

Public Procurement: Award Mechanisms and Implementation Process

by

Chusu He

A Doctoral Thesis

Submitted in partial fulfilment of the requirements

for the award of

Doctor of Philosophy of Loughborough University

19 July 2018

© by Chusu He (2018)

To my parents

Thank you for your unconditional love and sacrifice

I will spend my lifetime to protect you

Abstract

This thesis investigates the choice of award mechanism and the process of implementing the award of contracts in public procurement. Public procurement is an activity conducted by the public sector to purchase goods and services. Government spending on public procurement accounts for 10% to 25% of GDP in each country ([World Bank Group, 2017](#)).

Because of its large sharing in government expenditure, public procurement can shed light on important practical policy issues, including those as investigated here: the choice of award mechanism (i.e. the process for selecting contractors); the possibility of costly delays in awarding contracts; and the concern that corruption may lead to inefficient outcomes.

This thesis uses public procurement data for the UK and other EU countries plus Iceland and Norway. These countries adopt the same benchmark award mechanisms (the EU benchmark award mechanisms). The EU benchmark award mechanisms are implementations of the award mechanisms defined by the World Trade Organisation (WTO) Agreement on Government Procurement (GPA), which influences the award mechanism arrangement in 88 countries. There are four EU benchmark award mechanisms: the open procedure, the restricted procedure, the negotiated procedure and the competitive dialogue. Few empirical studies have investigated these EU benchmark award mechanisms.

This thesis contains three independent and interrelated studies. The first study examines the choice of award mechanism in the UK, using the logit model. The results show that UK public buyers choose award mechanisms that are consistent with the theoretical suggestions. When a contract is complex, a UK public buyer is likely to employ an award mechanism that allows for greater discretion of selection. It also provides evidence that public buyer's experience is an important factor in award mechanism choice.

Also based on UK data, the second study compares the decision speed of awarding a contract, using the logit model and survival analysis. It uncovers that delay in contract award is a serious issue for public procurement, as almost half of the contracts in our sample experienced delays in contract awards. The empirical results show that the negotiated procedure (which contains negotiations) is likely to be associated with a more rapid decision speed and a lower probability of delay than the restricted procedure (which does not contain negotiations). Therefore, this study casts doubt on the general expectation of practitioners that negotiation causes delays.

The third study explores the relationship between discretion, corruption and competition in public procurement. Based on the revenue equivalence theorem and extensive form game, it proposes a game theory model showing that discretion fosters corruption, which in turn depresses the number of bidders and softens price competition. This is a mechanism that the procurement literature agrees but few formal models exist. The OLS estimates show a negative correlation between corruption and the number of bidders and suggest that procuring agents may disguise the impact of corruption by inflating the estimated contract value.

Keywords: Public Procurement; Award Mechanism; Auction; Negotiation; Delay; Discretion; Corruption.

Acknowledgements

When I decided to dedicate myself to the field of finance and economics, I knew it would be a tough journey because I do not hold a first degree in this field. I am very grateful to many people who have believed and helped me to accomplish this transformation.

I would like to express my deepest gratitude to my supervisors Prof. Alistair Milne, Prof. Ali Ataullah and Prof. Huainan Zhao for their precious time, kind guidance, insightful comments, social supports and tolerance. Prof. Milne walked me through my MSc and PhD. I enjoyed taking up much of his office hour to consult him in my year of MSc. He commented on my thesis in great detail and devoted a substantial amount of time to improving my academic writing style. He always patiently and exhaustively answered my questions. Prof. Ataullah trained me to be a qualified researcher by gently pinpointing my problems, introducing high-quality references in econometrics and game theory to me and “forcing” me to learn R and LaTeX, which reveal a completely new world to me. He also cared about my physical and emotional well-being. Prof. Zhao made me deeply realise the shortcomings in my thesis by sternly pointing them out and gave me great career advice. I feel so warm whenever I recall scenes like these. Moreover, I gained wonderful experience of teaching post- and under-graduates from opportunities provided by Prof. Milne and Prof. Ataullah.

I am very grateful to my external examiner Prof. Stephen Thompson from the University of Nottingham and my internal examiner Dr Karligash Glass for their informative comments and the enjoyable conversation during my viva. I am greatly honoured for their decision to recommend me pass with no corrections required.

I am heavily indebted to Dr Lawrence Leger, my teacher and personal tutor who patiently and exhaustively answered my academic and career questions during my MSc. He recommended me in my PhD application and kindly proofread this thesis with very constructive suggestions.

My sincere thanks goes to Dr Simeon Coleman (my internal reviewer) who carefully examined my progress annually, to Mr Jáchym Hercher from the European Commission without whom I could not have understood my data so thoroughly, to Dr Seyoung Park who generously helped me with my models and arranged a job interview for me, to Dr Adrian Gourlay who kindly wrote me a reference letter for my PhD application, and to Prof. Yukun Zhang who encouraged and helped me a lot since I was an undergraduate.

I would also like to sincerely thank Dr Kavita Sirichand, Prof. David Llewellyn, Prof. Andrew Vivian, Dr Hang Le, Ms Tracey Preston, Ms Aly Howells-Chivers, Mrs Chunlin He and Mr Xiaozhi Hu for their support and encouragement.

Finally, I would like to give a big thank you to my beloved School of Business and Economics and Loughborough University for funding this research and the excellent student experience.

Contents

- Abstract** **i**

- Acknowledgements** **iii**

- List of Tables** **ix**

- List of Figures** **xi**

- 1 Introduction** **1**
 - 1.1 Introduction 1
 - 1.2 Motivation and Contribution of the Thesis 2
 - 1.3 Structure of the Thesis 4

- 2 Overview of Public Procurement and Public Procurement Data** **6**
 - 2.1 Introduction 6
 - 2.2 Award Mechanism Classification in Practice 7
 - 2.2.1 Award Mechanisms for EU Public Procurement 8
 - 2.2.2 Award Mechanisms in Non-EU Countries 9
 - 2.3 Timeline for Public Procurement 10
 - 2.4 Public Procurement Data 12
 - 2.4.1 Data Structure 13
 - 2.4.2 Data Description 16
 - 2.5 Conclusions 22

- Appendix A: Top 20 Most Popular Words in Award Criteria 24

- Appendix B: Methods for Adjusting (Estimated) Contract Values 26

3	Theories in Public Procurement	28
3.1	Introduction	28
3.2	Contract Design	29
3.2.1	Cost-reimbursement Rules	30
3.2.2	PPPs versus Traditional Procurement	31
3.3	A Typology of Award Mechanism Design	33
3.3.1	Award Mechanism Classification in Theory	35
3.3.2	Discrepancies in Theoretical and Practical Classifications	38
3.4	Award Mechanism Design	42
3.4.1	Popular Discussions since the Early Literature	42
3.4.2	More Recent Development	49
3.4.3	Considerations on Corruption and Collusion	52
3.5	Conclusions	54
4	Study 1: Choice of Award Mechanism in UK Public Procurement	55
4.1	Introduction	55
4.2	Relevant Literature	57
4.2.1	Theoretical Framework	58
4.2.2	Empirical Studies	60
4.3	Data	61
4.3.1	Data Source	61
4.3.2	Data Description	63
4.4	Methodology	71
4.4.1	Dichotomous Logit Model	72
4.4.2	Multinomial Logit Model	74
4.4.3	The IIA Assumption	75

4.4.4	Nested Logit Model	76
4.5	General Problems of the Models	78
4.5.1	Endogeneity	79
4.5.2	Multicollinearity	85
4.6	Results	86
4.6.1	Open Procedure versus Restricted Procedure	86
4.6.2	Auctions versus Negotiations	87
4.7	Conclusions	92
	Appendix: Results from the Nested Logit Regressions	95
5	Study 2: Award Mechanism and Decision Speed in Public Procurement	98
5.1	Introduction	98
5.2	Significance and Determinants of Decision Speed	100
5.2.1	Significance of Decision Speed	103
5.2.2	Environmental Factor: Level of Competition	105
5.2.3	Organisational Factor: Authority Experience	106
5.2.4	Organisational Factor: “On Behalf” Purchase	106
5.2.5	Organisational Factor: Authority Type	107
5.2.6	Decision-Specific Factor: Complexity and Quality Concerns	109
5.3	Hypotheses and Data	109
5.3.1	Hypotheses about Award Mechanism	110
5.3.2	Descriptive Statistics of Decision Speed	111
5.3.3	Kaplan-Meier Curve	117
5.3.4	Variable Definition	118
5.4	Estimation Methodology	124
5.4.1	Dichotomous Logit Model	124

5.4.2	Survival Analysis	125
5.4.3	Split-Population Survival Time Model	130
5.5	Results	131
5.5.1	Main Estimates	131
5.5.2	Additional Tests	134
5.5.3	Interpretation of Confounders	134
5.6	Conclusions	137
	Appendix A: Non-parametric Methods to Describe Event Occurrence Data . . .	140
A.1	Life Table	140
A.2	Methods for Discrete-Time Data	141
A.3	Comparing Discrete- and Continuous-Time Hazard and Survival Functions	143
A.4	Methods for Continuous-Time Data	143
	Appendix B: Hazard Models	146
B.1	Discrete-Time Hazard Models	147
B.2	Semi-parametric Cox Regression Model	148
B.3	Parametric Continuous-Time Hazard Model	151
B.4	Justification for Using the Cox PH Model	151
6	Study 3: Discretion, Corruption and Competition in Public Procurement: a Cross-country Analysis	153
6.1	Introduction	153
6.2	General Consideration and Literature Review	155
6.2.1	Award Mechanisms with Considerations of Corruption	156
6.2.2	Discretion	157
6.2.3	Corruption and Competition	158
6.2.4	Other Determinants of Competition in Public Procurement	164

6.3	The Model	170
6.3.1	Case 1: A Game of a Potentially Dishonest Bidder and a Potentially Dishonest Procuring Agent	172
6.3.2	Case 2: A Game of a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder	174
6.3.3	Case 3: A Game of a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and Multiple Honest Bidders	180
6.4	Hypotheses and Data	183
6.5	Results	190
6.5.1	Main Results	190
6.5.2	Robustness Check	194
6.6	Conclusions	196
	Appendix: Extensive-Form Games	199
7	Conclusions	201
	Bibliography	205

List of Tables

2.1	Features of EU Award Mechanisms	8
2.2	Hypothetical Example of CN	15
2.3	Hypothetical Example of CAN	15
2.4	Summary Statistics of Estimated Value (€) by Contract Type	21
2.5	Top 20 Most Popular Words for Award Criteria	25
2.6	GDP Deflators by Country and Year	27
3.1	Classification of Award Mechanisms in Theory and Practice	39
4.1	Variable Definition	65
4.2	Descriptive Statistics	67
4.3	Logit Regressions: Open Procedure versus Restricted Procedure (Baseline: Restricted Procedure)	88
4.4	Multinomial Logit Regressions of Award Mechanism (Baseline: Negotiated Procedure)	89
4.5	Multinomial Logit Regressions of Award Mechanism (Baseline: Competitive Dialogue)	90
4.6	Nested Logit Regressions of Award Mechanism (Baseline: Negotiated Procedure)	96
4.7	Nested Logit Regressions of Award Mechanism (Baseline: Competitive Dialogue)	97
5.1	Duration of the Award Period (in Days)	115
5.2	The Difference between the Actual Date of Contract Award and the Planned Contract Start Date (in Days)	116
5.3	Variable Definition	121
5.4	Coefficient Estimates	133

5.5	Hazard Ratios of Alternative Award Mechanisms to the Negotiated Procedure	134
5.6	Coefficient Estimates for Accelerated Procedures	136
6.1	Variable Definition	186
6.2	Descriptive Statistics	189
6.3	OLS Regressions for the Number of Offers Received and Contract Rebate .	192
6.4	Predicting Contract Value and Estimated Value	193
6.5	Changes in Estimated Value Predicted by Changes in CPI for a Contract with an Average Level of Complexity (Estimated Value = €263,105) . . .	194
6.6	Robustness Check	195

List of Figures

2.1	Life-cycle of EU Public Procurement	11
2.2	Number of CNs by Country (2009-2015)	17
2.3	Adoption of Award Mechanisms by Country	18
2.4	Adoption of Award Mechanisms by Year	18
2.5	Adoption of Award Criteria by Award Mechanism	19
3.1	A Comparison between Ascending and Descending Price Auctions with Sealed-Bid Auctions	39
3.2	Directions of Signals Transmission	41
3.3	Parties in the Communication	41
4.1	Distribution of Contract Type by Year	68
4.2	Number of CNs by Award Mechanism	68
4.3	Distribution of Award Mechanism by Contract Type	69
4.4	Distribution of Award Criteria by Contract Type	69
4.5	Distribution of Award Criteria by Award Mechanism	70
4.6	Buyers' Experience by Award Mechanism	71
5.1	Strategic Decision Process: An Integrative Framework	102
5.2	Kaplan-Meier Curves for All Contracts	119
5.3	Kaplan-Meier Curves for Contracts with Delayed Award	119
5.4	Kaplan-Meier Curves for All Contracts (Accelerated Procedures)	135
5.5	Kaplan-Meier Curves for Contracts with Delayed Award (Accelerated Pro- cedures)	135

6.1	A Procurement with a Potentially Dishonest Bidder and a Potentially Dishonest Procuring Agent	173
6.2	Expected Payoffs of a Procurement with a Potentially Dishonest Bidder and a Potentially Dishonest Procuring Agent	174
6.3	A Procurement with a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder	176
6.4	Expected Payoffs of a Procurement with a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder (the Honest Bidder Chooses to Enter)	179
6.5	Expected Payoffs of a Procurement with a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder (the Honest Bidder Chooses to Stay Out)	179
6.6	A Procurement with a Potentially Dishonest Bidder, Potentially Dishonest Procuring Agent and More than One Honest bidders	182
6.7	Corruption Perception Index (CPI)	187
6.8	GDP and Imports (% of GDP)	188

Chapter 1

Introduction

1.1 Introduction

Public procurement is an activity initiated by the public sector to purchase goods, works (e.g. construction) or services from private firms. Public procurement plays a significant role in the economy. According to the [World Bank Group \(2017\)](#), public procurement takes up 10% to 25% of GDP in each country. Examples of public procurement include purchasing computers for a local office, refurbishing a community park, building a bridge, constructing a school campus, and providing electricity.

Most studies on public procurement have focused on its cost and efficiency, i.e. providing the best value for money. The literature mainly examines the following issues: compensation schemes, e.g. fixed-price versus cost-plus contracts ([Laffont and Tirole, 1993](#), [Tadelis, 2012](#)), operational and financial structures, e.g. traditional procurement versus public-private partnerships (PPPs) ([Hart, 2003](#), [Schmidt, 1996](#)), and award mechanisms¹, e.g. auctions versus negotiations ([Bajari et al., 2008](#), [McAfee and McMillan, 1987a](#), [Tadelis, 2012](#)).

The award mechanism is a process for deciding on the winner of a contract from a group of bidders. A better choice of the award mechanism helps improve the time schedule of procurement, identify a suitable contractor, and reach a better price-quality outcome.

¹An award mechanism is also known as an award process, award procedure, procurement process or procurement procedure. As these five terminologies are used interchangeably in practice and in the literature, we follow this custom throughout the text.

1.2 Motivation and Contribution of the Thesis

This thesis investigates the process of procurement, using data for the UK and other EU countries, plus Iceland and Norway. The EU (including the UK) implements award procedures which are defined by the World Trade Organisation (WTO) Agreement on Government Procurement (GPA).² Besides the 28 EU member states, 50 members of the WTO, including the US and Canada are participants of the GPA, and 10 WTO members, including China and Australia, are in their process of joining in this agreement. Therefore, this thesis also has implications for many countries outside the EU.

While many studies have examined the choice between auction and negotiation in public procurement, few empirical studies have investigated all four benchmark award mechanisms in the EU. These are the open procedure, the restricted procedure, the negotiated procedure and the competitive dialogue. The principal goal of this thesis is to compare the features of the four award mechanisms and reveal the current award mechanism practice and the relevant factors to procurement outcomes. The thesis contains three independent but interrelated studies, each of which examines one or more aspects of the procurement process. A subsidiary goal is to explain both the public procurement process and public procurement data so that anyone who wants to understand EU public procurement would find it useful to review this thesis.

The contributions of this thesis are as follows:

First, the thesis explains the EU public procurement data in detail, including the operating steps of each award mechanism, the sequence of procurement notices and the utilisation of each award mechanism. We also point out some of the limitations of public data in the EU public procurement and provide suggestions for improving data accuracy.

