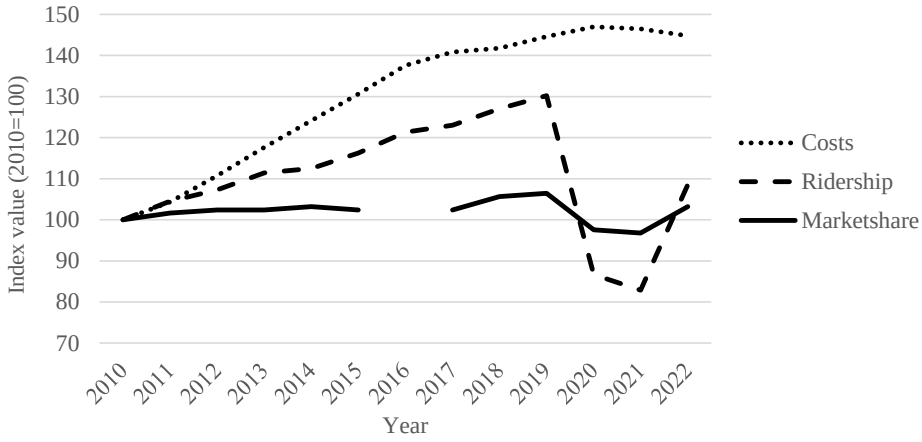

Figure 3. The ridership, market share, and costs of public transport 2010-20224. Indices with 2010 as the base year (100). The costs are adjusted for inflation. Sources: Swedish Public Transport Association (SPTA, 2023a), Trafikanalys (2017, 2023b).

In 2022, the key stakeholders in the Swedish public transport sector agreed on a new overarching goal termed 'The new start goal' (Nystartsmålet in Swedish), stating that four out of ten motorized trips are with public transport by 2030 (SPTA, 2023b). One reoccurring criticism of the doubling project, apart from efficiency concerns, was that the public transport ridership and market share could be increased by attracting inhabitants to choose public transport over walking or biking. This concern is addressed by focusing on motorized trips in the new overarching goal. As evident from the previously presented goals of the PTA in Skåne, set in a TSP from 2020, individual PTAs had already incorporated similar formulations for goals concerning their market share.

[4] The method for deriving the market share of public transport changed in 2010. Hence 2010 is used as the base year for Figure 2, although 2006 is the base year for the goals of the doubling project. The market share for 2016 is exluded due to missing data for some of the PTAs (SPTA, 2023).

2.4. Key similarities and differences between the examined procurements

Comparing the characteristics of the examined procurements carried out by Trafikverket and a PTA, there are both similarities and differences. Beginning with the latter, the examined procurements by Trafikverket are for highway pavement replacement work, which are typically procured in early spring and completed during the summer the same year. Furthermore, they are relatively small-scale (median contract value of EUR 0.9 million, see Essay 1) and standardized compared to, for example, a construction project. Therefore, these procurements are quite different from the bus service contracts, which usually have a length of 8 to 10 years and with a median contract value of about EUR 4 million per year (Vigren, 2018). Another key difference that follows by the duration of the contracts is that Trafikverket procures many pavement replacement contracts each year, whereas the PTAs can have several years between each round of procurement. Moreover, the sub-division at Trafikverket that handles the procurements of this work is benefitted by organizational know-how and centralized functions and systems within the larger organization; Trafikverket is Sweden's largest procurers in terms of frequency (about 600 per year) and only the region of Stockholm has larger payments to external suppliers (Upphandlingsmyndigheten, 2020).

While the characteristics of the examined type of contracts differ, there are some important similarities between Trafikverket and the PTAs as procuring organizations. Firstly, both the PTAs and the sub-divisions at Trafikverket specialize in specific kinds of procurements. With this specialization, they can be expected to have better knowledge about what they procure, including both cost drivers and which qualities that matter, compared to a public agency that procures a wide range of items but in relatively low volumes, like a municipality.[5] Secondly, both these public agencies are experienced procurers with accumulated knowledge from a large number of completed procurements. Thirdly, both their supplier markets are highly concentrated, with only a few large suppliers active across the country. On the median, Trafikverket's procurements of pavement replacement attract four bidders (see Essay 1), and the PTAs' procurements for the bus service three (Vigren, 2018). Lastly, transport-related issues tend to attract public interest and political involvement, regardless of the level of government. Hence, both Trafikverket and the PTAs may experience more outside influence regarding what and how they should procure compared to, for instance, public procurers of health care equipment and medicine, IT-systems, and support services.

[5] This motivates the use of framework agreements, where the main part of the procurement process is handled by a specialized and centralized public authority, like Kammarkollegiet in Sweden.

3. Auction and contract theory

The theoretical framework for this thesis primarily comprises auction and contract theory. These strands of economic theory provide insights about the incentive-structures created by how the auctions and contracts are designed and carried out, and how these incentives impact costs and the suppliers' performance. This framework reflects the scope of this thesis, indicating how a public procurer can improve its efficiency once it has already decided what to do; the issue of *doing things right.*

In essence, the theoretical starting point is that the bidders, and ultimately the winning bidder, seek to maximize their payoff given the incentives presented to them, both in the auction and during the contract. Based on this fundamental assumption, auction and contract theory derive bidding strategies and *ex post* performance of the winning bidder under various settings. With this perspective, understanding and managing the agents' incentives are key determinants for a public agency's performance as a procurer.

Auction theory is an application of game theory, treating the case of multiple bidders competing within a game formulated by the procurer. There are multiple kinds of auctions, such as open ascending ("English") auctions, open descending ("Dutch") auctions, sealed first price auctions, and sealed second price ("Vickery") auctions where the winner pays the second-best bid. For transparency and fairness reasons, public procurement is typically carried out in a sealed format, where each bidder prepares and submits its offer without information about other submitted bids. While the first price format is more straightforward as an award mechanism, the second price format has the theoretical benefit of incentivizing the bidders to bid no more (or less) than their true valuation of the auctioned object (Vickrey, 1961). Still, most public procurers appear to prefer sealed first price auctions over sealed second price auctions.[6] In standard applications of auction theory, the best outcome refers to revenue maximization, however, in the case of public procurement of government contracts the best outcome would typically refer to cost minimization or welfare maximization.

Assumptions about the following three characteristics are fundamental in the theoretical models of auctions and for their implications (Krishna, 2009):

1. The bidders' valuations: Whether they are independent (e.g., with different preferences), common (e.g., with common resale value) or a mix thereof.
2. Information: Whether information about, for instance, the auctioned item or the bidders' type is symmetrically or asymmetrically distributed.
3. Risk preference: Whether bidders are risk-averse o risk neutral (risk-seeking is seldom treated).