Second, to the best of our knowledge, it is among the first studies to systematically examine features of the competitive dialogue, which is a widely used award mechanism

²See WTO GPA website: https://www.wto.org/english/tratop_e/gproc_e/gp_gpa_e.htm.

for very complex contracts, such as a public-private partnerships (PPPs) project for constructing and operating an underground rail line. We offer insights of factors that are relevant to the choice of award mechanism.

Third, although the public procurement literature acknowledges that both cost and time escalations imply inefficiency in procurement and that the social welfare of public contracts often depends on delivery time, it focuses on time spent by contractors, i.e. time after a contract is awarded (Gori et al., 2017, Guccio et al., 2012, Lewis and Bajari, 2011, Love et al., 2013), and ignores time spent on making award decisions.³ This thesis synthesises the strategic management and public procurement literatures to propose and test novel hypotheses regarding the link between the choice of award mechanisms and decision speed.

Fourth, most studies on public procurement equate corruption with discretion (Baldi et al., 2016, Spagnolo, 2012), but discretion and corruption are not equivalent. We use a measure other than discretion to account for corruption in public procurement and examine the relationship between discretion, corruption and competition. We are among the few studies that separately and simultaneously analyse discretion and corruption in public procurement. Others are Coviello et al. (2018) and Knack et al. (2017). Since corruption interacts with both discretion and competition, corruption and discretion should be simultaneously considered in any regressions that take competition as a dependent variable.

Lastly, we contribute to the theoretical literature on corruption in procurement by introducing a model that shows how discretion contributes to corruption. While many studies have proposed such a mechanism, very few have provided formal analysis.

In summary, by reviewing EU public procurement data, this thesis suggests the kind of improvement that can be made in managing public procurement information, e.g. con-

³An UK public contract to widen highway M25 had an overall delay of 18 months in preparing and executing the procurement. The delays is estimated to increase the net present cost by £660 million, which is 24% of the £3.4 billion total cost. The award decision was made nine months behind schedule. Source: UK National Audit Office (2010).

tract value and matching a series information regarding a subcontract. Through empirical analysis, the thesis shows that public buyers are likely to have applied theoretically proper award mechanisms regarding contract complexity, i.e. award mechanisms that allow for greater discretion for more complex contracts. Empirical results also indicate that discretion, specifically negotiation, may slow down award decision speed, but bureaucratic procedures in award processes are likely to be more detrimental to decision speed than negotiation. A formal model confirms that discretion can be transferred to the risk of corruption. The model shows that corruption may increase the expected profit of both the corrupt bidder and the procurer. Our empirical results support the widely accepted view that higher discretion and corruption levels are associated with fewer bidders and higher contractual price. Overall, this thesis casts doubt on the application of the restricted procedure and competitive dialogue (the more complicated versions of auction and negotiation) and suggests a need for further studies on the procurement performance of contracts awarded through these two mechanisms.

1.3 Structure of the Thesis

The remainder of the thesis is organised into the following chapters:

Chapter 2 provides an overview of public procurement and the public procurement data employed by this thesis. It first introduces the WTO GPA, a cornerstone of the institutional framework of many countries, and subsequently reviews the classification of award mechanisms and the life-cycle of procurement. Lastly, it describes the structure of EU public procurement data, provides graphical and statistical descriptions of the data, and points out some of the limitations of the data.

Chapter 3 is structured into three substantive sections to review the main issues in the public procurement literature. The section on contract design compares different compensation rules and compares public-private partnerships (PPPs) with traditional procurement. The next section contrasts the terminologies for award mechanism classi-

fication in theory and in practice. The penultimate section introduces the literature on award mechanism design.

Chapter 4 is an empirical study of public buyers' choices of award mechanisms, using UK data. The multinomial logit model and the nested logit model are used to assess the probability of employing the four EU benchmark award mechanisms. Specific questions include: whether and how the levels of complexity and quality concerns are related to the choice of award mechanism; whether and how the buyer's experience in procurement is related to the choice of award mechanism?

Chapter 5 presents an empirical study of the decision speed of awarding contracts, using UK data. It underlines the significance of decision speed by combining the strategic management literature with the public procurement literature. This chapter uses a dichotomous logit model to evaluate the probability of delaying an award. It applies survival analysis to explore the duration of the award process and the duration of delays in awarding contracts. Factors include the award mechanism, contract complexity, quality concerns, and buyer's experience are considered.

Chapter 6 explores the relationship between discretion, corruption and competition in public procurement. This chapter discusses the importance of discretion in award mechanism design. It also stresses that the risks of fewer participants and less price competition are related to corruption, which accompanies discretion almost naturally. The theoretical part shows a model that establishes a link between discretion and corruption, by referring to the revenue equivalence theorem and the extensive form game. Lastly, this chapter provides OLS estimates for the effects of discretion and corruption on the number of bidders and price rebates, based on data from the EU member states, Iceland and Norway.

Chapter 7 summarises the primary results and implications of each previous chapter. It concludes the thesis with suggestions for practitioners, policymakers and researchers.

Chapter 2

Overview of Public Procurement and Public Procurement Data

2.1 Introduction

This chapter provides background information of public procurement. It discusses the link of public procurement arrangements in many countries, illustrates the procurement process and introduces the structure of the public procurement data. Equipped with knowledge from this chapter, readers will find it easier to understand analyses in Chapters 4 to 6.

Public procurement processes in many countries are similar, owing to the Agreement on Government Procurement (GPA) established by the World Trade Organisation (WTO) in an attempt to facilitate open public procurement.¹ The GPA sets up the rules and requirements that ensure open, fair and transparent competition in public procurement and defines the basic types of award mechanism. The agreement involves 78 WTO member countries as existing participants, including the UK and the other 27 EU member states, US, Japan, Canada and India. In addition, 10 WTO member countries, including China and Australia, are negotiating their accession to the agreement.

The GPA is implemented by local public procurement laws in each country. As a political and economic union, the EU is the GPA party that applies harmonised legislation to the greatest number of countries. All EU member states follow the same EU public procurement directives.²

¹See WTO GPA website: https://www.wto.org/english/tratop_e/gproc_e/gp_gpa_e.htm.

²The UK will follow the EU public procurement directives during the two-year course of Brexit ne-

The remainder of this chapter is organised as follows. Section 2.2 explains the award mechanisms that are allowed under the GPA and how these GPA award mechanisms are implemented in the EU member states and some other countries. Section 2.3 reviews the stages of public procurement with a focus on the procurement stage. Section 2.4 introduces our data source, i.e. the official platform for publicising EU public procurement information and describes the public procurement data of the EU, Iceland and Norway. Section 2.5 closes this chapter. Appendix A provides examples of award criteria. Appendix B shows the methods for adjusting contract values in this thesis.

2.2 Award Mechanism Classification in Practice

The WTO GPA allows three award mechanisms. In their terminology, these are: open tendering, selective tendering and limited tendering (World Trade Organisation, 2012). Open tendering allows any interested suppliers to submit bids. Selective tendering allows only qualified suppliers to submit bids.³ In particular cases, a procuring authority may turn to limited tendering to contact a supplier (or suppliers) directly without calling for tenders. These particular cases occur when open tendering or selective tendering fail and when the goods or services can only be purchased from a particular supplier.

Negotiations may be conducted during the award process when the intention of negotiation has been expressed in a notice of intended procurement or when no tender obviously dominate other tenders.

gotiation, which lasts until 29 March 2019. After this date, the UK public procurement legislation is not expected to change dramatically, because the UK will still be under the framework of the GPA and significant changes in laws take a great deal of time for discussion.

³The GPA define the qualified supplier as “a supplier that a procuring entity recognizes as having satisfied the conditions for participation”. See Article I from the Revised Agreement on Government Procurement. https://www.wto.org/english/docs_e/legal_e/rev-gpr-94_01_e.htm.

2.2.1 Award Mechanisms for EU Public Procurement

Until 2006, EU public procurement law permitted three benchmark award mechanisms – the open procedure, the restricted procedure and the negotiated procedure. In 2006, the EU introduced a fourth benchmark award mechanism, the competitive dialogue, through the EU Directive 2004/18/EC ([European Parliament and European Council, 2004](#)).⁴ The open procedure is the same as GPA open tendering and the restricted procedure is the same as GPA selective tendering. The negotiated procedure and the competitive dialogue are implementations of GPA selective tendering incorporating negotiation.

The four main EU award mechanisms are distinguished by both their requirements for prequalification and whether they allow negotiation (see [Table 2.1](#)). The open procedure allows any interested firms to submit a tender and does not include prequalification. The restricted procedure may preselect bidders who submit a request to participate and allow only prequalified bidders to submit tenders. The open and restricted procedures forbid discussion and negotiation.

The negotiated procedure and competitive dialogue allow preselection. The competitive dialogue permits negotiations only before final bids are submitted and concludes with a competitive bidding stage after the last round of negotiation. The negotiated procedure permits one or more rounds of negotiation and does not conclude with competitive bidding. Rather, negotiations continue until a winner is selected.

Table 2.1: Features of EU Award Mechanisms

Award mechanism	Prequalification	Minimum No. of participants after prequalification	Discussion <i>before</i> final bids are submitted	Discussion <i>after</i> final bids are submitted
Open procedure	No	n.a.	No	No
Restricted procedure	Yes	5	No	No
Competitive dialogue	Yes	3	Yes	No
Negotiated procedure	Yes	3	Yes	Yes

⁴The EU public procurement is currently governed by the Directive 2009/81/EC ([European Parliament and European Council, 2009](#)), Directive 2014/23/EU ([European Parliament and European Council, 2014a](#)), Directive 2014/24/EU ([European Parliament and European Council, 2014b](#)), Directive 2014/25/EU ([European Parliament and European Council, 2014c](#)).

The EU public procurement directives allow a procuring authority to freely choose between open and restricted procedures. A procuring authority can use the negotiated procedure and competitive dialogue only under specific circumstances, e.g. for contracts that require complex technology.

The EU public procurement directive also allows for two accelerated procedures, which may be applicable in urgent cases. Compared with the restricted procedure, the accelerated restricted procedure shrinks the length of the procurement process but is otherwise the same. The accelerated negotiated procedure is similarly a contracted version of the negotiated procedure.⁵

All EU award mechanisms discussed so far require a notice to be published, as a call for competition. In exceptional conditions, for example, if no satisfactory suppliers are found under competitive award mechanisms, a procuring entity may seek for candidates without prior publication of a call for competition. This exceptional award procedure stems from limited tendering in the GPA.

2.2.2 Award Mechanisms in Non-EU Countries

The non-EU countries that are participants of the GPA or that are in the process of joining in the GPA adopt public procurement procedures that are similar to those in the EU. We illustrate with the public procurement procedures in the US and China as examples.

The primary public procurement law in the US is the Federal Acquisition Regulation, 48 C.F.R. (FAR) (2002). The FAR specifies sealed bidding and the negotiated competitive proposal as the two principal award mechanisms. Sealed bidding is essentially identical to the open procedure in the EU. The negotiated competitive proposal can be similar to

⁵The minimum response period is 30 days for the restricted and negotiated procedures and 10 days for the two accelerated procedures. The minimum screening period is 35 days for the restricted procedure and 10 days for the accelerated restricted procedure. The (accelerated) negotiated procedure is not bound by a legally stipulated minimum screening period. See explanations of the response period and the screening period in Section 2.3.

either the competitive dialogue or the negotiated procedure in the EU.

The Government Procurement Law of the People’s Republic of China (2002) is the main law that rules Chinese public procurement. China allows several award mechanisms. The public tender is equivalent to the open or restricted procedures in the EU. Competitive negotiation operates like the competitive dialogue in the EU. Bid by invitation, sole source procurement and price inquiry are the three Chinese award mechanisms that are similar to the limited tendering in the GPA, which does not require a call for tenders to be published.

Countries that are not associated with the GPA tend to have less developed institutional infrastructure for public procurement. For example, South Africa has no prescribed public procurement procedures (Tucker and Gilfillan, 2014), although it is considered as one of the most developed countries in Africa.

2.3 Timeline for Public Procurement

The life of a public procurement contract has three stages. First, in the feasibility stage, the necessity of carrying out a procurement is evaluated. For more complex contracts, e.g. public-private partnerships (PPPs) projects, the feasibility of the contract is assessed by various factors. These factors include demand, supply, net present value and internal rate of return. The next stage is the procurement stage, in which bids are called for, received and evaluated, and a contractor is chosen. The last stage is the delivery of the contract. For PPP contracts, the delivery stage consists of construction and operation (Yescombe, 2007).

Since this thesis focuses on the procurement process, we describe the procurement stage in detail, using EU award mechanisms as an example. Figure 2.1 is a timeline that depicts the life-cycle of an above-threshold public contract within the EU.⁶ The release of

⁶The EU resets its procurement thresholds of contract value annually. See <https://www.ojec.com/thresholds.aspx>. Contracts with a value that is equal to or above the procurement thresholds are legally bound by the EU public procurement directives.

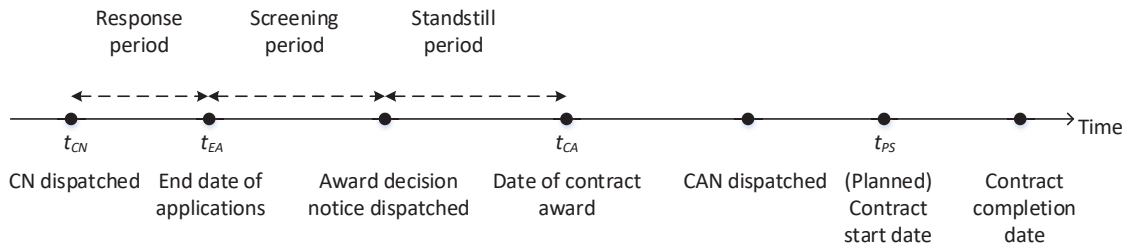


Figure 2.1: Life-cycle of EU Public Procurement

Notes. 1. Response period: for submitting requests to participate under the (accelerated) restricted, (accelerated) negotiated, and competitive dialogue procedures; for submitting tenders under the open procedures. 2. Screening period: for preselection and bid evaluation under the (accelerated) restricted, (accelerated) negotiated, and competitive dialogue procedures; for bid evaluation under the open procedure. 3. Standstill period: a publicity period for challenging the winning bid.

a contract notice (CN), which announces a contracting opportunity to the public, starts the procurement stage. The CNs of above-threshold public contracts are required to be published on the Official Journal of the European Union (OJEU). A CN specifies items such as the target to be purchased, estimated value, award mechanism, requirements, and end date of application. Some CNs also provide the planned contract start and end dates.

A procurement process is formed by three consecutive periods: the response period, the screening period and the standstill period. The type of award mechanism determines the content of the first two stages. The response period lasts until the end date of the application. During this period, complete tenders are submitted under the open procedure, and requests to participate are submitted under the (accelerated) restricted procedure, (accelerated) negotiated procedure and competitive dialogue.

Immediately following the response period, the screening period allows the contracting authority evaluates bids and chooses the contractor under the open procedure. The contracting authority examines the qualification of interested bidders, issues the invitation to tender to qualified bidders, and subsequently evaluates bids from prequalified bidders in the screening period for the (accelerated) restricted procedure, (accelerated) negotiated procedure and competitive dialogue.

An award decision notice is issued to all bidders at the end of the screening period

with a standstill period of at least 10 days during which a winning bid can be challenged before a contract is formally awarded and signed. Later, a contract award notice (CAN) is published on the OJEU to announce the awarding outcome. Once a contract is awarded, the contractor inputs production factors for delivering the contract.

2.4 Public Procurement Data

We have obtained all public procurement data of the 28 EU member countries, Iceland and Norway that are published on the Tenders Electronic Daily (TED) during the period 2009–2015. The data are downloadable from the European Union Open Data Portal (EU-ODP).⁷ ⁸ The TED is the digital version of the OJEU. EU Public procurement contracts above the EU value thresholds must be advertised on OJEU by publishing a contract notice (CN) and a contract award notice (CAN).

Meanwhile, the EU also encourages publishing under-threshold contracts on the TED. As a result, this database contains all above-threshold contracts and some under-threshold contracts during the defined time window.

The boundary between public-private partnerships (PPPs) and traditional procurement is blurred.⁹ Many PPP contracts are concessions that fall under the Public Procurement Directive 2014/23/EU (European Parliament and European Council, 2014a). These PPP contracts are included in the TED dataset. However, the dataset from the EUODP does not distinguish PPP contracts from traditional public procurement contracts. It is only possible to identify PPP contracts by carefully reading through the original soliciting documents. Quite a few PPPs are not public procurement and are not covered by EU procurement directives.¹⁰

⁷See the EUODP website <https://data.europa.eu/euodp/en/data/dataset/ted-csv>. Our data are the 2nd February 2017 version.

⁸Iceland and Norway are in the European Economic Area. Their institutional arrangements in public procurement are very close to those adopted in the EU.

⁹See Section 3.2.2 contrasts between PPPs and traditional procurement.

¹⁰Source: private communication with an officer from the European Commission.

2.4.1 Data Structure

Our public procurement data consist of the contract notice (CN) dataset and the contract award notice (CAN) datasets. In most cases, one CN corresponds to one CAN. The two datasets can be linked by matching the *future CAN ID* from CN data and the *CAN ID* from the CAN data.¹¹

The CN describes the basic profile of intended contracts, including the identification of the procuring authority, description of the procurement, estimated value of CN, lots (i.e. proposed sub-contracts) included in a given contract notice, contract duration, award mechanism to be used, award criteria.

Within the CAN there is data on the overall procurement as well as individual sub-contracts, i.e. contract award (CA). The CAN updates procurement information by adding both the contractual value of the overall CAN and CA information. The CA information includes the winning bidder identification, the number of offers received, the estimated value of the CA, and the contractual value of the CA.

A CA usually corresponds to a “lot” in a CN. In most cases, if a CN is divided into lots, the number of CA equals the number of lots; if a CN is not divided into lots, the number of lots has a value of zero and the CAN contains only one CA. There are occasionally complicated cases where a CA is linked to several lots or a lot is linked to several CAs. However, the management of sub-contract identifiers is generally not satisfactory, it is often difficult to identify the lot(s) and CA(s) that match each other. This is an obstacle to conducting research at the sub-contract level.

Table 2.2 and Table 2.3 show simplified examples of hypothetical CN and CAN data. Suppose a public authority intends to construct a highway that connects London, Leicester, Loughborough and Nottingham. It publishes a CN that divides the overall work of the highway into three lots (Table 2.2). Therefore, the overall contract may be signed

¹¹A Notes & Codebook that offers background information of the CN and CAN dataset and a short description of each variable is available from the EUODP website.

with at most three contractors. Table 2.3 illustrates two potential results of awarding contracts. In Example 1, the three lots are awarded to three contractors, which results in three sub-contracts (i.e. three CAs). In Example 2, firm A wins lot number 1 and firm B wins lots number 1 and 2, so two sub-contracts are signed (i.e. two CAs). In EU public procurement practice, the corresponding lot number is often missing or hard to recognise.

Table 2.2: Hypothetical Example of CN

ID CN	Description	Lot number	Lot description	Estimated value
201811	Highway construction	1	London to Leicester segment	€500,000
201811	Highway construction	2	Leicester to Loughborough segment	€100,000
201811	Highway construction	3	Loughborough to Nottingham segment	€150,000

Table 2.3: Hypothetical Example of CAN

Panel A: Example 1						
ID CAN	Description	ID Award	Award description	Contract value	Corresponding lot number	Winning bidder
201821	Highway construction	123	London to Leicester segment	€550,000	1	A
201821	Highway construction	456	Leicester to Loughborough segment	€120,000	2	B
201821	Highway construction	789	Loughborough to Nottingham segment	€150,000	3	C

Panel B: Example 2						
ID CAN	Description	ID Award	Award description	Contract value	Corresponding lot number	Winning bidder
201821	Highway construction	123	London to Leicester segment	€550,000	1	A
201821	Highway construction	456	Leicester to Loughborough segment; and Loughborough to Nottingham segment	€270,000	2 and 3	B

2.4.2 Data Description

Our raw data contain 1,244,504 entries of CN observations and 1,084,536 entries of CAN observations. The number of CANs is about 15% less than the number of CNs. This may be because contracting authorities of below-threshold contracts have a higher tendency to publish CNs than to publish CANs, although they do not have to publish either notice. A CN increases the exposure of procurement and may attract more bidders, but the contracting authority can benefit little from the increased paperwork for publishing a CAN.

Since the CN dataset contains more observations than the CAN dataset does, we describe the CN dataset in order to reveal a more complete overall picture of the EU public procurement. Figure 2.2 breaks down the number of CNs by country. France, Germany and Poland are the countries with most CNs published during the period 2009-2015. The total number of CNs from these three countries takes up more than half of the CN observations in the dataset. The UK ranks fourth in terms of the number of CNs.

Figure 2.3 shows how frequently each award mechanism was used in each country. Aggregately, around 82.74% of contracts were awarded through the open procedure, 8.24% through the negotiated procedure, 7.17% through the restricted procedure and only 0.55% through the competitive dialogue. The accelerated restricted procedure accounts for 0.95% of the observations. The number for the accelerated negotiated procedure was 0.33%. A negligible proportion of procurements (0.02%) involves other award mechanisms that do not publish a call for competition. Within each country, the open procedure was used most frequently in all countries except in the UK. The most popular award mechanism in the UK was the restricted procedure, followed by the open procedure and the negotiated procedure. In the remaining countries, the second most popular award mechanism was either the restricted procedure or the negotiated procedure.

Figure 2.4 presents how, on an aggregate level, the preference for each award mechanism evolves. The frequency of using the open procedure increased from just below 80%

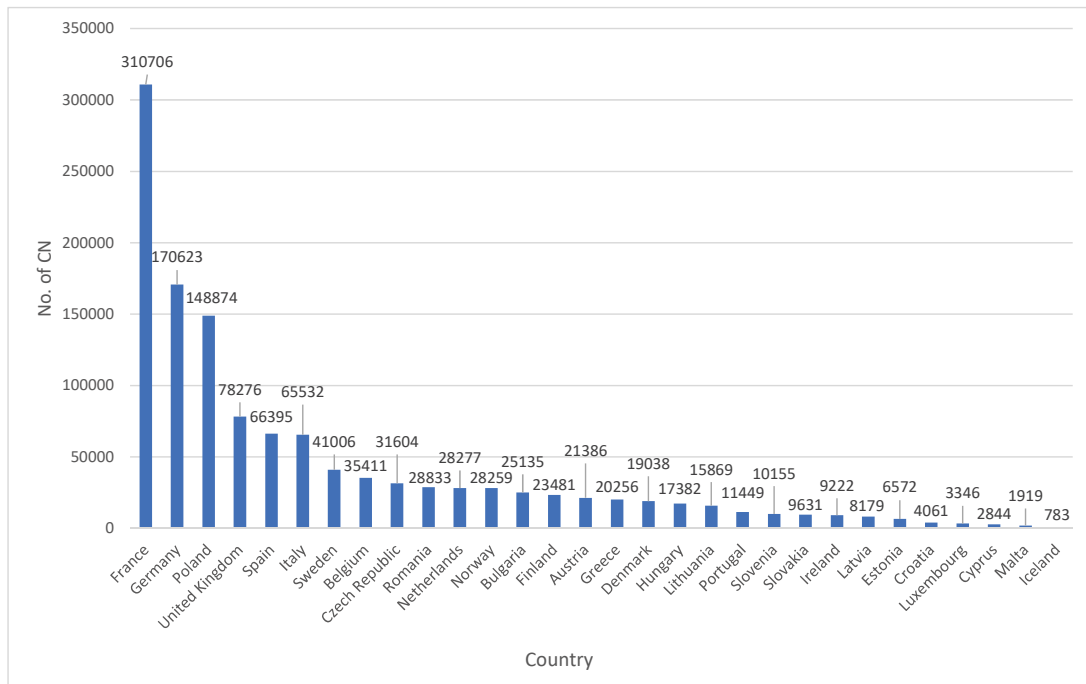


Figure 2.2: Number of CNs by Country (2009-2015)

to about 85% over the period from 2009 to 2015. Correspondingly, the frequency of using the restricted procedure dropped from around 10% to 5%. The application of accelerated restricted procedure also declined. The frequencies of using remaining the award mechanisms remained relatively stable.

“Lowest price” and “most economically advantageous tender” are the two broad award criteria. When bids are evaluated under the “lowest price” award criteria, decisions are based on price alone. When evaluating bids, public buyers using the award criteria of “most economically advantageous tender” consider quality-related aspects along with the price. The EU advocates less reliance on price-only award criteria. 30.69% of the 1,244,504 CNs take price as the single award criterion, 65.56% takes both price and quality into account, and 3.75% do not specify the award criteria. Some CNs provide textual information of award criteria. Appendix A summarises the top 20 most popular words in the textual field of award criteria in UK public procurement from 2009 to 2015.

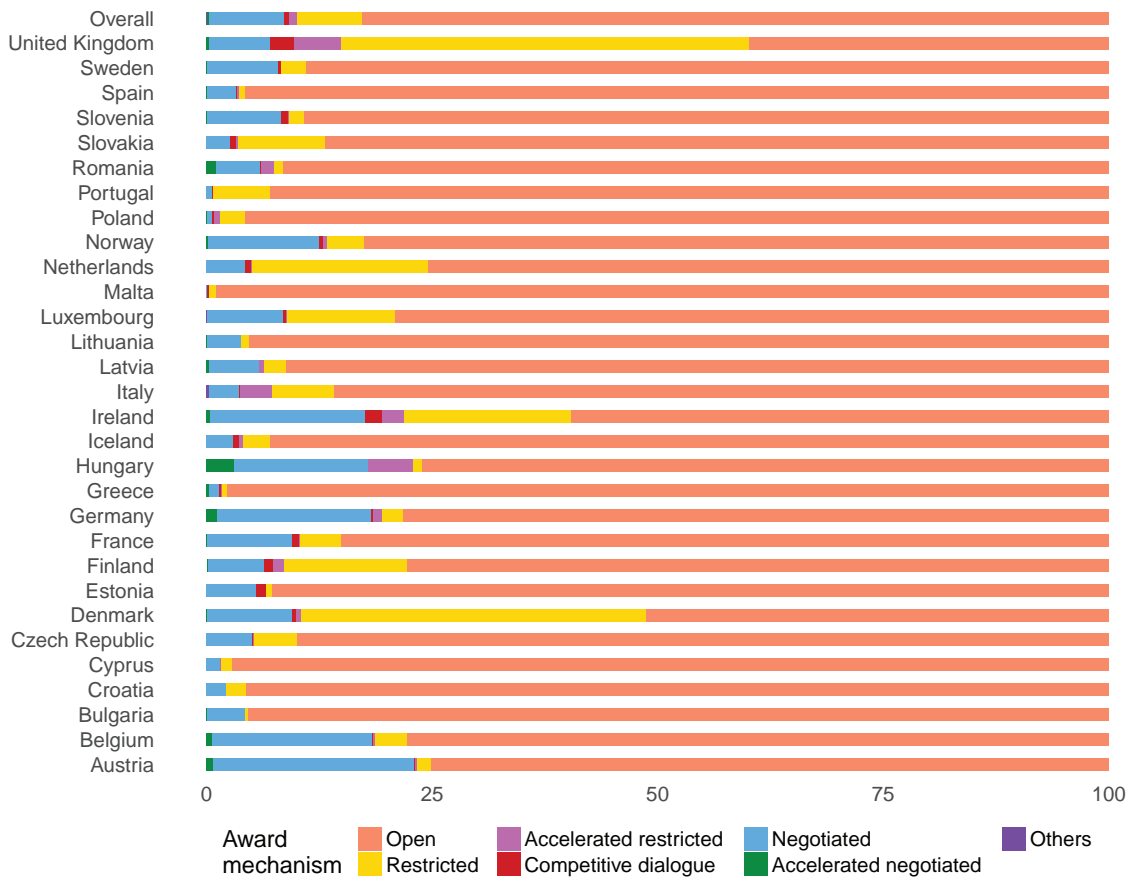


Figure 2.3: Adoption of Award Mechanisms by Country

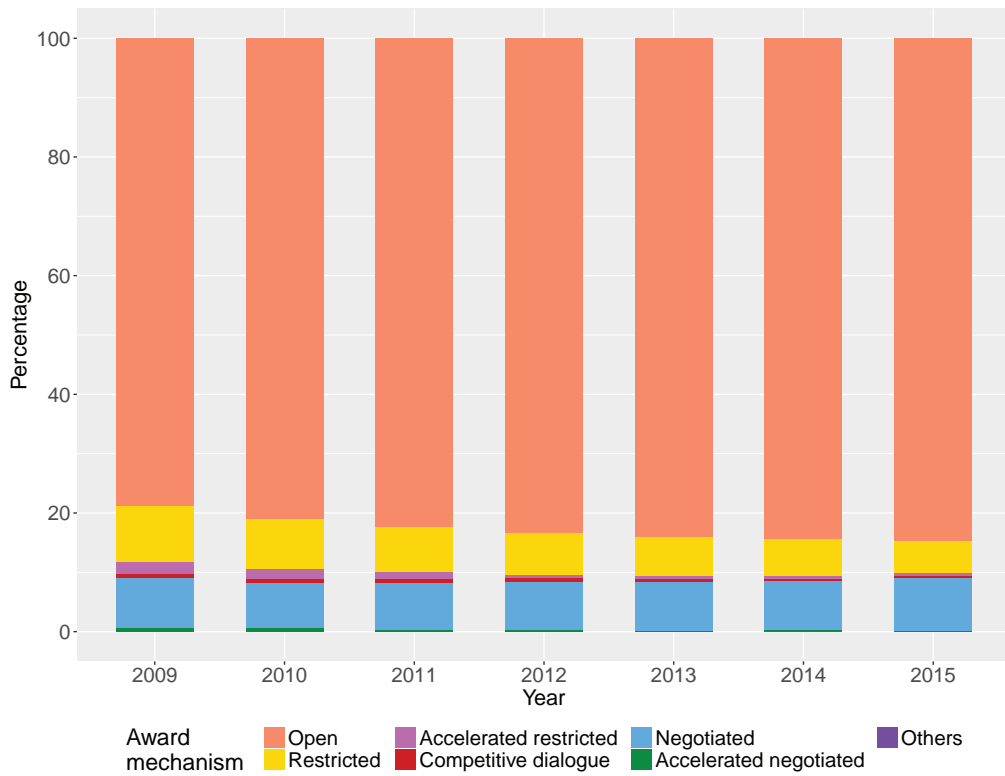


Figure 2.4: Adoption of Award Mechanisms by Year

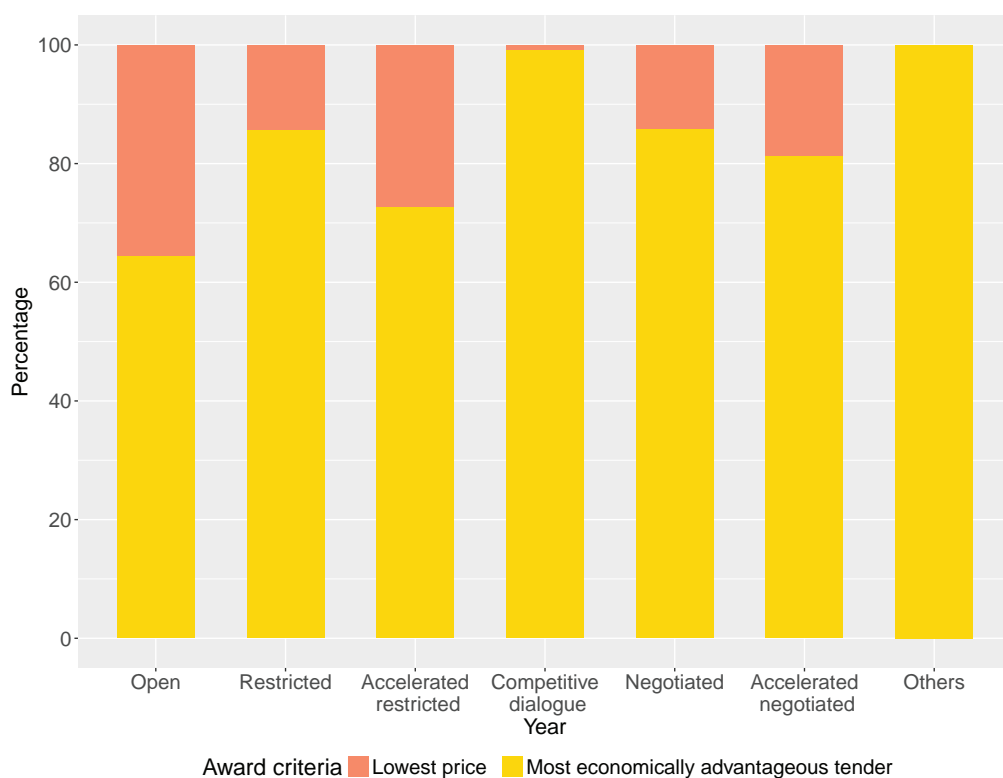


Figure 2.5: Adoption of Award Criteria by Award Mechanism

Figure 2.5 illustrates how the two broad award criteria were used in combination with each award mechanism. The open procedure is the award mechanism most likely associated with price-only award criteria. The restricted and negotiated procedures are equally likely to be used with price-only award criteria. A greater proportion of the accelerated procedures are linked to the price-only award criteria than their corresponding benchmark award mechanisms. Almost all contracts awarded through the competitive dialogue were evaluated based on the “most economically advantageous tender”.