Nash's (1951) breakthrough work derived the existence of an (Nash) equilibrium behavior, i.e., a predictable outcome, in non-cooperative games, if each player attempts to maximize payoff given the best response of all rivals. Vickery (1961) was formative in applying these

[6] Until recently, the second price format was the standard choice of the giants of e-commerce and online display advertising (e.g., Amazon, Facebook, Google, eBay; Roth and Ockenfels, 2002; Despotakis et al., 2021), giving the impression that the public agencies were laggards in adopting a best practice. However, first price auctions have rapidly become the dominant approach for selling online display advertising, for reasons that are currently being researched, lessening that previously prevailing impression.

insights to explain bidding strategies in auctions. He modeled a case where the bidders have independent private values of the auctioned item, for instance due to their preference or cost structure, while the underlying value distribution is known to all. This model can be seen as the baseline model for bidding strategies in auction. It serves as the basis for continued theoretical work on similar auctions (e.g., Myerson, 1981; Riley and Samuelson, 1981) and a point of reference in work treating other cases, such as common value auctions (Wilson, 1977) and mixed value auctions (Milgrom and Weber, 1982).

In auction theory, the degree of competition is a key factor for the expected outcome. In simple terms, if bidders have independent valuations of the auctioned item, more competition is expected to increase the chance of some bidder having a particularly high valuation and decrease how much of a mark-up each bidder adds above their valuation. Both effects are, of course, good for the auctioneer, like a procuring public agency. If the valuation is instead the same but uncertain for all bidders, the winning bidder is the one most optimistic about the true valuation. This causes a risk of the so-called winner's curse, where the winning bid is less than the true value (Capen et al., 1971; Thaler, 1988). The risk and severity of this so-called winner's curse increases with more competition. Hence, for an auctioneer of a common-value item, more competition either provides better bids in the short-term but risks adverse consequences (e.g., the supplier defaulting or cutting corners), or worse bids if the bidders identify and account for the risk of the winner's curse (Bulow and Klemperer, 2002; Hong and Shum, 2002).

Since the 1980s, theoretical models of entry have been developed (e.g., Samuelson, 1985; McAfee and McMillan, 1987; Levin and Smith, 1994), which capture the case when bidders are not only concerned with what bid level to offer but also whether to submit a bid at all. This is a relevant assumption if there is a cost of preparing a bid. In previous models, the number of bidders was treated as an exogenous factor, which is reasonable for auctions where some given pool of bidders, like a group already gathered at an auction house, can submit bids reflecting their valuations at no cost. For an auctioneer, endogenous entry implies that the characteristics of what it procures, and how, impacts the degree of competition, as it affects the bidders' entry costs and their expected chances of winning. Several common characteristics of public procurement suggest that the bidders' cost of preparing a bid is significant, including the long terms and complexity of many public contracts, and use of rigid bid evaluations motivated by the transparency and fairness ideal for the public sector. This points at the importance of considering not only the bid levels but also the impact on competition assessing public procurement practices.

In contract theory, information asymmetry and incomplete contracts have been identified as two defining characteristics in contracting. Information asymmetry is when a principal and an agent, or multiple agents, have different information. Incomplete contracts refer to contracts having gaps and ambiguities, which is true for most real-world contracts due to, among other things, uncertainty about the future and the practical infeasibility of covering each conceivable eventuality in a contract. Correspondingly, these characteristics are defining also for public procurements. For instance, the public procurer typically has considerably less information about the production cost and the delivered quantities and quality (effort) than does the contractor. Similarly, the long-term and complex character of many publicly procured contracts implies a large degree of incomplete contracts.

Arrow (1963) coined the term *moral hazard* for individuals becoming more risk taking in response to having medical insurance[7]. Moral hazard has since developed into a more general concept, referring to the incentives for an agent to exert low effort when the effort is not known to the principal (e.g., Holmström, 1979; Grossman and Hart, 1983). The strength of these incentives decreases with the degree of observability and verifiability, where the former refers to the possibility to monitor the agent's actions and the latter to the possibility to confirm them, for instance in court. Still, effort cannot be perfectly monitored. Mirrlees (1999) and Holmström (1979) are important early contributions to the highly influential literature formally deriving optimal incentives schemes for an agent's unobservable effort. In essence, this literature suggests that the principal proposes an incentive scheme linked to outcome (observable) such that the agent is happy to choose the effort level desired by the principal, based on a symmetric belief about the distribution of outcome for a given level of effort (due to factors beyond their control). Related to government procurement auctions, this strand of the theoretical literature emphasizes the need of effective monitoring and well-designed incentives for the winning bidder to perform with high effort throughout the contract.

Whereas moral hazard arises from asymmetric information during a contract, adverse selection arises from asymmetric information when the contract is awarded. As a concept stemming from the literature on insurance, the standard case of adverse selection is that individuals with higher risk factors can be expected to be more likely to purchase a health insurance, leading to higher insurance premiums. Another famous example is how a seller of a used car has an information advantage regarding whether a car is truly "peach" (of high quality) or a "lemon", possibly decreasing the buyer's willingness to pay below the price of the peaches, leaving only the lemons being traded (Akerlof, 1978). Similar information asymmetries can be present also in procurement auctions. For instance, bidders may have private information about their type, for instance regarding cost efficiency, effort, ethics, or lawfulness, which may cause the procurement process to systematically favor a sub-optimal type.

Seminal work such as Grossman and Hart (1986), Hart and Moore (1990) and Hart (1995) established that in practice, almost all contracts are incomplete, due to the unfeasibly costly or simply impossible task of specifying for every possible contingency. This implies that most contracts have room for renegotiation, in which case bargaining power may be different compared to when the initial contract was written. In the case of public procurement, it is often costly to cancel a contract and redoing the procurement. Hence, the winning bidder can be expected to have an increased bargaining power, which may be used to set higher prices for additional work, adjust deadlines, reduce quality etc. Moreover, the extent to which contracts change *ex post* may exacerbate the issue of adverse selection discussed above, i.e., bidders winning procurements with a low bid but with private information or signals about ex post changes in the contract.

[7] Arrow (1963) also covers the closely related issue of information asymmetries between the insurance companies and the physicians, which could incentive more costly medical treatments.