The contract price is one of the most crucial aspects of a project. Table 2.4 is a summary of inflation-adjusted estimated contract values disaggregated by contract type. Appendix B describes how estimated values are adjusted by inflation. Less than half of CNs in the raw data provide an estimated value of the contract. The missing estimated value in a CN may not necessarily indicate that the public buyer does not have a budget for the procurement. The public buyers may not provide estimated value due to strategic considerations. For instance, an estimated value can be taken as a reserve price, which signals the amount that the public buyer is able to pay. If bidders agree that an estimated

value is set too high, they may collude and collectively bid at a high price that is close to the estimated value.¹²

The estimated values in all contract types have abnormally huge spans and standard deviations. The minimum value is €0.01 and the maximum value is €1.95×10²³. By going carefully through hundreds of contract notices, we discover two common causes of error. (1) A unit of either “million” or “billion” is missing. Adding a unit of either “million” or “billion” after a number which is less than 1 makes the overall value more reasonable. For example, €0.01 then becomes €0.01 million or €0.01 billion. (2) When a range of values is provided, a number without the connecting words is displayed, which is an unrealistically large number. For example, an input of “between 85,000 and 102,000 euros” is displayed as “85,000,102,000 euros”.

To rule out the influence of extreme values, we filter out the potentially incorrect numbers by excluding numbers that are smaller than €0.01 million, i.e. €10,000, and that are larger than the top 1st percentile, i.e. 6.42×10⁸. Columns (4) to (6) in Table 2.4 summarise estimated value by contract type after data cleaning. For each contract type, the mean is much higher than the corresponding median, which implies that the estimated values are positively skewed. The estimated value of works contracts is on average three-times that of services contracts and four-times that of supply contracts.

¹²Klemperer (2002) discusses the pitfalls of setting a publicly-known reserve price.

Table 2.4: Summary Statistics of Estimated Value (€) by Contract Type

	Raw data			Data after cleaning		
	Works (1)	Services (2)	Supply (3)	Works (4)	Services (5)	Supply (6)
Total No. of obs.	211057	564384	469056	46157	197542	184857
No. of obs. with estimated value	46729	202220	189285	46157	197542	184857
No. of obs. without estimated value	164328	362164	279771	0	0	0
Min.	0.01	0.01	0.01	10030.61	10013.29	10021.47
Median	3904941.16	548878.59	438651.63	4021107.38	569651.72	455016.47
Mean	4.17074×10^{18}	5435497878	2797381245	11826157.21	3832987.329	2916991.638
Max.	1.94894×10^{23}	1.0949×10^{15}	5.28081×10^{14}	642055638.9	668168356.9	657464974.2
S.D.	9.01583×10^{20}	2.43479×10^{12}	1.21379×10^{12}	34543278.74	20906168.22	17442786.05
CI (lower)	-4.00395×10^{18}	-5176588033	-2670700221	11511017	3740795	2837477
CI (upper)	1.23454×10^{19}	16047583790	8265462711	12141298	3925180	2996507

2.5 Conclusions

The World Trade Organisation Agreement on Government Procurement (WTO GPA) guides public procurement for its 78 participants and 10 potential participants. As a result, public procurement institutional arrangements are alike in many countries. This makes analyses of award processes in any of these countries meaningful to the other countries. We focus on institutional arrangements in the EU because all its member countries unanimously adopt the same EU public procurement law.

The WTO GPA defines the open tendering, the selective tendering and the limited tendering as the official award mechanisms. Based on the GPA award mechanisms, the EU develops its benchmark award mechanisms: the open procedure, the restricted procedure, the negotiated procedure and the competitive dialogue. These award mechanisms mainly differ in their treatment of prequalification and negotiation. EU public procurement using different award mechanisms follows the similar timelines. A contract with a value above the EU threshold must publish a contract notice (CN) to announce an intended procurement and release a contract award notice (CAN) to conclude the contractor selection.

The data description of public procurement in the EU, Iceland and Norway reveals that the open procedure is generally the most widely used award mechanism and that the uses of the restricted and negotiated procedures are balanced. The exception is the UK, which uses the restricted procedure most frequently. The EU member countries do not use the competitive dialogue often. Over time, in the EU, employment of the restricted procedure is declining, application of the open procedure is rising while uses of the negotiated procedure and the competitive dialogue remain stable.

The EU encourages to evaluate bids based on both price and quality. The open procedure is most likely to be associated with the price-only award criteria. Almost all procurements with competitive dialogue adopt award criteria that consider both price and quality. Price is the only award criterion for a small proportion of contracts awarded

through the restricted or negotiated procedures.

The EU public procurement data exhibit two major deficiencies. First, corresponding sub-contract information cannot be easily paired for CN and CAN. Second, some information is incorrect, either due to missing the unit of measurement for a single value or to missing the connecting words for a value range. We have reported the causes of incorrect contract values to the EUODP to help improve the quality of the public procurement information.

Appendix A: Top 20 Most Popular Words in Award Criteria

Table 2.5 shows the top 20 words that most frequently appear in the free text field of award criteria adopted by UK public procurement during the period 2009-2015. 8,703 contract notices (CNs) contain textual information. The table also illustrates some examples of how these words are phrased as award criteria. The words *price* and *quality* are most frequently used. 7,782 out of 8,703 CNs in this sample mention *price* or its synonyms such as *cost*, *charges*, and *fees* in the award criteria. 5,489 CNs mentions *quality*. From examples of award criteria in column (e), we can see that most non-price award criteria essentially reflects consideration of quality.

Table 2.5: Top 20 Most Popular Words for Award Criteria

(a) frequency ranking	(b) Word	(c) Count	(d) Synonym	(e) Examples of relevant award criteria stated in CNs
1	price	7782	price, priced, prices, pricing, cost, costed, costing, costings, costs, charge, charged, charges, charging, fees, discount, discounts	price, fixed contract price, total cost
2	quality	5489	qualities, quality	quality
3	service	2384	service, serviceability, serviced, services, servicing	after sales services and warranty
4	technical	2166	technical, technically	compliance with the technical specification, technical
5	delivery	1699	delivered, deliveries, delivery	delivery and customer service
6	managing	1128	manage, managed, management, manager, managers, managing	contract management, operational management
7	ability	1011	abilities, ability, capabilities, capability, capable	ability to deliver full specification, operational service - technical ability & capacity, finance status , capability, capability to deliver the contract
8	experience	975	experience, experience, experiences	experience, relevant experience, experience of successful dispute resolution
9	value	747	value, values, valuing	added value, best value (price, programme, quality), value for money
10	support	707	support, supported, supporting, supportive, supports	ongoing support, quality and support
11	commercial	700	commercial, commercials	commercial, commercial and value for money
12	specifications	679	specific, specifically, specification, specifications, specified, specificity	compliance with specification
13	financial	627	financial, financially, financials	financial status, financial stability including credit rating
14	contracts	623	contract, contracted, contracting, contracts	contract management
15	proposed	616	proposal, proposals, propose, proposed, proposes	proposals, assessment of contractor's proposals
16	requirements	549	require, required, requirement, requirements, requirements	experience of tenderer to provide required service, operational requirements
17	customers	457	customer, customers	delivery and customer service
18	performed	457	perform, performance, performed, performing	performance, delivery performance, performance and risk consistency
19	sustainability	456	sustain, sustainability, sustainable, sustainability	sustainability, environmental impact & sustainable development
20	methodology	442	methodological, methodologies, methodology	methodology, quality and methodology, methodology and track record

8,703 contract notices (CNs) provide textual information of award criteria.

Appendix B: Methods for Adjusting (Estimated) Contract Values

To remove the effects of inflation on contract price, all (estimated) values used in this thesis are (estimated) real values. These are (estimated) nominal values (from the raw data) divided by the GDP deflator of the procuring country in the year when the contract notice was released and then multiplied by 100:

$$\text{Real (estimated) value} = \frac{\text{Nominal (estimated) value}}{\text{GDP deflator}} \times 100.$$

Table 2.6 presents the GDP deflators.

Table 2.6: GDP Deflators by Country and Year

Country	2009	2010	2011	2012	2013	2014	2015
Austria	90.041	90.746	92.41	94.308	95.839	97.738	100
Belgium	91.745	93.473	95.344	97.227	98.244	98.898	100
Bulgaria	90.142	91.14	96.589	98.091	97.401	97.842	100
Croatia	95.202	95.994	97.599	99.142	99.94	99.988	100
Cyprus	98.088	100.058	101.968	103.898	102.806	101.197	100
Czech Republic	95.061	93.706	93.725	95.094	96.455	98.848	100
Denmark	91.606	94.56	95.164	97.424	98.289	99.304	100
Estonia	85.084	86.561	91.115	93.994	97.336	98.769	100
Finland	88.811	89.123	91.426	94.126	96.528	98.162	100
France	94.555	95.576	96.478	97.595	98.353	98.919	100
Germany	91.333	92.025	93.01	94.443	96.299	98.027	100
Greece	104.252	104.954	105.792	105.4	102.921	101.035	100
Hungary	85.251	87.236	89.215	92.232	94.94	98.15	100
Iceland	79.314	83.633	86.116	88.944	90.612	94.302	100
Ireland	94.117	91.085	90.744	92.621	93.586	93.214	100
Italy	93.951	94.251	95.635	96.955	98.13	99.071	100
Latvia	88.415	87.697	93.305	96.679	98.271	99.999	100
Lithuania	88.058	90.153	94.866	97.426	98.681	99.695	100
Luxembourg	85.757	88.859	93.101	95.481	97.1	98.698	100
Malta	86.383	89.691	91.63	93.554	95.422	97.6	100
Netherlands	95.402	96.211	96.348	97.715	99.053	99.201	100
Norway	85.559	90.652	96.772	100.02	102.565	102.904	100
Poland	91.683	93.204	96.214	98.475	98.76	99.249	100
Portugal	95.15	95.762	95.504	95.125	97.281	98.011	100
Romania	80.195	84.539	88.547	92.696	95.863	97.479	100
Slovakia	96.487	96.955	98.553	99.796	100.314	100.153	100
Slovenia	96.155	95.205	96.271	96.713	98.262	99.042	100
Spain	98.981	99.14	99.169	99.236	99.587	99.393	100
Sweden	92.242	93.156	94.26	95.26	96.265	97.976	100
United Kingdom	91.263	92.696	94.56	96.039	97.867	99.546	100

Note. Data source: the World Bank.
The GDP deflator is the ratio of GDP in current local currency to GDP in constant local currency. The base year is 2015.

Chapter 3

Theories in Public Procurement

3.1 Introduction

This chapter aims to provide a relative complete framework of literature review on public procurement. It reviews the literature on contract design and award mechanism design, which are used to deal with the two primary issues in public procurement: asymmetric information and contractual incompleteness.

Asymmetric information arises when one party in a transaction owns more substantial knowledge than the other party. Because different parties usually have different incentives, the party with the informational advantage may exploit this advantageous status.¹ For instance, a private firm aims to gain profit from procurement contract, while the public sector is interested in achieving value-for-money by ensuring private firms carrying out their contractual obligations properly and efficiently ([Grimsey and Lewis, 2002](#)). Conflicts may exist in the different incentives of the private and public sectors. Cost-reduction efforts by the private sector can be detrimental to quality ([Hart, 2003](#)). For example, using low-quality cement to pave a road reduces the contractor's cost but makes the road less durable. As a result, the contractor will hide the fact of using low-quality cement from its contracting authority.

Contract incompleteness comes from three sources: (1) difficulty of fully specifying the intended goods or services due to insufficient expertise or unaffordable costs ([Tadelis and](#)

¹[Mas-Colell et al. \(1995\)](#) (Chapter 13 and 14) show application of ex-ante information asymmetry (i.e. adverse selection) and ex-post information asymmetry (i.e. the principal-agent problem, ex-post hidden actions, and moral hazard) to contract theory. See also [Akerlof \(1970\)](#) and [Spence \(1973\)](#) which are two of the seminal papers on asymmetric information.

Bajari, 2006); (2) a potential contractor being unwilling to uncover its true cost function in the selection process and planning to modify the contract once it wins (Flyvbjerg et al., 2003); (3) unforeseeable incidents or endogenous changes in the procurer's choice (Ganuza, 2007). Contract incompleteness often leads to the need for ex post renegotiation and overruns in cost and time.

A procurer determines, in sequence, the goods or services to be bought, contractual obligations and compensation rules, the award mechanism, and perhaps ex post changes (Tadelis, 2012). The public sector and social welfare suffer from asymmetric information and incomplete contracts. To relieve the adverse impacts of these two issues, efforts are made in contract design and award mechanism design.

Contract design interacts with award mechanism design in selecting contractor and procurement outcomes. Since some concepts in contract design form the foundation of some arguments in award mechanism design, we introduce theories in contract design before turning to a discussion of award mechanism design. Section 3.2 covers the two main topics in contract design: cost-reimbursement rules and the option between public-private partnerships (PPPs) and traditional procurement. Section 3.3 discusses how award mechanism classifications differ in theory and EU public procurement practice. Section 3.4 summarises the award mechanism design literature. Conclusions are drawn in Section 3.5.

3.2 Contract Design

This thesis focuses on award mechanism design in public procurement. The literature review on award mechanism is incomplete if the literature of contract design is not referred to. In particular, the cost-reimbursement rules in contract design is closely related to award mechanism design.

Section 3.2.1 discusses the cost-reimbursement rules and Section 3.2.2 discusses the

choice between public-private partnerships (PPPs) and traditional procurement. We provide a brief literature review of PPPs and traditional procurement for the completeness of the literature review of theories in public procurement. Readers may feel free to skip Section 3.2.2.

3.2.1 Cost-reimbursement Rules

In a world with asymmetric information and hidden actions (often referred to as moral hazard), cost-reimbursement rules deal with the tradeoff between incentives provision and rent extraction, which are two conflicting aims of buyers. [Laffont and Tirole \(1993\)](#) provide a summary of this literature. According to them, “cost-reimbursement rules refer to the extent of cost sharing between the firm and either the taxpayers or the consumers”. In the context of public procurement, for simplification, we assume that the contracting authority represents the interest of taxpayers and consumers.² Nearly all cost-reimbursement contracts are somewhere between the fixed-price contract and the cost-plus(-fixed-fee) contract ([Bajari and Tadelis, 2001](#)).

A fixed-price contract is a high-powered incentive scheme, where a procuring authority pays a prespecified fixed price to a private contractor for its efforts to meet its obligations. It is an incentive scheme with high power because the private firm is required to bear all the realised cost. Under a fixed-price contract, the private firm is the residual claimant of every unit of money it saves, so the private firm is motivated to conduct cost-saving actions. Since the payment is fixed, the government shares no benefits from the firm’s cost reduction efforts.

A cost-plus(-fixed-fee) contract is a low-powered incentive scheme. The contractor is paid with the realised cost plus a stipulated fee. In a cost-plus contract, the contractor does not internalise the cost and the government is the residual claimant. Therefore, a cost-plus contract provides very low incentive for private firms to reduce the cost ([Cox](#)

²Technically speaking, procuring authorities are agents of taxpayers and consumers. The incentives of procuring authorities are not necessarily in line with the interests of taxpayers and consumers. Agency problems due to asymmetric information exist in this relationship.

et al., 1996). A cost-plus contract induces moral hazards. However, it offers the flexibility to adopt suggestions from the public sector without incurring costly ex post haggling.

Bajari and Tadelis (2001) show that a cost-plus contract is superior to a fixed-price contract when the contract is complex, hard to specify fully and thus subject to a high probability of renegotiation. The flexibility of a cost-plus contract accommodates ex post adaptation well because the reimbursement rule is simply for the public sector to cover all costs of adaptation. By contrast, ex post design revision is difficult and costly under a fixed-price contract. The overall contract value has to be re-evaluated. The public authority is vulnerable to the hold-up problem because the contractor is able to utilise his position of being in the midst of the contract (Decarolis, 2014, Tadelis and Bajari, 2006). For example, the contracting authority has to meet the contractor's request for a large amount of extra payment because replacing the current contractor may incur even larger costs. By contrast, simple contracts with a high level completeness are less prone to unexpected ex post changes, so the fixed-price contracts are suitable for simple contracts (Bajari and Tadelis, 2001, Tadelis and Bajari, 2006).