4. Methodology

4.1. Data collection

4.1.1. The underutilized properties of the procurement format

The public procurement format offers significant opportunities for collecting and utilizing data. This is a beneficial consequence of the substantial rigidity and standardization in the procurement process, driven by the ideals of transparency and fairness in the use of public funds. First and foremost, the tendering documents published prior to the bidding phase are rich with information describing what the supplier is to perform and the policies used by the procurer. These policies include the choice and design of the requirements, incentives, and the award mechanism. A key point is that a public procuring entity is legally obligated to adhere to the stated rules and procedures. Hence, if a public procurer deviates from the tendering documents, parties such as the supplier, a losing bidder, or a competition authority may take the procurer to court. In short, the tendering documents are a valuable source of detailed and reliable information describing the contract and how it was procured. Corresponding information is not readily available for efficiency analysis of in-house production. Moreover, while the private sector also procures and publishes tendering documents, these are not always written to be legally binding.

Regarding data availability, a second beneficial aspect of the public procurement format is the high level of standardization in how one, or even multiple, procuring entities specify the tendering documents. In addition to contributing towards transparency, the heavy use of standards is likely the result of efforts to reduce the transaction costs (Williamson, 1979), both between the procurer and the suppliers and within the procuring organizations. These standards greatly enhance the prospects for accurately compiling information from different tendering documents into datasets covering multiple contracts.

While the public procurement format offers significant opportunities for compiling rich, micro-level datasets with observations on the procurement or contract level, there are currently several limiting factors for the extent to which these opportunities can be utilized. Three of these limiting factors can be highlighted as particularly important. Firstly, relevant information in the tendering documents is often not recoded as data points during the procurement process. Hence, the resource-demanding process of extracting data from many such documents has been a threshold for such endeavors.[8] Secondly, compiling data from the tendering documents requires that these are accessible. Thirdly, although the tendering documents are rich with valuable information, they do not contain information on the final outcomes of the procurement. As discussed in section 3, most or all contracts are incomplete, and the supplier may have incentives to not perform in accordance with the contracts. This points at the importance of so-called *ex post* data, describing what was ultimately performed and the final costs. The availability of such data is mainly determined by the procurer's systems and processes for monitoring these factors, which have generally been non-existent or rudimentary. Moreover,

[8] This process can likely be made much more efficient following the current advances in AI-technology.

also in cases when *ex post* data are available, it can be difficult to accurately match these with the *ex ante* data, due to the lack of common identifiers.

In Sweden, these issues about data availability and the possibility to follow up on contracts have been acknowledged and criticized in several official reports, with an emphasis on Trafikverket (e.g., Trafikverket, 2020, 2021b; Nilsson et al., 2021a; 2021b; Riksrevisionen, 2010; 2011; 2019; 2021). Correspondingly, Trafikanalys has been commissioned by the government to evaluate Trafikverket's work on cost control, with the aim of improving its procedures (Government Commission I2022/01644; I2021/01049). In this work, Trafikanalys has identified the management and use of information as one key area to evaluate (Trafikanalys, 2023d). This focus on Trafikverket does not imply that it is the worst-in-class but rather that Trafikverket is one of Sweden's largest procurers. These issues appear to be at least as pronounced within smaller and less specialized public agencies, like the municipalities.

In recent years, Trafikverket has initiated several improvements processes regarding the information management, including a new system for following up on contracts and establishing that invoices should include a reference to contracts (e.g., Trafikverket, 2020). While the outcomes of these measures have not yet been externally examined, there is a potential that Trafikverket instead ends up being a source of best practices and insights regarding management of procurement data. Arguably, this would be suitable given its leading position among the many Swedish public procurers.

4.1.2. The preparatory work for the essays

The general descriptions of the prospects for collecting micro-level contract data apply also for the cases examined in this thesis. Beginning with the beneficial opportunities, this thesis utilizes the tendering documents for information on how the examined procurement policies were implemented. The essay on bundling of highway pavement replacement work is facilitated by fact that the Bill of Quantities specifies the start and end point of each project (object) included in the contract, either in terms of the coordinates or by referring to a road intersection. Not only did this give information on the number of objects in one contract, but also facilitated obtaining information about the spread between the objects and the distances to the potential bidders (locations of their asphalt mixing plants). This was achieved by extracting the available coordinates and, for the remaining objects, finding the coordinates for the road intersections.

With information on the number of objects and the related spatial measures, combined with information about the number of tasks and total scale of the contracts, Trafikverket's design of these bundles could be captured in great detail. Moreover, with these coordinates, I could geomatch the contract data to Trafikverket's databases describing the characteristics and level of degradation of the treated road segments. These databases are rich with information at a highly granular level, particularly the road surface measurements which are observed at 20-meter road segments, for each lane of the road. As an example, this database contains about 400.000 yearly observations on such measurements only for the region of Dalarna. The detailed information is advantageous for micro-level analyses but complicates the matching process. Consequently, the process of matching our contract data set, with 1450 road replacement projects (tendered as 290 contracts), to road surface data for the whole of Sweden and multiple years, was one of my greatest but also most exciting challenges in my work with this thesis. I

would here also like acknowledge the great efforts by my former colleague Daniel Wikström, who aggregated the vast amounts of data to the contract level. Both the matching and aggregation processes pushed our software (ArcGIS and R) and computers to, and in many attempts beyond, their limits.

The two essays on procurements of public bus services, focusing on the choice, design, and effects of the award mechanism, are also based on information in the tendering documents. For these, I have manually extracted information from the tendering documents for 181 contracts awarded based on the evaluation of both price and quality, referred to as *scoring rules*. The extracted information includes the formulations of the quality criteria, the point scale, and the formula used for weighing together price and quality. The data set has since been expanded, for instance by counting the number of distinct quality criteria and their number of letters, and dummy variables capturing properties of the scoring formula. Ultimately, this data set provides a rich and reliable description of the implementation of this award mechanism.

The tendering documents for both the highway pavement replacement work and the public bus services mainly include quantitative rather than functional requirements. This implies that they specify in great detail what the winning bidder is to perform, i.e., the output of the contract. The essays on the highway pavement replacement work mainly utilize the so-called Bill of Quantities, which is a document (provided in Excel or PDF-format) specifying all the quantities and qualities of each task that are to be performed, using an industry-standard classification system. For essays 1 and 2, I manually compiled this information for about 300 contracts.[9] The resulting data set contains 1,400 variables on whether a classification code was referred to, the quantity, and the unit-price set by the winning bidder. Similarly, for one of the essays of public bus services, I have compiled information such as the vehicle kilometers, number of service lines, and number of stops on the traffic assignment level.

Regarding the accessibility of tendering documents, the essays presented in this thesis are based on almost the total population of these documents for the examined periods. However, this access to tendering documents was facilitated by the helpfulness of two key individuals rather than the public agencies having well-structured processes for archiving and handling of external requests. The Bill of Quantities for the highway pavement replacement contracts were provided by an already established contact at Trafikverket, namely Johanna Thorsenius, a senior officer at the sub-division for road reinvestments and maintenance. In addition to providing the necessary documents, Thorsenius made significant contributions by describing these procurements in more detail, including the motivations for why and how they bundle this work.

The tendering documents for the public bus service contracts were generously provided by my former colleague Andreas Vigren. In his PhD-thesis, Vigren (2017) describes how the process of collecting these tendering documents required considerable effort and endurance. In his request for these documents, for all contracts that were active at the time, Vigren referred to Sweden's principle of public access to official documents (SFS 1949:105). This principle states that such requests for public documents should be administered in a timely manner and

[9] Linking back to the prior footnote about technologies for increasing the efficiency of how data are collected from tendering documents, a former colleague (Oskar Johansson) later developed a script for automatically compiling the information from multiple Bill of Quantities. A great tool for future studies.

that a refusal to comply must be motivated with a reference to an applicable paragraph in the legislation. Still, only eight of the 21 PTAs complied to Vigren's request within two weeks, while five PTAs took at least 100 days and repeated requests to provide the documents. Once the documents were collected, Vigren compiled a rich and well-structured data set that led to several insightful papers (e.g., Vigren, 2018, 2020). This data set was also very useful for my thesis, providing a comprehensive list of the contracts and descriptive data, covering, among other things, the award mechanism used.

Finally, in line with the general limiting factors regarding the availability of procurement data, the present thesis highlights the current lack of *ex post* data. Ideally, the *ex ante* data describing the contract when it is awarded would have been complemented with data on what was ultimately performed and the final cost. Nilsson et al. (2021a; 2021b) describe how Trafikverket does not have systems that allows for such data on the contract level. The results on bundling are assumed to be robust to this, as this policy decision is not likely correlated with *ex post* changes in costs and quantities, whereas this issue warrants more discussion in the essay on the efficiency levels of different procuring entities. Conversely, one of the main contributions of the essay on the effects of a PTA's choice of award mechanism is that we retrieved *ex post* data on a relevant and reliable performance measure, namely punctuality. These data were not collected on the contract level but on the even more granular traffic assignment level. While the level of observation and reliable measures are advantageous, punctuality was only monitored by a small sub-sample of the PTAs' traffic assignments. As highlighted in the essay, this limits the statistical power of the analysis.

4.2. Quantitative methods for assessing efficiency

4.2.1. The efficiency of policy

The availability of data facilitates the application of quantitative methods for assessing the impact of a procurement policy on efficiency, each with its merits and limitations. A simple approach for a quantitative indication about the efficiency of a policy could be to compare the average costs and level of output, with and without the use of that policy. However, with such simple, macro-level measures, there is a risk that a found difference is not only, or not at all, caused by the policy. This issue is handled, to various extents, if instead the multiple points of observations are analyzed using inferential statistical methods. One simple method is a t-test, testing differences in the average while also accounting for the level of variation within each group. This allows for a standardized assessment of whether the found difference is generalizable to a larger population or due to chance, i.e., if the difference is statistically significant. However, this method does not account for potential correlation between the use of a policy and other factors, which can cause misleading inferences about the policy's impact.

In public procurement, outcomes such as the costs or the level of performance are influenced by numerous factors. These factors include the characteristics of the procured, the determinants of the suppliers' bidding and effort strategies, and the market conditions. Hence, when assessing the effect of a policy, it is important to account for other factors that may be correlated with both the use of that policy and the examined outcome variable. This is why the empirical work presented in this thesis is mainly based on multivariate regression methods. These methods are

used to estimate a best-fit model explaining a single outcome variable, such as the winning bid, using multiple explanatory variables, including those that capture whether and how a policy is implemented. The estimate of each explanatory variable is derived holding the other variables constant.

The use of multivariate regression analysis does not eliminate the common issues faced when applying statistical methods. Four such issues can be highlighted to emphasize that these methods are not a one-size-fits-all approach; instead, their effectiveness depends on appropriate preconditions and careful implementation. First, if the analyzed dataset does not include variables capturing all the factors which are correlated with both the policy variable(s) and the outcome variable, their effect will bias the estimate of the policy's effect (omitted variable bias) even if multivariate regression is used. Second, if the sample is not representative of the population, the estimates will be biased correspondingly (sample selection bias). Third, the functional form of the model specification is important. For instance, if a policy variable has non-linear and combined effects but the estimated model is only linear, these effects may bias the estimates of linear effects. Fourth, extreme observations (outliers) can exert disproportionate influence on how the regression model is fitted to the data.

As described in section 4.1.2, the compiled data sets are rich with information, offering good preconditions to mitigate bias from omitted variables. Regarding sample selection bias, the analyzed sample of road replacement work is almost complete for the examined years, which implies that selection bias is not an issue. Still, it should be noted that the inferences made are about a population including future contracts as well. Hence, selection bias could become an issue if policies and preconditions change over time, in ways that are not captured by the models. The multivariate regression on the performance effect of the choice of award mechanism in procurements of public bus service, is based on a more limited sample. While the sample covers most of the public bus services in and to the city of Gothenburg, inferences about the larger region or the entirety of Sweden could be affected by sample selection bias.

Regarding the functional form, the essays on pavement replacement estimate a model specified as a translog function, in which also nonlinear and combined effects of the explanatory variables are estimated. This allows for capturing more intricate patterns in the analyzed data, for instance if the effect of a policy varies depending on the circumstances. In the analysis of punctuality, the sample is too limited to specify such a complex and flexible model. Instead, the main model only includes first-order effects (except for weather). Possible interaction effects of the policy variable and the other explanatory variables are only examined in separate sensitivity analyses.