3.2.2 PPPs versus Traditional Procurement

The choice between public-private partnerships (PPPs) and traditional procurement is relevant to a project that contains a construction stage and an operation stage. In traditional procurement, the contracting authority funds and owns the infrastructure and unbundles the decisions of building and operating the infrastructure. The building and operation tasks are carried out by two separate contractors. In PPPs, one single agent is responsible for building and operating the infrastructure. In addition, the single agent funds and owns the asset. The contracting authority commits to buy services provided by this infrastructure.

PPPs were launched due to the need to decorate the public account under the strict financial control of the public sector in the 1980s and 1990s (Grout, 1997). The public sector seeks a private partner to finance public projects so that government debt shown on

the public sector's balance sheet and the public sector's financial exposure appears to be lower. One famous example is the Channel Tunnel Rail Link between the UK and France (Yescombe, 2007). In the UK, PPPs are called Private Finance Initiatives (PFIs), named after their reliance on private finance. Although the private sector funds and owns the project, the public sector may still bear the risk of PPPs. The public sector's long-term commitment to purchase services in effect indirectly finances the project (Grout, 1997). Besides, the public sector has to pay a risk premium to compensate for the risk borne by the contractor (Dewatripont and Legros, 2005).

Starting with Grossman and Hart (1986), Hart (1995) and Hart and Moore (1990), abundant studies have emphasised the effect of contract incompleteness and the importance of ownership. Asset ownership confers residual rights of the asset and the owner internalises externalities in different stages of the contract (Bennett and Iossa, 2006). An example of the externality is that effort in the building stage reduces (increases) the operational cost. When a contract is incomplete, the private contractor will under-invest in the project in fear of being held-up ex post by the public sector who owns the project, i.e. the public sector captures a proportion of benefits generated by the private sector's investment. The owner of the infrastructure should be the party that values the overall value of the infrastructure most (Besley and Ghatak, 2001).

Grout (1997) contends that rewards based on service quality in PPPs motivate private firms to reduce costs in both the building and operating stages without sacrificing quality. Hart (2003) demonstrates that PPPs (bundling) is preferred to traditional procurement (unbundling) when the quality of services provided during the operation stage can be reliably verified and the quality of construction cannot be; traditional procurement dominates PPPs when a contract for building can be well specified and a contract for service cannot be. In the second case, creating a competition for the right to operate the infrastructure encourages efforts in building because the builder's payoff is based on the potential operators' valuation of the building (Iossa and Legros, 2004). Such competition also helps to price the service contract because it (partly) reveals potential operators' cost function of operating the asset.

[Bentz et al. \(2005\)](#) emphasise the role of asymmetric information. The operator has private information on the amount of operating cost. This private information leaves the operator with an informational rent. In PPPs, where the contractor is both the builder and operator, the knowledge of operation enables the contractor to adopt a design that minimises operational cost. However, the contractor will choose to do so only if the investment can be covered by the reduction in operational cost. If the investment is too large relative to the amount of cost reduction or the amount of cost reduction is uncertain, the contractor will not invest in operational cost reduction. In this latter case, unbundling is preferred to PPPs.

Private finance helps restore the benefits of PPPs when productivity shocks are highly uncertain and expertise of external financiers could assist in evaluating operational risk ([Iossa and Martimort, 2012](#)). [Dewatripont and Legros \(2005\)](#) point out that as in corporate finance, large outside equity in PPPs dilutes the private partner's incentives to make efforts in cost-reduction because benefits of effort are proportionally collected by outside equity holders. Since debt leads to no residual claims of outside debt holders, external debt reserves the private partner's incentives to exert effort. The benefits of outside expertise survive when the number of outside investors is concentrated because a dispersed structure gives rise to a free-rider problem in providing expertise ([Berle and Means, 1991](#), [Kaplan and Strömberg, 2003](#)). Therefore, for PPP projects, it is better to form a financial structure with concentrated external debt.

3.3 A Typology of Award Mechanism Design

There is an extensive theoretical literature on award mechanism design. As an essential part of the award mechanism design literature, the auction design literature emphasises the differences between various auction formats. The award mechanism literature, in general, compares auctions as a whole with other award mechanisms.

The award mechanism design literature is developed in two settings. 1) The *single-*

seller-many-buyers context: a monopolist designs a selling mechanism and sells goods, services or franchises to potential buyers. 2) The *single-buyer-many-sellers context*, i.e. procurement: a monopsonist designs a purchasing mechanism to buy goods or services from many potential sellers. Henceforce, in this and the next sections, we use the phrase “the award mechanism designer” to represent either the monopolist or monopsonist and the word “bidders” to refer to either buyers in a monopolist case or sellers in a monopsonist case, depending on the context discussed.

From a theoretical point of view, the objectives of award mechanism design in the single-seller and single-buyer contexts are essentially the same (Easley and Kleinberg, 2010, McAfee and McMillan, 1987a,b). In both settings, the award mechanism designer aims to maximise its own expected utility, e.g. to maximise its expected profit, minimise its expected cost, or maximise the social surplus. Because of their similar attributes, the award mechanism literature has not set a very clear boundary between the two contexts. Many studies rooted in one context refer to studies developed in the other context.

There are however differences between the two settings. Sellers usually have informational advantages over buyers, so transactions under both the single-seller and single-buyer contexts are games with information asymmetry. However, buyers in the single-seller context tend to be exposed only to ex-ante information asymmetry, while buyers in procurement can be jeopardised not only by ex-ante information asymmetry but also by ex-post hidden actions, especially for works and services contracts.³

Here we cite two examples of ex-post problems suffered by a procurer in a single-buyer context. Contractors may reduce the cost by sacrificing building or service quality, e.g. using steels with inferior quality to reduce the cost of building a bridge. During the contracting period of service, a consulting company may hold up the procurer by asking for higher payment than agreed in the contract.

Adverse selection is an ex-ante problem that can exist in both single-seller and single-

³Supply contracts are usually guided by commonly accepted product standards, so they are less likely to suffer from ex-post hidden actions.

buyer contexts. In procurement, a contract may be awarded to a contractor who offers a low price merely because it expects to profit from ex-post renegotiation due to a design defect that has been identified only by him but not by anyone else (Flyvbjerg et al., 2003); a highest-cost-and-least-able bidder may be awarded the contract under a cost-plus(-fixed-fee) contract when more competent bidders bid for a fee that is higher than the least able bidder (Tadelis and Bajari, 2006).⁴ In a single-seller case, a buyer purchases a product without detecting its deficiencies.

The “winner’s curse” is another ex-ante problem that may take place in both the contexts. In the single-seller context, it appears when the winning bidder (buyer) overpays for the target item due to overestimating the value of the object.⁵ In the single-buyer context, the “winner’s curse” may also occur because the winner (seller) underestimates the cost. But, unlike the single-seller case, in a single-buyer context the winner that suffers from the “winner’s curse” may be able to transfer its losses to the buyer through ex-post hidden actions.

The classifications of award mechanisms in theory and in public procurement practice, though share commonalities, diverge in some essential features. The remainder of this section introduces the theoretical award mechanism classification (Section 3.3.1) and compares the award mechanism classifications in theory and in practice (Section 3.3.2).

3.3.1 Award Mechanism Classification in Theory

The theoretical literature on award mechanism design compares auctions with bargaining formats. This subsection introduces firstly the main auction formats and then the bargaining formats.

⁴See Section 3.2.1 for the definition of cost-plus(-fixed-fee) contract.

⁵The “winner’s curse” in the single-seller context may take one of two forms: 1) the winner pays for the object at a higher price than its value; 2) the value of the asset is less than that is estimated by the winner, so the winner gets less utility than anticipated (Thaler, 1988). For more discussions on the “winner’s curse”, see also the seminal paper Capen et al. (1971) that first put forward the concept and Kagel and Levin (1986) that discuss how the “winner’s curse” and availability of public information interactively affect revenue of the seller (award mechanism designer).

The auction design literature explores four main auction formats: the ascending-price auction, the first-price sealed-bid auction, the second-price sealed-bid auction and the descending-price auction. In most cases, the four auction formats are discussed under the single-seller-many-buyer context. Based on descriptions by [Easley and Kleinberg \(2010\)](#), [Eastin and Arbogast \(2014\)](#), [McAfee and McMillan \(1987a\)](#) and [Vickrey \(1961\)](#), the following introduces the main auction formats under the single-seller context:

- The *ascending-price auction* (also called the *English auction*, or the *oral open auction*). Bids are offered interactively in real time. The auctioneer starts with a low price and increases the price gradually. The essential feature of the ascending-price auction is that all bidders can observe others' bids and can accordingly revise their own bids. The buyer with the highest bid becomes the winner. Antiques and artwork are commonly sold through the ascending-price auction.
- The *descending-price auction* (or *Dutch auction*). It is like a mirror image of the ascending-price auction. The auction begins with a price that is higher than the price that bidders are willing to offer. Then the price is lowered incrementally until a buyer accepts the current price.
- The sealed-bid auction. All buyers submit their bids and the values of the bids are kept confidential from other bidders during the auction. That rivals' bids are unobservable in real-time is the key feature that distinguishes the seal bid auction from the ascending and descending-price auction.
 - The *first-price sealed-bid auction*: the buyer with the highest offer wins the goods or services and the payment is its actual bid price.
 - The *second-price sealed-bid auction* (or *Vickrey auction*): the bidder with the highest price wins the target object at a cost that equals the second-highest bid ([Vickrey, 1961](#)).

Several minor changes need to be made, to convert standard auction formats from the single-seller-many-buyers case to the single-buyer-many-sellers (i.e. procurement)

case. Under the ascending-price auction, the descending-price auction, and the first-price sealed-bid auction, the seller with the lowest bid becomes the winner and the contractual price is the same as his bid. In a second-price sealed-bid auction, the bidder with the lowest price is awarded the contract with a contractual price at the amount of the second-lowest bid.

In procurement, the *scoring auction* has been developed to incorporate some non-monetary dimensions (i.e. dimensions in addition to price) in award criteria. The award mechanism designer scores and ranks bids according to prespecified scoring rules. Quality is often considered as the most crucial non-monetary factor.⁶

The theme of auction design is centred around how to avoid collusion and to alleviate the “winner’s curse” problem. As illustrated in Figure 3.1, the recipients of the bidders’ signals are the main difference between the ascending (descending) price auctions and the sealed-bid auctions. In ascending (descending) auctions, each bidder’s signals are transmitted not only to the award mechanism designer but also to other bidders, so a bidder would respond to its rival’s signals and update its tactic accordingly. In sealed-bid auctions, signals from each bidder can only be received by the award mechanism designer but not by other competitors.

In auctions, an award mechanism designer processes information from all bidders simultaneously, so all bidders have an equal opportunity to submit bids or accept an offer. While auctions are cases of multilateral communication, bargaining formats are usually cases of sequential bilateral communication.

In bargaining formats, the award mechanism designer only communicates with counterparties and makes price offers to or considers price offers from counterparties, one at a time (Ehrman and Peters, 1994). A bargaining format may end up with multilateral communications depending on how firmly the award mechanism designer sticks to its initial offer and on whether any of the previous offers has been accepted (Riley and Zeckhauser,

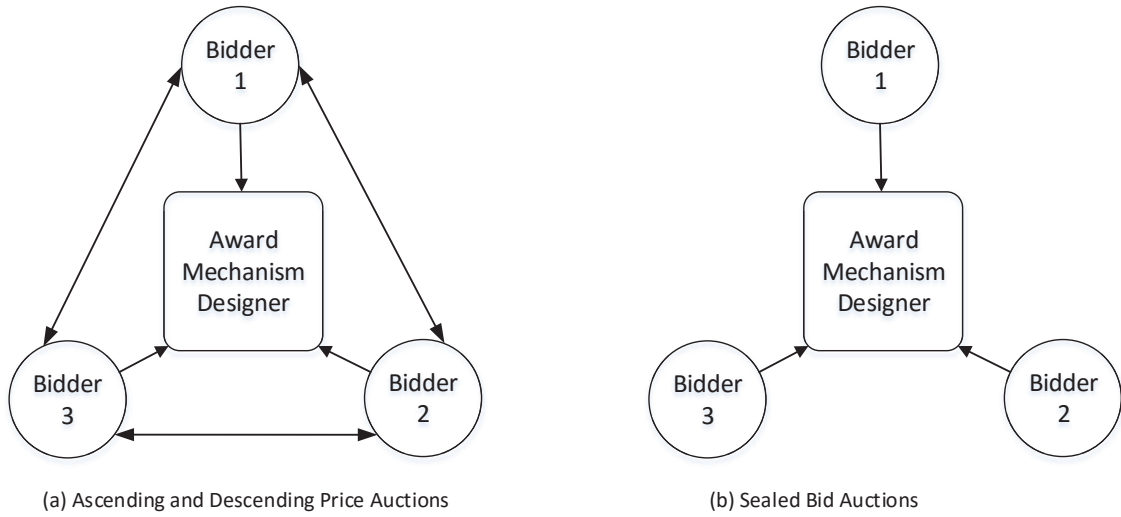
⁶To reveal the use of various award criteria, Appendix A in Chapter 2 summarises the most popular words in award criteria in 2009-2015 UK public procurement.

1983). The three benchmark bargaining formats may be described as:

- If a bidder refuses to accept a pure *take-it-or-leave-it offer*, the award mechanism designer terminates the communication with this bidder.
- It is possible that a bidder who declines the offer provided by the award mechanism designer subsequently submits its own offer, and the award mechanism designer reserves the option to accept that offer depending upon later bidders' actions. The award mechanism designer turns to multilateral communication by comparing all bids that have been offered by bidders only when no bidder accepts its initial offer. In other words, the award mechanism designer sequentially discusses with potential bidders about their willingness to trade. It would look for new bidders if no agreement can be reached with the current bidder. If no bidder accepts its provisions, the award mechanism designer would trade with the previously contacted bidder who offers the most favourable bid (Ehrman and Peters, 1994). In the literature, this award mechanism is usually called a *sequential process*, though all the three bargaining formats discussed here have some sense of “sequence”.
- At the opposite pole to the pure take-it-or-leave-it offer is *haggling*. A haggling session may contain several rounds of negotiations with a single bidder before the award mechanism designer moves on to next bidder. Haggling may also end up with a multilateral communication where the award mechanism designer compares bids from several buyers.

3.3.2 Discrepancies in Theoretical and Practical Classifications

It is worth stressing that the award mechanisms in the theoretical award mechanism design literature and those in the public procurement practice, though they share some similarities, are not identical. Table 3.1 contrasts award mechanisms in the literature and in EU public procurement on four dimensions: whether they enable one-way or two-



Note: arrows represent directions that signals are transmitted.

Figure 3.1: A Comparison between Ascending and Descending Price Auctions with Sealed-Bid Auctions

Table 3.1: Classification of Award Mechanisms in Theory and Practice

		One-way communication	Two-way communication
	Public procurement practice	Open procedure Restricted procedure	Negotiated procedure Competitive dialogue
Simultaneous communication	Award mechanism design literature	Ascending-price auction Descending-price auction First-price sealed-bid auction Second-price sealed-bid auction Scoring auction	n.a.
Sequential bilateral communication	Award mechanism design literature	n.a.	Take-it-or-leave-it offer Sequential process Haggling

way communication, and whether they enable simultaneous communication or sequential bilateral communication.

To recap, the four benchmark types of award mechanisms in EU public procurement practice are the open, restricted, negotiated and competitive dialogue procedures.⁷ The open and restricted procedures are sometimes collectively referred to as auctions. In the theoretical award mechanism design literature, the auction formats include the ascending-price auction, first-price sealed-bid auction, second-price sealed-bid auction, and scoring auction, while the bargaining formats include take-it-or-leave-it offer, sequential process

⁷See Sections 2.2 and 2.3 for more details.

and haggling.⁸

The auctions in theory and in practice facilitate one-way communication. Signals are transmitted from bidders to the award mechanism designer. The remaining award mechanisms allow two-way communication. Signals are transmitted from bidders to the award mechanism designer and from the award mechanism designer to bidders. Figure 3.2 illustrates the direction of signal transmission.