4.2.2. The efficiency of units

The efficiency of a unit, such as a procuring agency or one of its procurement teams, can be thought of as the net-efficiency of all its policy choices. A simple approach for quantitatively assessing the performance of decision-making units, like a public agency or its sub-units, is to calculate a single measure of how much of one output is performed per one input. Such measures, often termed key performance indicators (KPIs) are often used in the private sector, for instance revenue or profit per employee or return on assets. Corresponding KPIs are also used in the public sector, for example staff-to-patient ratios in healthcare or the graduation rates

in education. While the widespread use of simple KPIs is a testament of their usefulness, they are limited in capturing whether a unit is efficient. The main limitation is that such indicators collapse multidimensional problems into a ratio between only two selected components, ignoring other inputs, outputs, and outcomes, and, not the least, the preconditions. By this, multiple such indicators may send conflicting signals about the relative performance of units, and there is typically no established structure for deriving a single measure based on the importance of each indicator (Lovell, 2002).

Figure 3 illustrates an alternative approach where the performance of several units with the same objectives, in this case public procuring units, is evaluated in comparison to a technical or empirical production frontier, where the maximum output is produced for a given budget. The units at the frontier are defined as efficient and the inefficiency of the other units is captured by their distance to the frontier. This approach can be extended to multiple outputs and inputs. A technical production frontier is a theoretical construct assuming ideal conditions whereas an empirical production frontier is derived from actual observations. Each variant has its limitations. For instance, the technical frontier can be unattainable under real-world conditions whereas the empirical frontier can hide inefficiencies that are spread among all the observations.

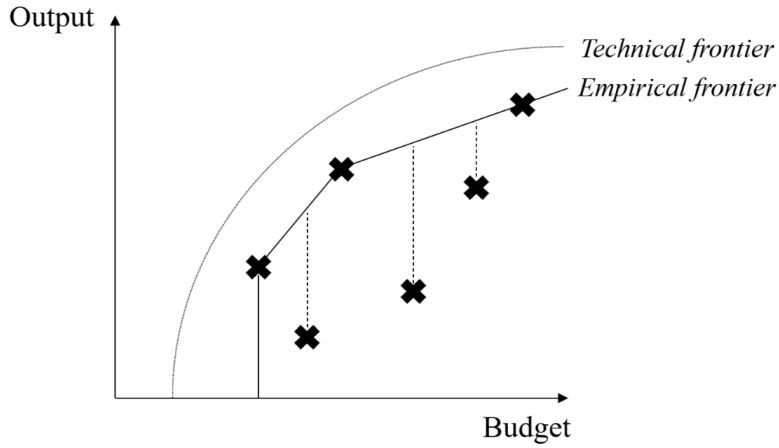

Figure 3. The production frontier. Cross mark: Public procuring units. Black line: Empirical production frontier. Gray line: Technical production frontier. Dotted line: Inefficiency measure.

The empirical production frontier can be derived using mathematical programming techniques[10] or estimated statistical methods, like multivariate regression described in section 4.2.1. One of the most common variants of the former approach is Data Envelopment Analysis (DEA), initially described in "Measuring the efficiency of decision-making units" by Charnes, Cooper and Rhodes (CCR; 1978)[11]. The following methodological development and

[10] Specifically linear programming, i.e., when a linear function is maximized or minimized when subject to a set of constraints.

[11] Building on work in the seminar article by Farrell (1957), as described in the "Origins of data envelopment analysis" by Førsund and Sarafoglou (2002).

dissemination of DEA have been rapid (see Seiford, 1997). With DEA, the full distance to the frontier is defined as inefficiency. In the original form of DEA (CCR), constant returns to scale were assumed, implying that the production frontier is linear from the origin and tangent to the most efficient observation, i.e., all units are assumed to be able to achieve the same ratio of output per input even at different scale of production. Later developments Banker, Charnes and Cooper (1984) extended the DEA (the BCC form) to allow for variable returns to scale, facilitating a production frontier like the one in Figure 3.

One of the most common variants for estimating a production frontier is Stochastic Frontier Analysis (SFA), proposed simultaneously by Aigner et al. (1997) and Meeusen and Van den Broeck (1977). In Essay 2, this method is used for estimating a (minimum) cost frontier. In contrast to DEA, SFA is based on regression analysis. This allows for the distance from the production frontier to consist of both an inefficiency term and a noise term, where the latter can capture random shocks influencing the realized ratio between the inputs and the output. By this, a temporary external shock improving the output for a given amount of inputs can be captured by the noise term rather than increasing the frontier to a level which is unattainable under normal preconditions. Similarly, negative shocks need not ruin the efficiency score of a unit. The noise term can also capture measurement errors. For estimating a stochastic frontier, assumptions must be made about the functional form of the production function, i.e., what parameters to estimate. Even if the functional form can be assumed to be flexible, for instance a translog function, DEA has an advantage of not imposing this restriction.

A key issue when measuring and comparing efficiency between units quantitatively is to what extent external factors are accounted for. A comparison of the efficiency of units bears little weight if the efficiency measure is mainly influenced by external factors over which the units cannot control. The impact of external factors influencing the output can be accounted for with DEA, but only by deriving the production frontier and the relative efficiencies for corresponding subsamples, i.e., by separating observations with different preconditions. Hence, DEA works best for comparing similar units under similar preconditions. SFA can be implemented using multivariate regression, with inclusion of control variables when estimating the association between the inputs and outputs. In this way, SFA can facilitate comparisons between units under different preconditions, as long as these preconditions can be captured by control variables. Similarly, with SFA, control variables can be included to account for qualitative differences in the inputs and outputs.

While there can be a value in solely identifying efficiency differences between public procuring units, it is generally preferable to also learn why some units outperform others. One way of examining this issue is to stepwise control for differences in how the units procure and assess how this impacts the differences in efficiency scores. A less structured approach, but one highlighted in the literature (Lovell, 2002), is that the units that are found to be inefficient simply learn from the units with best practice, possibly by studying or imitating their methods.

4.3. The interplay between case-specific expertise and quantitative insights

A quantitative analyst is seldom the most knowledgeable about the studied cases. When the quantitative analyst developed skills in quantitative methods, others developed skills and experiences about the mechanisms at work. Hence, the quantitative analyst is often dependent

on theory as well as others' expertise and practical experience to learn about the important case-specific matters. These matters include what issues are of interest, aspects that are important for the outcome, and the expected associations. However, if the quantitative analyst obtains adequate insights on these matters, a toolbox is available to contribute valuable knowledge that is difficult to gain by individual experience. Moreover, compared to individual judgement, quantitative analyses of observational data are less sensitive to cognitive bias when describing the state of the world and causal effects.