The main auction formats in theory and the EU benchmark award mechanisms are simultaneous-communication modes. The award mechanism designer processes signals from all bidders at the same time. Most of the time, the bargaining formats only facilitate sequential bilateral communication. The award mechanism designer communicates and decides whether to deal with the bidder, one at a time. Figure 3.3 displays the simultaneous and sequential bilateral communication modes.

In award mechanisms that allows two-way communications, a public procurer discusses design and terms of contract with bidders one by one. The literature tends to blur the boundary between the negotiated procedure in practice, which allows simultaneous two-way communication, and the sequential process in theory, which allows sequential bilateral two-way communication. Some theoretical papers occasionally refer to the take-it-or-leave-it-offer or the sequential process as the “negotiation” (e.g. Aktas et al., 2008, Bulow and Klemperer, 1996), while empirical papers refer to the negotiated procedure as the “negotiation” (e.g. Chong et al., 2014, Europe Economics, 2011, Lædre et al., 2006).

The award mechanism designer has more discretion on whether to contact an additional bidder in a sequential process than in a negotiated procedure or competitive dialogue. The award mechanism designer will search for the next bidder only when it is not satisfied with the current bidder. It is possible that the award mechanism designer accepts an extremely alluring bid, i.e. “jump-bid”, and stops looking for additional bidders (Bulow and Klemperer, 2009). In practice, the identification of the bidders who will attend the award process has been determined when the invitation to tender is issued to

⁸See Section 3.3.1 for more details.

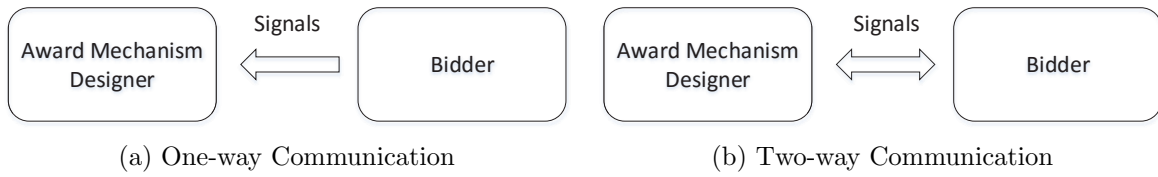


Figure 3.2: Directions of Signals Transmission

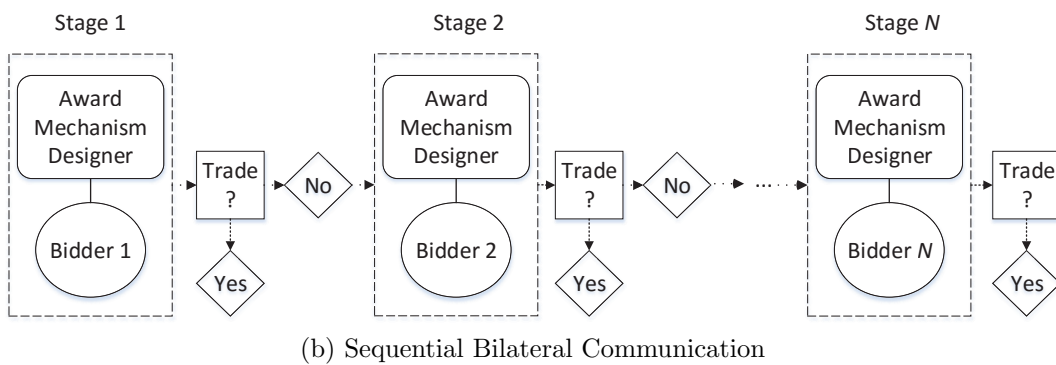
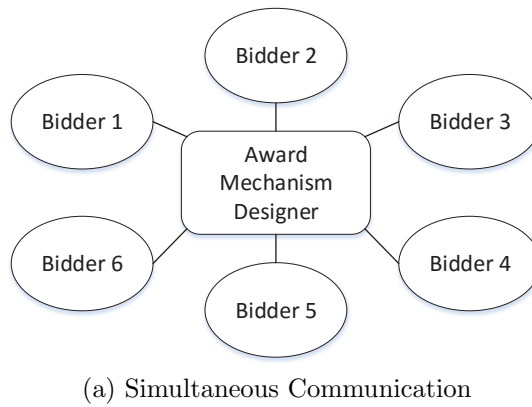


Figure 3.3: Parties in the Communication

qualified bidders, unless the procurement fails.

3.4 Award Mechanism Design

Information asymmetry is pervasive in transactions (McAfee and McMillan, 1987a). The party that possesses informational advantages (e.g. holding private information on production cost) can acquire surplus (i.e. informational rent) by just meeting the minimum requirement of the other party. If a bidder's private information becomes publicly known, his expected surplus is zero (Engelbrecht-Wiggans et al., 1983, Milgrom, 1981, Milgrom and Weber, 1982). People make efforts in award mechanism design to (at least partially) reveal bidders' true valuation, which bidders prefer to keep confidential in order to earn the informational rent. McAfee and McMillan (1987a) provide a thorough review of the award mechanism design literature before the late 1980s. Extending McAfee and McMillan (1987a), this section outlines the award mechanism design literature up to more recent years.

3.4.1 Popular Discussions since the Early Literature

The early award mechanism design literature focuses on the auction design under the single-seller-many-buyer context. As the seminal papers in award mechanism design, Vickrey (1961, 1962) establish the *revenue equivalence theorem*. Later on, Myerson (1981) and Riley and Samuelson (1981) generalise the *revenue equivalence theorem*, which then becomes a cornerstone of the award mechanism design.⁹

The *revenue equivalence theorem* is built on what is now referred to as the benchmark model that meets four conditions: (1) bidders' type (based on bidders' true valuation on the target) is drawn independently from a distribution, the cumulative distribution function of which is strictly increasing and continuous; (2) risk neutrality holds for each bidder and the seller; (3) the bidder with the highest type (i.e. highest true valuation

⁹See Jackson (2013) and Tadelis (2013) for summaries of this theorem.

on the target) wins; (4) the bidder with the lowest type has an expected payoff of zero. According to the *revenue equivalence theorem*, any auction game that meets these conditions generates the same payment rule and expected payoff for each type of bidder and yields the same expected revenue for the seller.

Take the four main auction formats as an example to illustrate the *revenue equivalence theorem*.¹⁰ The descending-price auction and the first-price sealed-bid auction are equivalent because in both cases bidders must decide the amount of their bid while not knowing other bidders' decisions and the winner pays the exact amount that he bids (Vickrey, 1961). A sophisticated bidder will offer a bid that is just above the second-highest bid so that he can win the contract and earn a profit of the difference between his own valuation and the value of the second-highest bid. Therefore, the price that derives from the descending-price auction and the first-price sealed-bid auction is, on average, the expectation of the second-highest valuation conditional on the valuation of the winner (McAfee and McMillan, 1987a).

In the ascending-price auction and the second-price sealed-bid auction, the price exactly equals the second-highest valuation. In an ascending-price auction, the bidder with the second-highest valuation will quit the competition once the price exceeds his valuation of the object. The bidder with the highest valuation wins and pays the amount of the second-highest valuation. The second-price sealed-bid auction gives bidders incentives to reflect their own valuation truthfully. If a bidder submits a bid that is higher than his true valuation, he runs a risk of winning with a negative profit; if a bidder submits a bid that is lower than his true valuation, he lowers the probability of winning and thus lowers his expected gain. The payment rule defined by the second-price sealed-bid auction is to pay the amount of the second-highest bid, which equals the second-highest valuation due to the incentive compatible mechanism.

Under the benchmark model setting, the expected second-highest valuation and the second-highest valuation are equal on average and the award mechanism designer would

¹⁰See Section 3.3.1 for an introduction of the four main auction formats

be indifferent to the four main auction formats. However, the validity of the *revenue equivalence theorem* is very sensitive to the assumed conditions. If any of the four conditions is removed, the revenue equivalence collapses and some award mechanism(s) become(s) superior to others.

3.4.1.1 Relaxing the Assumptions in the Benchmark Model

Here we discuss the situations when relaxing the assumptions in the benchmark model.

Information Asymmetry

When bidders' valuations are not drawn from a uniform distribution and bidders are asymmetric, bidders of the low valuation type perceive a higher level of competition than bidders of the high valuation type. The outcomes of the ascending-price auction and the first-price sealed-bid auction diverge (Maskin and Riley, 2000, 1985, Vickrey, 1961). Unlike the ascending-price auction, the first-price sealed-bid auction does not transmit signals of bidders' valuations between the competitors. In the first-price sealed-bid auction, low valuation bidders tend to bid more aggressively than high valuation bidders. The bidder with the highest valuation may not necessarily win.

Affiliated Valuations

When bidders share a common value of the target or bidders' valuations are highly affiliated, publicising information about the valuation of the target helps price discovery and lightens the problem of winner's curse (Milgrom and Weber, 1982).¹¹ Bidders adjust their valuations by referring to the valuations of others. This lessens the potential of negative gains and reduces excessive conservatism in bidding. Therefore, the ascending-price auction, which conveys valuation information across bidders, produces a higher revenue for the seller than the other three main auction formats.

¹¹For example, when bidding for an oil field, bidders' valuations of the oil field are affiliated. Their valuations depend on the same factors such as the storage and quality of oil, the difficulty of extraction and the expected oil price.

Risk Aversion

If buyers are risk averse instead of risk neutral, for the seller, the first-price sealed-bid auction strictly dominates the ascending-price auction and the second-price sealed-bid auction ([Harris and Raviv, 1981](#), [Holt, 1980](#), [Riley and Samuelson, 1981](#)). The expected buyers' gain is expressed as

$$\text{Expected buyers' gain} = \text{Private valuation} \times \text{Prob. of winning} - \text{Expected payment.}$$

Buyers bear a risk of earning a positive rent when they win and earning nothing when they lose. To increase the bid would increase the probability of winning and the amount of payment. By properly balancing this tradeoff, a buyer may still get a positive expected gain. Facing unobservable rivals' actions under the sealed-bid auction and uncertain value of the item, bidders are driven by risk aversion to offer a higher bid than that they would offer in the ascending-price auction. Because the winner pays the second-highest price instead of the price he bids in the second-price sealed-bid auction, the first-price sealed-bid auction generates the highest expected income for the seller. [Reynolds and Wooders \(2009\)](#) show that the seller can take advantage of buyers' risk aversion by offering a sufficiently but not prohibitively high buyout price and receive a higher expected revenue in a sequential process than by using the ascending-price auction.

The above discussion of risk aversion may, however, neglect possible interactions between information and risk aversion. When the value of the object is uncertain and valuations are common or affiliated, information can increase or lower the seller's revenue ([Albano, Dimitri, Pacini and Spagnolo, 2006](#)). Buyers tend to behave more conservatively and underbid when they are aware of the winner's curse and are more risk averse; they tend to bid more aggressively and overbid when they believe that the risk of the winner's curse is low.¹²

¹²[Kagel and Levin \(1986\)](#) provides empirical supports to this conclusion: providing public information about the target value lowers the seller's revenue in the presence of winner's curse and increases the seller's revenue in the absence of the winner's curse.

3.4.1.2 The Ability to Make Commitments

The early theoretical literature also discusses the benefits and costs of making commitments. By setting and committing to a reserve price, the seller will choose from one of the bidders that bid above the reserve price and refuse to sell the object when all bids are below the reserve price. A credible reserve price pushes buyers to bid higher and transfers part of buyers' surplus to the seller (Engelbrecht-Wiggans, 1993, McAfee and McMillan, 1987a). Riley and Zeckhauser (1983) show that the primary cost of haggling is a failure to sell at a high price and this cost cannot be made up by the price discrimination opportunities offered by haggling. The downside of committing to a reserve price is that the item is not sold even when bids are above the seller's valuation but below the reserve price. According to Mathews and Katzman (2006), a risk-averse seller would choose a low buyout price in a sequential process so that the object will be sold at the buyout price with a positive probability. This arrangement is likely to improve Pareto efficiency compared with a second-price sealed-bid auction. Such improvement takes place because the risk-averse seller is better off by shifting risk to risk-neutral bidders while the risk-neutral bidders are not worse off.

3.4.1.3 Competition and the Number of Bidders

Increasing the number of bidders strengthens the intensity of competition. The second-highest valuation on average increases as the number of bidders increases. The threat of losing forces high-valuation bidders to bid closer to their actual valuations. Therefore, the revenue of the seller on average increases with the number of bidders; as the number of bidders approaches infinity, the second-highest bid and hence the transaction price get infinitely close to the highest possible valuation (Harris and Raviv, 1981, Holt, 1979).

The *revenue equivalence theorem* generalises the effects of increasing the number of bidders on bidders' tactics under a Nash equilibrium. In a case of N bidders whose types are drawn from a uniform distribution defined over an interval $[\underline{v}, \bar{v}]$, a Nash equilibrium

is that each bidder bids $\frac{N-1}{N}v_i$, where v_i is bidder i 's actual valuation. $\frac{N-1}{N}$ is called the bid shading factor, which represents the fraction that a bidder is willing to pay out from his actual valuation and is defined over $(0,1)$.

The bid-shading factor is the outcome of balancing the tradeoff between the amount of payment and the probability of winning. Increasing the bid increases the probability of winning but also increases the amount of payment if one wins; lowering the bid makes one pays less if he wins but lowers the probability of winning. As the number of buyers increases, each buyer bids closer to his true valuation and the bid shading factor increases from nearly zero to one.

[Bulow and Klemperer \(1996\)](#) assess the benefits of a large number of bidders by marginal revenue (MR). Assuming the seller's expected revenue equals the MR of the successful buyer who has the highest MR among all buyers, the seller's expected MR with $N + 1$ buyers is greater than or equal to his expected MR with N buyers. [Bulow and Klemperer \(1996\)](#) note that when risk neutrality holds for both parties, the seller should not accept any "jump-bid" in exchange for not introducing additional bidders.

The strength of competition is also affected by the dispersion of bidders' valuations. [McAfee and McMillan \(1986\)](#) show that for certain distributions of bidders' valuations, e.g. normal and uniform distributions, increasing the variance increases the average payment to the seller and average rent to the winner. Holding the mean valuation constant, a larger variance is on average accompanied with a higher second-highest valuation and a greater difference between the highest valuation and the second-highest valuation.

In addition, competition can be arbitrarily enhanced by introducing price discrimination. Favouring bidders with lower valuation motivates bidders with higher valuation to increase their bids more than they otherwise would ([McAfee and McMillan, 1989](#)). The favourable term is an add-up to the lower valuation bids and has the potential to increase the second-highest bid perceived by the highest valuation bidder. For instance, to protect domestic firms, the seller announces that an operating license will be sold to a foreign firm only when the foreign firm bids 6% higher than the highest bid from domestic firms.

This stipulation on the one hand exploits surplus of the highest valuation bidder but on the other hand runs the risk of selling the item at a low price to a domestic firm.

3.4.1.4 Communication Costs

The communication cost of including a large number of bidders is non-negligible. The award mechanism designer incurs costs of locating and evaluating bidders and bidders bears bid-preparation costs and opportunity costs (Ehrman and Peters, 1994, McAfee and McMillan, 1988, Samuelson, 1985). Introducing too many bidders may increase social costs while not increasing social benefits. It may ultimately bring in many nearly identical bidders, not increase the dispersion of bidders' valuation distribution, and lead to a higher aggregate bid-preparation cost. The anticipation of competition with many low valuation bidders drives high valuation bidders away from investing time and capital in bid preparation (Tadelis and Bajari, 2006). With many potential homogeneous bidders or many potential low valuation bidders, to restrict the number of bidders and conduct a non-competitive procedure may improve social welfare (French and McCormick, 1984, Samuelson, 1985, Tadelis and Bajari, 2006).

McAfee and McMillan (1988) point out that the benchmark model fails to take communication costs into account. In absence of communication costs, implementing any of the four main auction formats together with a reasonable reserve price is an ideal choice (McAfee and McMillan, 1987a, Myerson, 1981, Riley and Samuelson, 1981). However, pure auctions are not efficient in terms of communication costs (Bulow and Klemperer, 2009, Ehrman and Peters, 1994, McAfee and McMillan, 1988). To convene an auction with simultaneous presence of multiple bidders, the award mechanism designer incurs a large amount of sunk cost. A sequential search enables the award mechanism designer to communicate with bidders one after another and avoid a large sum of sunk cost (McAfee and McMillan, 1988).

Bulow and Klemperer (2009) and Ehrman and Peters (1994) discuss the communication cost from the standpoint of bidders. Bidders bear opportunity costs because they

forego alternative trading opportunities while they are waiting for the result of a particular selling or buying scheme. A particular bidder faces a higher opportunity cost in auctions than in a take-it-or-leave-it scheme. An award mechanism designer tends to take more time to evaluate multiple bids in an auction than to compare one bid against the reserve price in a take-it-or-leave-it process. Admittedly, if bidders value time more and have a higher discount rate measured by time than the award mechanism designer, the award mechanism designer can extract a larger surplus by slowing down the selection process (Bulow and Klemperer, 1996). However, the award mechanism designer must balance the tradeoff between extracting bidders' surplus and discouraging participation (Bulow and Klemperer, 1996, Mathews, 2004).

Bulow and Klemperer (2009) examine the acquisition of firms, where the current price of the target firm and bidding history are publicly available to potential bidders. In a sequential process, bidders can use public information to decide entry. By entering the competition only when earlier bids are of low value, a later potential bidder can circumvent losing and spending entry cost in vain when previous bidders have higher valuations than its valuation but fail to win the contract.

3.4.2 More Recent Development

As early as forty years ago, Goldberg (1977) and Williamson (1976) put forward that in the presence of uncertainty and relationship-specific investments, the selection process should be designed to convey information that is not restricted to price. Not until the recent two decades do more people start to emphasise the nature of the target object other than price, most predominantly quality, in determining the proper award mechanism (Albano et al., 2017, Asker and Cantillon, 2008, 2010, Che, 1993, Laffont and Tirole, 1993, Manelli and Vincent, 1995, Tadelis, 2012, Tadelis and Bajari, 2006).

Multidimensional screening is more of a matter to award mechanism design under the single-buyer-many-seller context (i.e. procurement) than under the single-seller-many-buyer context. The quality of target object in a single-seller-many-buyer context is fixed

whether or not it is ex ante verifiable; but quality in procurement is endogenously determined throughout the life of procurement ([Asker and Cantillon, 2010](#)). When quality is an important factor in determining costs, selection solely based on price may result in the provision of the poorest quality ([Manelli and Vincent, 1995](#)). [Manelli and Vincent \(1995\)](#) show that the conditions to maximise buyers' expected profits, social surplus or seller's surplus are less stringent in a sequential process than in a price-only auction.

Competitive tendering is appropriate when quality is verifiable and is modelled into the selection criteria. By prescribing criteria and scoring rules, a procurer can score proposals on merits of both price and quality ([Dini et al., 2006](#)). The selection can then be implemented through any of the four basic auction forms. [Asker and Cantillon \(2008\)](#) show that a scoring auction dominates both a price-only auction and negotiation. [Asker and Cantillon \(2010\)](#) further show that a scoring auction performs better than bargaining in utility maximisation primarily because bargaining fosters a lack of commitment to delivering the contract in the agreed quality. They also demonstrate that the scoring auction is close to the optimal mechanism.

However, not all quality aspects can be easily verified. Unverifiable quality dimensions cannot be scored ([Albano et al., 2017](#), [Dellarocas et al., 2006](#)). For example, a consultant's proactivity in a legal service contract is difficult, if not impossible, to verify. Unverifiable quality nurtures suppliers' opportunistic behaviour ([Dellarocas et al., 2006](#)). Ex-ante opportunism takes place during the selection process. An undesirable supplier is awarded the contract because the buyer cannot properly judge the valuation of the goods or services with unverifiable characteristics. Post-contracting opportunism emerges when the contractor takes actions against the procurer's welfare (in order to reduce its own costs). This unsatisfactory outcome is unknown to the buyer until he takes ownership of the product. Besides, the unsatisfactory outcome may be detected by actual users but hard to verify by a third party.

To tackle opportunistic behaviour caused by non-verifiability of quality, reputation mechanisms are suggested, in which suppliers' future trading opportunities are affected

by their previous performance (Dellarocas et al., 2006). One approach is to build the past performance into a scoring auction (Albano et al., 2017). Handicapping suppliers with poor performance history is an effective threat to firms who intend to gain from non-verifiable quality when this approach is widely adopted and applied over time. An extreme case of this approach is to exclude cheating firms from future contracting opportunities (Board, 2011, Dellarocas et al., 2006, Klein and Leffler, 1981). Although this harsh punishment disciplines suppliers to provide the agreed quality, it may be harmful to the strength of competition in the future, especially for the procurement that requires special expertise that is acquired by only a few suppliers (Albano et al., 2017).

The other approach to deal with unverifiable quality is to negotiate with a limited number of reputable suppliers instead of using a competitive auction (Goldberg, 1977, Manelli and Vincent, 1995, Tadelis, 2012, Tadelis and Bajari, 2006). Unlike auctions which stifle communication, negotiation facilitates communication between the buyer and sellers. Negotiation is particularly helpful for complex contracts where both buyers and sellers share uncertainty about the profile of the final product (Bajari and Tadelis, 2001, Brown et al., 2016). Mutual communication lets both parties understand what exactly is to be procured, improves contract design and avoids wasting relationship-specific investments that lock up both parties (Brown et al., 2016).

Bajari and Tadelis (2001) and their subsequent empirical study Bajari et al. (2008) combine award mechanism design with cost-reimbursement rules. They point out that it is sometimes impossible to completely specify a contract and that leaving a contract incomplete may turn out to be necessary due to dynamic uncertainty. A cost-plus(-fixed-fee) contract is known to accommodating ex post adaptations well so that it is suitable for complex contracts which contain uncertain prospects and unverifiable features.¹³ Since the actual cost is unknown until the product is delivered, a competitive auction only enables competition on the “fixed fee”. More able efficient suppliers tend to ask for a higher fixed fee for providing efficiency. Bidding for the “fixed fee” results in choosing

¹³Section 3.2.1 discusses the cost-reimbursement rules: the cost-plus(-fixed-fee) contract and the fixed-price contract.

the least efficient supplier and the overall cost when accounting for the realised cost (i.e. the cost-plus component) is the highest. Instead, negotiation enables the procurer to get a more complete understanding of the ability of sellers and ensures choosing a more cost-effective supplier. Bajari and Tadelis suggest a rule of thumb: for simple contracts with a high level of completeness, to use a fixed-price contract combined with competitive tendering; for complex contracts with low level of completeness, to negotiate a cost-plus contract with a reputable seller; for intermediately complex contracts that can be specified with moderate costs, a fixed-price contract and competitive tendering is favoured when the number of potential bidders is large, whereas the cost-plus contract and negotiation is preferred when the number of potential bidders is small.

While accepting the benefits of negotiating contracts with uncertain aspects, some knowledge of contract attributes and bidders' valuations is nevertheless a prerequisite for using negotiation. When a bidder can exploit the buyer's ignorance and make a credible take-it-or-leave-it offer, it may extract a significant amount of surplus. Buyers who lack knowledge are vulnerable to this trap in negotiation. On the other hand, a simultaneous competitive auction allows the buyer to obtain a substantial amount of surplus without any pre-required knowledge ([Bulow and Klemperer, 2009](#)). Thus, when the buyer has little knowledge, a competitive auction that considers past performance should be favoured over negotiations.

3.4.3 Considerations on Corruption and Collusion

Corruption and collusion are two interlinked crimes that undermine the efficiency of award mechanisms in selling an item at a high price or buying products at a cost-effective price. We sketch some fundamental ideas from the literature on these two topics.

Corruption is inherently a principal-agent problem ([Celentani and Ganuza, 2002](#), [Lambert-Mogiliansky and Sonin, 2006](#), [Rose-Ackerman, 1975](#)). In public procurement, the principal is a public authority which purchases the goods or services. A public official or an external expert is the procuring agent who is supposed to act on behalf of the public

authority. Corruption occurs when the the procuring agent distorts the selection criteria to receive bribes from bidders who are treated favourably in the distorted selection. Corruption comes from the agents' discretionary power (Burguet and Che, 2004, Rose-Ackerman, 1975). Therefore, transparent rule-based award mechanisms, e.g. auctions, that limit the the procuring agent's discretionary power and expose the the procuring agent's behaviour to the public supervision can alleviate the problem (Lengwiler and Wolfstetter, 2006).

The early auction literature, represented by the literature on the revenue equivalence theorem (e.g. Myerson, 1981, Riley and Samuelson, 1981) assumes that participants bid non-cooperatively. However, collusion occurs when a group of bidders reach an explicit or tacit agreement and play coordinately to soften price competition and increase joint profit (Albano, Buccirosi, Spagnolo and Zanza, 2006). When compounded with collusion, it is not easy to solve the problem of corruption. As a remedy for corruption, transparency nevertheless facilitates collusion because the collusive cartel can swiftly detect and retaliate against any bidder who betrays the agreement (Stigler, 1964). Moreover, the the procuring agent may direct the coordination among collusive bidders and share the illegal gains (Albano, Buccirosi, Spagnolo and Zanza, 2006). Sequential purchasing of several different but related items is also a channel for collusive cartels to punish internal deviations (Klemperer, 2002, McAfee and McMillan, 1987a). It allows bidders to interact repeatedly and at least reveals some information after each award.

Collusion is less likely to be sustained when the number of bidders is large. It is difficult to coordinate a large number of competitors, and each bidder's share of collusive gains declines with the increasing number of bidders (Klemperer, 2002). As collusion effectively reduces the number of bidders and changes the bidding distribution, setting a reserve price, which increases with the number of participants in the cartel, can restore the effects of competition (McAfee and McMillan, 1987a).

3.5 Conclusions

This chapter attempt to provide an outline theoretical literature review of public procurement, which contains two main topics: contract design and award mechanism design. Both contract design and award mechanism design deal with rent extraction and incentive provision. The theories under the contract design – cost-reimbursement rules and the choice between public-private partnerships (PPPs) and traditional procurement – make less stringent assumptions and are closer to the real world than the theories under the award mechanism design. Thus, contract design theories seem to be more complete and practically valid than award mechanism theories.

Award mechanism design requires sophisticated skills. Many interacting factors should be considered, including, but not limited to, what has been discussed: common or affiliated valuations versus independent valuations, risk preference of both buyers and sellers, ability to make commitment, competition and the number of (potential) bidders, communication costs of both parties, dispersion of bidders' valuations, discrimination arrangements (e.g. discrimination based on valuation and discrimination based on past performance), quality dimensions in addition to price as award criteria, the level of contract completeness, buyer's competence, and problems of corruption and collusion.

There are indications that the waste of public money is pervasive ([Bandiera et al., 2009](#), [Coviello and Mariniello, 2014](#), [Eklöf, 2005](#)). Applying inappropriate award mechanisms is a factor leading to such waste. Therefore, empirical studies that uncover the facts of award mechanism practice in public procurement and check practice against theory should always be welcomed. This helps the public sector to understand what has been done poorly and make improvements accordingly.

Chapter 4

Study 1: Choice of Award Mechanism in UK Public Procurement

4.1 Introduction

Based on UK public procurement data from 2009 to 2015, this study estimates the probability of adopting the four EU benchmark award mechanisms (the auction-based open and restricted procedures, and negotiation-based negotiated procedure and competitive dialogue) using the logit model. It focuses on the relationship between the choice of award mechanism, contract complexity, quality concerns and buyer's experience.

This study is among the first to compare the competitive dialogue and other procedures. To our knowledge, it is also the first study that explicitly tests the link between quality concerns (an important factor suggested by the theoretical literature) and the choice of award mechanism rather than proxying quality concerns by the level of complexity. In addition, we uncover some facts about the reputation mechanism that considers bidders' past performance in public procurement selection.

Auctions are known for providing competition and avoiding favouritism ([Bulow and Klemperer, 1996](#)). Because of the market discipline introduced by the competition of many bidders, auctions impose fewer requirements than negotiations on the award mechanism designer's knowledge in reaching a desirable outcome. Mainly due to these reasons, procurement policymakers advocate the use of auctions over negotiations. For example, the current EU public procurement directives encourage the use of open or restricted procedures and require justification for using negotiated procedure or competitive dialogue

(which contain a stage of negotiation).

There are reasons why negotiation may be preferred to an auction-based award mechanism. Pre-contracting communication costs and post-contracting renegotiation costs should be counted in designing award mechanisms (Ehrman and Peters, 1994, McAfee and McMillan, 1988, Tadelis and Bajari, 2006). The costs of conducting auctions, e.g. costs of specifying awarding rules, are higher than those of conducting negotiations. Such costs erode benefits from competition created by auctions and are usually high when it is difficult to clearly specify the contract.

Although the (potential) competition of extra bidders improves the outcomes of both auctions and negotiations (Bulow and Klemperer, 2009), the benefits of auctions rely more on the number of participants and the distribution of participants' valuations (Calzolari and Spagnolo, 2009, French and McCormick, 1984). In particular, auctions are more likely to produce the expected outcome when there is a group of heterogeneous suppliers.

When contracts are complex and characterised by uncertainties, it is misleading to judge award mechanisms only on the monetary cost of the tenders (Bajari et al., 2008, Bajari and Tadelis, 2001, Goldberg, 1977, Williamson, 1971, 1976). Instead, the quality of the product and the total final payment encompassing any renegotiation costs should be considered. These considerations favour negotiations. Auctions by their nature impede communications that customise contract design and hinder adaptation to ex post changes. Bajari et al. (2014) and Decarolis (2014) show empirical evidence that ex post renegotiation costs are high. Cameron (2000) reveals that contracts awarded through first-price sealed-bid auction are more susceptible to renegotiations than those awarded through negotiations in US long-term supply contracts in the energy industry.

When quality is a key concern, regardless of its verifiability, a reputation mechanism that evaluates bids at least partially on the basis of bidders' past performance is a helpful weapon against opportunistic behaviour (Albano et al., 2017, Board, 2011, Coviello et al., 2018, Klein and Leffler, 1981, Spagnolo, 2012). An example of the reputation mechanism is that procurers discriminate against bidders that underperformed in past deliveries.

Translated into EU public procurement practice, this arrangement is a pre-qualification process implemented by a restricted procedure, a negotiated procedure or a competitive dialogue.

Many theoretical studies investigate the optimal choice of award mechanism ([Albano et al., 2017](#), [Bajari and Tadelis, 2001](#), [Bulow and Klemperer, 1996, 2009](#), [McAfee and McMillan, 1988](#)). Some empirical studies test the impact of award mechanism on procurement outcomes ([Cameron, 2000](#), [Coviello et al., 2018](#), [Decarolis, 2014](#), [Eklöf, 2005](#), [Europe Economics, 2011](#), [Hyytinen et al., 2018](#)). However, empirical analyses that examine the choice of award mechanism are scant. [Bajari et al. \(2008\)](#), [Baldi et al. \(2016\)](#) and [Chong et al. \(2012, 2014\)](#) seem to be the only empirical studies on this topic.

The remainder of the chapter is organised as follows. Section [4.2](#) reviews relevant theoretical and empirical studies. Section [4.3](#) introduces the data source and provides data descriptions. Section [4.4](#) discusses the empirical models relevant to this study: the dichotomous logit model, the multinomial logit model and the nested logit model. Section [4.5](#) explains the endogeneity and multicollinearity problems in this study. Section [4.6](#) discusses the results from the dichotomous logit model and the multinomial logit model and Section [4.7](#) concludes. The Appendix provides results from the nested logit model as a robustness check of the results from the multinomial logit model.

4.2 Relevant Literature

This chapter presents an empirical study on the factors (contract complexity, quality concerns and buyer's experience) that are related to the choice of auction-based and negotiation-based EU benchmark award mechanisms. It is closely related to the theoretical literature that compares auctions and negotiations under different circumstances. This literature focuses on the impact of the number of bidders, complexity and quality concerns on award mechanism design.

This study shares a similar theme with a small empirical literature that explores the influential factors on the choice of award mechanism. Among these factors, complexity and buyer's experience have attracted the most attention. However, none of them has explicitly tested the relationship between quality concerns and the award mechanism choice. This study is also related to a larger empirical literature on the choice of award mechanism and procurement outcomes.

4.2.1 Theoretical Framework

Auctions have been recognised as an effective mechanism in extracting surplus for the award mechanism designer when the number of participants is large, communication cost is low, and the contract is well-specified (Bulow and Klemperer, 2009, McAfee and McMillan, 1987a, Myerson, 1981, Riley and Samuelson, 1981, Tadelis, 2012). According to the revenue equivalence theorem, a cornerstone of the award mechanism theory in the single-seller-many-buyer context, the seller benefits from the competitive pressure created by auctions (Myerson, 1981, Riley and Samuelson, 1981, Vickrey, 1961, 1962).¹ Increasing the number of participants pushes the highest- and second-highest valuations to a high level and the difference between these two values becomes small. In order to win, the buyer with the highest valuation has to bid closer to its true valuation, and therefore more surplus is transferred to the seller. This competitive environment allows the award mechanism designer to extract surplus without acquiring knowledge of bidders' valuations (Bulow and Klemperer, 2009). Bulow and Klemperer (1996) show that under certain assumptions, the extra competition from auctions is more effective than any skillful negotiation in extracting surplus from firms.