The notion of cognitive bias refers to peoples' systematic errors when responding to judgement and decisions problems. Tversky and Kahneman (e.g., 1974; 1996) made significant contributions on these issues, including presenting new evidence on how common heuristics misguide peoples' decisions in everyday situations. A rich literature on this subject has since defined and presented evidence for a broad catalogue of cognitive biases[12], including:

- Confirmation bias: Selectively searching for or interpret information confirming their preconceptions (e.g., Wason, 1960; Nickerson, 1998).
- Endowment effect: Demanding more to give up on something than to obtain it (loss aversion) (e.g., Thaler, 1980; Kahneman et al., 1990).
- Illusory correlation: Perceiving a correlation between unassociated variables (e.g., Chapman and Chapman, 1969; Mullen and Johnson, 1990).

Seemingly, such cognitive biases limit the prospects for the procurer (an individual or the organization as a whole) to accurately assess its efficiency and the effects of various implemented procurement practices. For instance, an individual carrying out procurements may tend to search for external rather than internal factors explaining bad outcomes, requiring more evidence for changing a current procurement policy than for implementing it, or perceive non-existent correlations between the outcome and certain procurement policies (or exogenous factors). These are, of course, *ad hoc* hypotheses about plausible tendencies in these individual judgments. How cognitive biases influence the perceptions and actions of procurers is a separate, and to my knowledge sparsely examined, topic of research.

It should be noted that cognitive bias can be expected to also influence decisions by a quantitative analyst. Common cognitive biases may influence what issues and associations are measured and examined and how the findings are interpreted. However, a key property for credible quantitative analysis is that the results should be replicable if another analyst applies the same method on the same data. Hence, even if the scope of the analysis and interpretations of the results may be influenced by cognitive bias, quantitative methods can contribute reliable results on the examined associations and levels.

[12] Whereas the replication crisis of social psychology (e.g., Ferguson and Heene, 2012; Loken and Gelman, 2017) may cause doubts about the existence and magnitude of some the less researched cognitive biases, there is plentiful evidence supporting the existence of the most famous ones.

5. Summaries of the essays

This thesis includes four empirical essays contributing novel insights about the efficiency of procurement policies and entities in the public sector. The examined cases are Swedish contracts for road infrastructure work and public bus service procured by the national infrastructure manager Trafikverket and the regional Public Transport Authorities (PTAs), respectively. All essays utilize micro-level contract data, which facilitates reliable, in-depth descriptions and analyses of how the examined procurement policies have been implemented and their effects, respectively. Moreover, the methodological approach offers reliable quantifications on how the outcome of analyzed procurements, and even the effects of the examined policy, are influenced by the preconditions. Each essay is summarized below.

5.1. Essay 1. Economies of scale versus the costs of bundling: Evidence from procurements of highway pavement replacement

While most, if not all, public procurements involve decisions about whether to acquire a set of goods or services separately or bundled as one single contract, there are only a few empirical studies providing guidance for efficient policy on this matter. Hence, the aim of the study is to identify favorable preconditions and strategies for bundling, that could improve the procurer's cost efficiency. In pursuit of this aim, we examine the existence and magnitude of multiple potential costs and competition effects associated with the bundling decision, and subsequently assess the net-cost effect under various circumstances.

The examined case is procurements of highway pavement replacement by the Swedish national Infrastructure Manager (IM) Trafikverket, which frequently but to varying extents involve bundling of geographically spread objects. One contribution of this essay is that it provides empirical findings from Europe and the harmonized procurement framework of the European Union. Prior research about bundling in similar procurements is not only scarce but also mainly confined to data from one US state. A rich set of micro-level data was collected comprising 290 contracts, which represent most of the population of contracts for this kind of work during the period 2012-2015. Their total contract value is about EUR 350 million.

The analysis is conducted in three steps. First, a translog cost function of the procurer[13] is estimated using Ordinary Least Squares, to test hypotheses on the separate (both linear and non-linear) and combined effects of:

- The number of bundled objects
- The area of replaced road pavement (the scale).
- The spread between the bundled objects.
- The number of different tasks in a contract.
- The transportation distances of the potential bidders.
- The number of bidders.

[13] The winning bid is used as a proxy for the procuring entity's costs, which thereby comprise both the supplier's production costs and mark-up on the bid. The procurer's internal costs and latter changes in the payments are not accounted for, due to data availability.

The results show that bundling influences the procurer's costs in multiple and counteracting ways. On the one hand, we find that the economies of scale are of significant magnitude. These economies of scale are not influenced by the number of bundled objects or different tasks, or the distances between the objects or for the potential bidders. On the other hand, the number of objects bundled into a contract is found to increase the procurement cost at an increasing rate. Moreover, the number of different tasks, which increases if the bundled work is not perfectly similar, is found to increase the procurer's cost. Increasing the transportation distances of the potential bidders is found to increase both the cost directly and the cost effect of adding additional objects to a bundle. Similarly, an increase in the number of bidders is found to decrease the cost directly, while also reducing the cost increase of bundling more objects. The geographical spread between the objects is not found to influence the procurer's cost.

The second step of the analysis helps to grasp the net-effect of these many cost effects by predicting the procurer's cost under various assumptions about the examined characteristics. Eight cases are constructed, including a baseline with an average number of objects, tasks, and transportation distances for the potential suppliers. The remaining cases represent procurements where adding one additional object to the bundle increases either or both the number of tasks and the transportation distances moderately or strongly. If the additional object only moderately increases either of these two characteristics, the benefit from economies of scale dominates, particularly if the total scale is below average. However, if adding an additional object strongly impacts the number of tasks or the transportation distance, or both, the associated increase in scale must be substantial for bundling to have an advantageous net-effect.

The third step of the analysis is estimating the potential bidders' probability to submit a bid. The findings suggest that neither the scale nor the number of objects or tasks influences this decision. However, the probability to submit a bid is found to decrease with the spread between the objects in a bundle and, particularly, the transportation distance. The latter effect is determined by the transportation distances of its rival, in line with prior research about similar markets.

While the essay offers many in-depth insights about many associations that can help guide policy on the bundling decision, the main implications can be summarized as follows: Bundling policies on highway pavement replacement should emphasize proximity and similarity rather than the scale of the objects. The Swedish IM's current bundling policy is found to be in line with these implications. However, the findings suggest that most of its contracts are still inefficiently sized. In relation to the recent U.S. policies promoting bundling of road-related work, this essay suggests that their focus is too narrow on small-scale work. Moreover, the findings suggest that is motivated that the scope for efficient bundling is accounted for when an infrastructure manager decides on the timing of this kind of measures. It may be worthwhile to replace pavements at a lesser state of degradation to have more similar and nearby work carried out during the same year.

5.2. Essay 2. Efficiency measurement in the tendering of road surface renewal contracts

The productivity growth of road construction and the wider construction industry has been poor relative to other industries. This may seem surprising given that much of such work is procured using formats aimed to induce competition between potential contractors. Not only should this competition limit the inefficiencies among the contractors, but also incentivize gradual efficiency improvements within the industry. Possibly, part of the explanation of the poor productivity growth lies in a lack of improvement in how public agencies and other clients specifies the contracts.

Against this background, this essay examines the cost efficiency of how Trafikverket procure road replacement work (termed road surface renewal in this essay). Using micro-level data describing 233 such contracts[14], we estimate the relative efficiency of the 24 individual engineers specifying what tasks and quantities the winning contractor is to undertake. The essay is novel in examining micro-level client-side efficiency, which is facilitated by the relatively rich micro-level dataset. Compared to analyzing aggregate measures for a larger organizational entity, this approach improves the possibility to account for preconditions and random variation. Moreover, the benchmark for the efficiency assessment comprises the best practices that are already employed within the same organizational entity. In an efficiency assessment based on macro-level data for multiple organizational entities, it is more difficult to adequately control for differences in preconditions and to construct a benchmark that is truly relevant to all.

The essay shows how the method of Stochastic Frontier Analysis (SFA) facilitates efficiency analyses that account for exogenously given differences between the analyzed cases and random variation. First, a procurement cost (winning bid) function is estimated using Ordinary Least Squares, with explanatory variables capturing the size of the pavement replacement area, the characteristics of the road (speed and traffic volume), the road quality before the treatment (track depth and surface roughness), the supplier's market (number of potential bidders and transportation distance), and regional differences. A flexible translog specification is used, implying that also the potential quadratic and combined effects of these preconditions are controlled for. Second, either by the inclusion of a dummy variable for each engineer (fixed effects) in the prior step, or by averaging the unexplained costs for each engineer (random effects), an individual cost effect is derived. Third, individual efficiency scores, ranging between 0 and 1, are derived by comparing each engineer to the most efficient engineer, who represents the cost frontier.

Since we assume that the procurement format eliminates most of the inefficiencies among the contractors, the efficiency differences are attributed to how the engineers have specified the procurement work. The mean efficiency is about 0.8, suggesting that 20% could be saved if all engineers adapted the best-practice of the most efficient engineer. Given that Trafikverket spends about EUR 200 million per year on pavement renewal, a 20% improvement in cost

[14] This is a sub-sample of the contracts examined in Essay 1. For 57 of the observations in the contract data set, we could not achieve a reliable matching to Trafikverket's databases with road characteristics and surface measurements.

efficiency corresponds to freeing up about EUR 40 million per year that could be used for more pavement replacement work or be reallocated to other uses. However, as underlined in the essay, we consider these to be preliminary estimates of the potential savings. One important limitation of the study is that we could not retrieve data on the final payment, which typically deviate considerably from the winning bid. While the analysis of relative efficiency is robust to this issue if the propensity and magnitude of cost changes are not systematically different among the individuals, the lack of data on final costs restricts us from making firm conclusions about the efficiency levels. Still, the findings indicate that there is a considerable scope for improving the client-side efficiency, motivating further research to uncover what the best practices are.

5.3. Essay 3. Evaluating bids on price and quality: The impact on the performance of Swedish public bus services

There seems to be a prevailing perception among the public that contracts for their public services are awarded solely based on price, overlooking the importance of quality and value for money. However, for some period, it has been common practice that public contracts are awarded to the bidder offering the best combination of price and one or multiple qualities. In the EU, the public directive from 2014 promotes such multi-criteria bid evaluation, which is already the default choice in many member states. This EU policy is in line with theoretical literature on auctions, which shows that this award mechanism dominates lowest price (and quality only) under standard assumptions. However, very few empirical studies have examined the realized effects of multi-criteria bid evaluation in public procurement.

The aim of this essay is to contribute empirical findings on the effectiveness of multi-criteria bid evaluation. We use the term “scoring rules” for award mechanisms of this kind, referring to the mathematical formula required for weighing together price and quality into a single rankable score. The essay examines the impact of using scoring rules rather than lowest price in procurements of public bus services. The empirical strategy utilizes two favorable preconditions provided by the actions of one Swedish regional Public Transport Authority (PTA). First, while most other Swedish PTAs used either lowest price or scoring rules, this PTA alternated between the two over an extended period. Second, unlike most of the PTAs, this PTA has and can share punctuality data. These preconditions enabled a micro-level analysis of how scoring rules impacted a relevant and observable outcome variable, with detailed controls for other potentially covarying factors.

The examined implementations of scoring rules are with quality criteria linked to the organizational quality of bus operators, similar to variants used also by other Swedish PTAs. The bidders submit written answers to several (13-22) questions about how they will organize and manage the traffic assignment, with a focus on internal processes. Each answer is graded by an evaluation team, based on the grading criteria outlined in the tendering documents. These implementations of scoring rules can be contrasted with variants involving more easily observable quality criteria, like technical characteristics of the offered vehicle fleet or stated levels of (measurable) performance. The PTA’s stated aim with the use of scoring rule is to select the most suitable operator and points at effectiveness rather than overall efficiency. This

motivates the essay's focus on the achieved quality effect, although the efficiency effect is also treated and discussed to some extent.

Using a panel structure with 30 observations on the mean monthly punctuality for each traffic assignment, from July 2016 to December 2018, we estimate the association between the use of scoring rules and punctuality. Micro-level data extracted from the tendering documents and the PTAs databases facilitates that important characteristics about the traffic assignments are controlled for, including the number of passengers, whether the traffic is for a city service area or an express route, the number of routes, the average number of stops per route, and the bus operator's prior experience of performing that traffic assignment. Monthly data on temperature and precipitation are also utilized but vary only over time as all traffic assignments are within the same area. Whereas several of these contextual factors are found to significantly influence punctuality, the estimated effect of scoring rules is not statistically significant in either of the main models.

The findings suggest that the use of scoring rules did not improve the performance of the bus operators, despite the PTA's efforts in formulating complex scoring rules and quality criteria, evaluating offers, and incentivizing performance throughout the contract. Conversely, the findings suggest that the PTA could attain equally good performance when using the simpler lowest price approach. These results are contrary to what is found in the prior empirical studies on the effects of scoring rules. In addition to noting that this empirical literature only covers a few and very different kinds of procurements, we discuss that the examined variant of the scoring rule award mechanism has properties that may limit its influence. These properties include the use of many quality criteria with limited observability, requiring complex and subjective bid evaluation processes. This is found to present issues regarding the weight of the incentives linked to each quality criteria and the prospects to deter moral hazard. Overall, we conclude that the knowledge about the effects of scoring rules, and how these vary with how scoring rules are implemented and the circumstances, is still very limited. The current use and promotion of this award mechanism mainly appear to reflect their theoretical merits.

5.4. Essay 4. The wild west of public procurement: A review of award mechanisms used for Swedish public bus services

Although it has become a common and promoted policy to award public contracts to the best combination of price and quality rather than lowest price, there is little empirical research examining how well public agencies implement this policy. The few prior studies on this subject indicate that there are large variations in what kind of quality criteria are used and how price and quality are weighted together. In many cases, the implementations have unsound and likely unintended properties that can be expected to worsen the outcome of procurements in terms of both costs and quality.

This essay examines whether and how Sweden's Public Transport Authorities (PTAs) have used an awarded mechanism with evaluation of both price and quality, using a sample of 560 contracts for public bus services. These contracts were tendered between 2006 and 2015, with a typical duration of eight to ten years. As in Essay 3, we use the term 'scoring rules' for award mechanisms with evaluation of both price and quality. The research question is: How consistent are the PTAs' use and design of scoring rules with economic theory and principles on the

attributes of well-functioning scoring rules? Based on hypotheses reflecting the theoretical merits of scoring rules, contract theory, and general economic principles, the following aspects are reviewed:

- The consistency of whether and how different PTAs implemented scoring rules.
- The mathematical formulations of the scoring rules.
- The development of how the PTAs implemented scoring rules over time.
- The number of quality criteria.
- The kind of quality criteria.

Even though the PTAs are similar and mature procuring organizations, and the procured service and the supplier's markets are very similar, the review shows a strong discrepancy in the PTAs' use and implementations of scoring rules. Moreover, many of the implementations are not consistent with the attributes characterizing well-functioning scoring rules. While some 'worst practices' were phased out over the examined period, like the scoring of price based on the lowest bid rather than a stable valuation of money, the findings suggests that best practices were not effectively disseminated among the PTAs. These findings strengthen the prevailing impression given by prior research on these matters, namely that policies on the use of scoring rules are developed in what can be characterized as the Wild West of public procurement, with public agencies acting independently rather than within a framework of centralized regulation and guidance. Seemingly, the resulting implementations are too diverse to perform equally well, suggesting that there is scope for improving the efficiency of public procurement by disseminating the best practices regarding the choice and design of the award mechanism.

6. Conclusions

The overall aim of this thesis is to contribute towards more efficient procurement policies and entities in the public sector, thereby facilitating the provision of more and better public services with limited public funds. The focus is on how a public agency influences its efficiency by the way it designs the auction and the contract – that is, once it has already decided on what to procure. While a well-established theoretical literature provides valuable insights into these mechanisms, empirical research on the way public agencies procure and the effects of these decisions is still limited and fragmented.

The thesis comprises four essays contributing new insights on these matters based on micro-level data on contracts for road work projects and public bus services. Three of the essays analyze such data using statistical methods. By this, the essays contribute novel insights on not only their specific topic but also the motivations and preconditions for analyzing public procurement issues using this quantitative micro-level approach. Whereas each essay is mainly focused on the contributions within its topic, this kappa emphasizes and expands on the insights gained about whether and how public agencies should enable and conduct quantitative micro-level efficiency analyses of their procurement policies and entities.

Two of the essays provide novel contributions and implications on how a public infrastructure manager can improve its efficiency in procurements of road pavement replacement after the selection of projects has already been made, and the potential savings (freed-up resources) that can be achieved in this phase. The other two essays provide new insights about how the use of the currently promoted scoring rule award mechanism can influence the outcome in procurements of public bus services, and the scope for improving how different public procurers of these services implement this policy. Overall, the findings presented on these issues show considerable potential for improving the efficiency of procuring public agencies, i.e., how much they deliver towards their objectives for a given budget, through how they design and specify their auctions and contracts.

Based on the essays, the kappa highlights the merits of compiling and assessing micro-level data from public procurements. Firstly, such data allow for detailed and reliable descriptions of how public agencies procure, which can be related to case-specific expertise and theory on best practices. Deviations between these can indicate potential for significant efficiency improvements. Secondly, micro-level data for multiple contracts allow for effective applications of statistical methods, including multivariate regression analysis. These methods provide for standardized and reliable assessments of systematic differences in efficiency, while accounting for important characteristics of each case and random variation. Conversely, the kappa discusses how cognitive biases can be expected to influence the reliability of an individual's perceptions about the efficiency of a policy or a unit, even if the individual is highly skilled and experienced. However, the kappa also underlines the importance of a successful interplay between a quantitative analyst and individuals with case-specific expertise.

The scope for future studies is closely related to how public agencies handle their tendering documents and data. On the one hand, the kappa and the essays point at properties of the procurement process and the contracts that go hand-in-hand with quantitative micro-level analysis. These properties include the standardized and detailed ways of specifying contracts and the transparent and reliable information provided in the tendering documents. On the other

hand, the thesis points out several issues regarding data availability, limiting the current prospects for such analyses. A systematic collection and management of micro-level contract data is typically not carried out even though it can be beneficial for the ongoing management and organizational learning of the public agencies. This implies that there is great potential for contributing novel and valuable insights about the efficiency effects of how the auctions and contracts are designed if new such data sets are constructed.

This thesis stresses the importance of public agencies having well-structured archiving of the tendering documents. Moreover, it suggests that it is well-motivated, and even warranted, that public agencies actively participate in improving how important data about each procurement are accumulated and managed. One pressing issue is the lack of both *ex post* information (the final quantities, qualities, and costs) and common identifiers that facilitate accurate matching of information from different sources. Development within this area is completely dependent on the public agencies internal systems and processes.

The efforts and skills of public agencies in developing the handling of procurement data are likely to be strengthened if they possess their own capacity for micro-level analysis, utilizing such data for on-going management and organizational learning. For small public agencies, such as local authorities, it seems reasonable that these developments and functions are greatly assisted or even performed by some larger, centralized agency. Trafikverket, on the other hand, should be able to take a leading role in this finding and disseminating best practices within this area, as they are one of Sweden's largest procurers. Since the public agencies do not set their own agenda, the responsibility for instructing and incentivizing the developments ultimately lies with their governing body.

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