However, although under both auctions and negotiations, increasing the number of (potential) bidders places the award mechanism designer in a more favourable position for rent extraction, the effectiveness of auctions depends particularly heavily on the number of bidders and also on the distribution of bidders' valuations (Calzolari and Spagnolo, 2009,

¹See more details of the revenue equivalence theorem in Section 3.4.1.

French and McCormick, 1984, Samuelson, 1985). A small group of bidders is less likely to create a competition between high valuation bidders. In addition, if there is not much dispersion in bidders' valuations, introducing more participants creates higher screening costs for the seller and incurs social welfare loss as more bidders waste their preparation costs (Ehrman and Peters, 1994, McAfee and McMillan, 1988). These higher costs of conducting auctions rather than negotiations can undermine the benefits of auctions.

Goldberg (1977) and Williamson (1971, 1976) point out that buyers care about quality in addition to price, but their preferences on quality cannot be effectively conveyed through auctions. Although scoring auctions can incorporate the provision of quality into a scoring system, scoring an auction requires the quality to be clearly stated (Albano et al., 2017, Dellarocas et al., 2006). There are indeed cases when buyers have a sense of what they need but are unable to clearly specify their needs in contract terms. In addition, it is expensive (if not impossible) to create a list of exhaustive scoring rules (Albano et al., 2017, Dellarocas et al., 2006).

Accounting for non-contractible quality and ex post renegotiation costs, some researchers argue that negotiating with reputable suppliers is better than an auction when contracts are complex and incomplete (Goldberg, 1977, Manelli and Vincent, 1995, Tadelis, 2012, Tadelis and Bajari, 2006). On the one hand, negotiations facilitate communication that enhances mutual understanding of what is purchased and therefore reduce the need for ex post changes. On the other hand, negotiations lend themselves to cost-plus compensation rules, which allow for and accommodate the need for renegotiating unavoidable incomplete contracts.²

The other strand of the literature advocates a reputation mechanism to ensure that suppliers deliver satisfied quality with a reasonable payment. The contractor is selected partially based on competitors' track records (Albano et al., 2017, Spagnolo, 2012). A harsh punishment for suppliers with poor performance is to ban them completely from future trading opportunities (Board, 2011, Coviello et al., 2018, Klein and Leffler, 1981).

²See 3.4.2 for detailed reasoning about this statement. See the definition of cost-plus contracts in Section 3.2.1.

Facing the threat of being disadvantaged in future competitions, suppliers are less likely to behave opportunistically and to profit from non-verifiable quality at the cost of buyers.

The EU public procurement directives apply a reputation mechanism in a pre-qualification arrangement that excludes bidders who do not satisfy certain requirements. The restricted and negotiated procedures and competitive dialogue contain the pre-qualification process, while the open procedure does not.

4.2.2 Empirical Studies

This study is closely related to empirical work by [Bajari et al. \(2008\)](#), [Baldi et al. \(2016\)](#) and [Chong et al. \(2012, 2014\)](#). These studies examine how the characteristics of the contract and the buyer are linked to the choice of award mechanism. [Bajari et al. \(2008\)](#) find a positive correlation between the level of contract complexity and the choice of negotiation rather than auction and a positive correlation between the buyer's experience and choice of auctions, using data from Northern California private sector building contracts between 1995 and 2000. They also find that more reputable suppliers are more likely to be selected regardless of the choice of award mechanism. This indicates that buyers consider suppliers' past performance in bid evaluation.

[Baldi et al. \(2016\)](#) offer an analysis of the choice between the open and negotiated procedures based on public contracts awarded by Italian municipalities in the period 2007–2012. They show a positive correlation between contract complexity and the use of the negotiated procedure. Their results suggest a more pronounced positive relationship between the two when the contracting municipality exhibits a lower level of corruption.

[Chong et al. \(2012\)](#) and [Chong et al. \(2014\)](#) base their studies on French public procurement. The prediction from [Chong et al. \(2012\)](#) indicates that considerations of avoiding suspicion of favouritism and corruption make public authorities favour auctions over negotiation. Using nonparametric approaches, [Chong et al. \(2014\)](#) show that auctions are more frequently used by more experienced buyers. They also find that contract value and

contract duration, as proxies of complexity, have no apparent link with the choice of any particular award mechanism for works contracts in France. However, their results should be interpreted with caution because their results may capture impact of other factors that they fail to consider simultaneously.

This study is also related to a larger empirical literature on the impact of award mechanisms on ex ante procurement outcomes (e.g. the number of participants and winning rebates) and ex post procurement outcomes (e.g. renegotiation costs, cost overruns, and time overruns) (Cameron, 2000, Coviello et al., 2018, Decarolis, 2014, Eklöf, 2005, Europe Economics, 2011, Hyytinen et al., 2018). These studies provide empirical evidence on why a particular award mechanism should be favoured or opposed.

4.3 Data

This study employs UK public procurement data from the Tenders Electronic Daily (TED) in logit models to analyse the probability of using the four EU benchmark award mechanisms. This section introduces the data source and describes the data.

4.3.1 Data Source

This research is based on UK public procurement data released on the TED. The TED is the official site for EU member states to publicise public procurement contracts.³ The time horizon of the data is from 2009 to 2015.

We choose the UK data in this period mainly because of our interest in competitive dialogue. First, as a pioneer in adopting innovation in public procurement, the UK swiftly enforced the EU directive 2004/18/EC, which formally introduced competitive dialogue as a new award mechanism, through the Public Contracts Regulations 2006 on 31 January 2006. By the end of 2008, public authorities should have developed some

³See detailed description of the data source in Section 2.4.

understanding of competitive dialogue and are less likely to reject this procedure merely because they are unfamiliar with it. The UK government and municipalities are active in public procurement (See Figure 2.2). The relatively large sample size from the UK allows us to catch sufficient variations for our prediction model.

Second, the EU changed the common procurement vocabulary (CPV) used to classify the type of procurement, in September 2008. The old and new CPV are difficult to compare because they have a many-to-many matching, i.e. there are some overlaps amongst the old and new definitions. Lastly, European Union Open Data Portal (EUODP), the source of the data, points out that more recent public procurement data have better quality.⁴ In order to improve data quality, the EU regularly updates the public procurement standard forms used by public buyers to publicise their procurement needs. However, data from 2016 and 2017 are excluded to avoid estimation bias that may be introduced by the adoption of the most recent EU public procurement directives which have been implemented in the UK nationwide since 2016.

We use information from contract notices (CNs) rather than contract award notices (CANs).⁵ The choice of award mechanism is an ex-ante decision. Public buyers have decided the type of award mechanism to be used by the time they publish CNs. While CANs summarise contractual outcomes after interactions with bidders, CNs more accurately reflect public buyers' ex-ante perceptions of contracts and thus are more relevant to award mechanism design. According to the EUODP, the choice of award mechanism is a CN/CAN decision. Therefore, it is better to examine this decision at an aggregate (i.e. CN/CAN) level than in a subcontract (i.e. lots/contract awards) level. The cost of using CNs is forgoing the number of bidders as an explanatory variable, which appears in CANs. This variable is expected to be endogenous to the award mechanism choice.

⁴See the Notes & Codebook in the EUODP website <https://data.europa.eu/euodp/en/data/dataset/ted-csv>.

⁵See Section 2.4 for descriptions of CNs, CANs, lots and awards

4.3.2 Data Description

Table 4.1 summarises the definitions of the main variables. The EU public procurement directives prespecify three contract types: works contracts, mainly for construction projects; services contracts, for example, technical, financial and legal services; and supply contracts, such as water and electricity supply.

There are four basic types of award mechanisms: the open procedure, restricted procedure, negotiated procedure and competitive dialogue. The open and restricted procedures are auctions that do not allow any discussion between buyer and sellers before or after bid submission. Competitive dialogue and the negotiated procedure permit different degrees of negotiation. While the open procedure allows any interested supplier to submit a bid, the remaining three procedures may pre-select bidders to limit the number of participants.⁶

We follow the literature by using contract value and duration as proxies of complexity (Bajari et al., 2008, Chong et al., 2014). Arguably, a more complex contract is usually more expensive and tend to take more time to develop. But instead of a contract value signed by the two parties, an estimated contract value is used. The estimated value reflects the public buyer’s perception of complexity when deciding the award mechanism to be used. These estimated values are adjusted by the GDP deflator to remove the effects of inflation.

We also use the number of lots as an additional measure of complexity. There are two arguments for this measure. First, more complex contracts involve more personnel from different professional fields, so more sub-contracts are needed. Second, the use of lots means that the responsibility of each party can be further clarified. The greater the number of smaller sub-contracts, the easier it is to carry out the overall contract.

A quality criterion dummy is introduced. It equals 1 for the criterion of “most economically advantageous tender”, which evaluates quality together with the price; much

⁶See Section 2.2 for more information on award mechanisms.

more rarely it equals 0 for the criterion of “lowest price”, which considers only the price.

We take the buyer’s experience as an explanatory variable because it may play a role in both the costs of implementing an award process and the buyer’s bargaining power. Following [Chong et al. \(2014\)](#) and [Bajari et al. \(2008\)](#), the number of times a buyer has appeared in the dataset is used as a measure of buyer’s experience.

The common procurement vocabulary (CPV) and region are used as control variables. The EU uses the CPV to classify contracts with further details beyond the contract type. The CPV has five levels and the first level contains 45 categories.⁷ Because the variation in the CPV for contracts awarded through the negotiated procedure and competitive dialogue is small, the CPV is not included in estimations that contain these two procedures. Lastly, we manually assign the region of the procuring authority. This variable is used to capture demographic and economic fixed effects.

⁷See the “Guide to the Common Procurement Vocabulary (CPV)” by [European Commission \(2008\)](#) for details. URL: https://simap.ted.europa.eu/documents/10184/36234/cpv_2008_guide_en.pdf.

Table 4.1: Variable Definition

Variable	Definition
Contract type	Defines the attribute of a contract. Contains three values: works, services and supply contracts.
Award mechanism	Contains four values: the open procedure, the restricted procedure, the negotiated procedure, the competitive dialogue.
Log contract value	The natural logarithm of the estimated contract value (in EUR, without VAT). A measure of complexity.
Duration	Duration of the contract in months. A measure of complexity.
No. of lots	The number of (potential) subcontracts that a contract is to be divided into. A measure of complexity
Quality criterion dummy	The general award criteria. Equals to 1 for "most economically advantageous tender" and 0 for "lowest price". A measure of quality concerns.
Log experience	The natural logarithm of the cumulative sum of CNs published by each public authority during the sample period. A measure of buyers' experience.
CPV code	Common procurement vocabulary. Used to classify in detail what is to be purchased.
Region	The place where the procuring authority locates. Contains six categories: England outside London, Greater London, Scotland, Wales, Northern Ireland and overseas territory.

Table 4.2 presents descriptive statistics of the main variables. Services contracts took up nearly 60% of UK public procurement, supply contract around 30% and works contracts just over 10%. The restricted procedure was most frequently used by the UK public authorities, followed by the open procedure, the negotiated procedure and competitive dialogue. Most contracts were evaluated by criteria on both price and quality. The majority of UK public procurement was initiated by public authorities located in England and the number of procurement contracts is greater in Greater London than in Scotland, Wales or Northern Ireland. This indicates that factors such as population and economic level affect the demand for public procurement.

All continuous variables are positively skewed. Since the degrees of skewness of contract value and experience are large, we use natural logarithms to transform these two variables. Nearly 75% of contracts did not use lots. Among the contracts with lots, the number of lots varies.

Next, we turn to figures for a closer look at some variables. Figure 4.1 summarises contract type by year. There are more services contracts than any other type in each year throughout the sample period. According to Figure 4.2, the use of the restricted procedure declined dramatically from nearly two-thirds of contracts in 2009 to roughly one-third of contracts in 2015. By contrast, the frequency of the open procedure surged. The uses of the negotiated procedure and competitive dialogue were fairly stable.

Figure 4.3 shows the distribution of award mechanism by contract type. For works contracts, the weight of restricted procedure (nearly 80%) is very much larger than the other award mechanisms; for services contracts the weight of the restricted procedure (more than 50%) is higher than the weight of the open procedure (just below 40%); for supply contracts the open procedure has the highest weight (more than 50%) and the weight of the restricted procedure is around 40%.

We learn from Figure 4.4 that a higher percentage of services contracts than works or supply contracts use the “most economically advantageous tender” criterion. The different patterns of award mechanism and award criteria exhibited by the services, supply and

Table 4.2: Descriptive Statistics

<i>Panel A: Categorical Variables</i>					
	No. of Obs.	Proportion			
Contract type					
Works	4632	12.16%			
Services	22547	59.18%			
Supply	10922	28.67%			
Award mechanism					
Open	15106	39.65%			
Restricted	20188	52.99%			
Competitive dialogue	711	1.87%			
Negotiated	2094	5.50%			
Others	2	0.01%			
Criteria					
Lowest price	1586	4.16%			
Most economically advantageous tender	36226	95.08%			
Not specified	289	0.76%			
Region					
England outside London	23356	61.30%			
Greater London	5992	15.73%			
Scotland	4556	11.96%			
Wales	1738	4.56%			
Northern Ireland	2451	6.43%			
Overseas	8	0.02%			
All observations	38101	100.00%			
<i>Panel B: Continuous Variables</i>					
	No. of Obs.	Mean	CI (lower)	CI (upper)	S.D.
Contract value (€)	38101	10500577	10182833	10818320	31643376
Duration (days)	38101	42.22	42.00	42.44	22.26
No. of lots	38101	1.60	1.53	1.66	6.15
Experience	38101	95.43	93.92	96.94	149.94
	Min.	25th	50th	75th	Max.
Contract value (€)	12031.59	402423	1246170	6015793	368958721
Duration (days)	2.24	24.01	36.02	48.03	162
No. of lots	0	0	0	2	393
Experience	1	15	45	106.75	882

Notes. Experience is measured by the cumulative sum of contract notices (CNs) by each public authority.

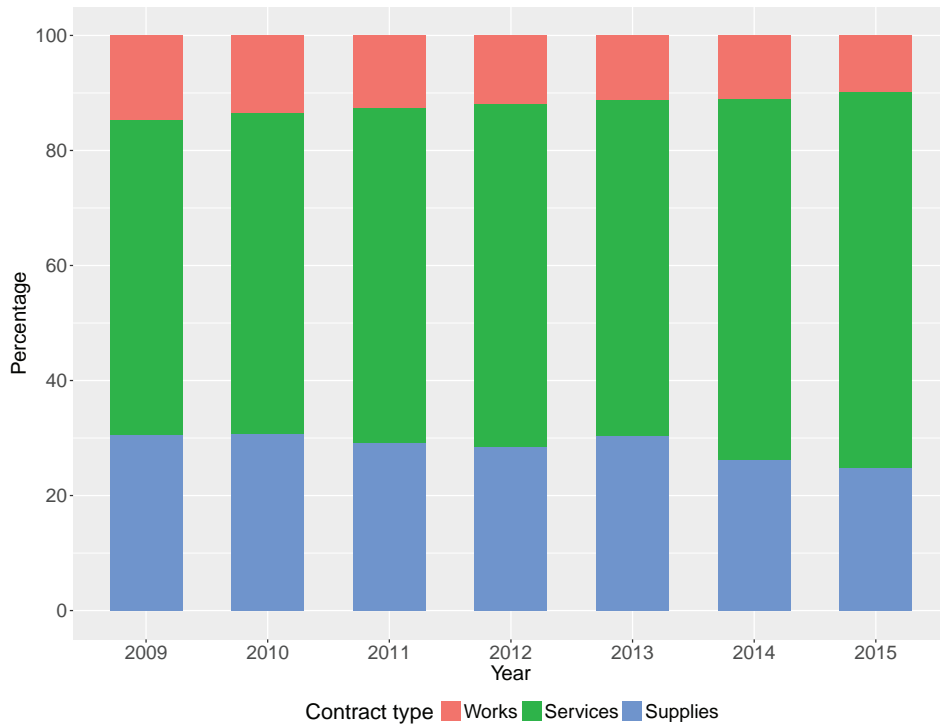


Figure 4.1: Distribution of Contract Type by Year

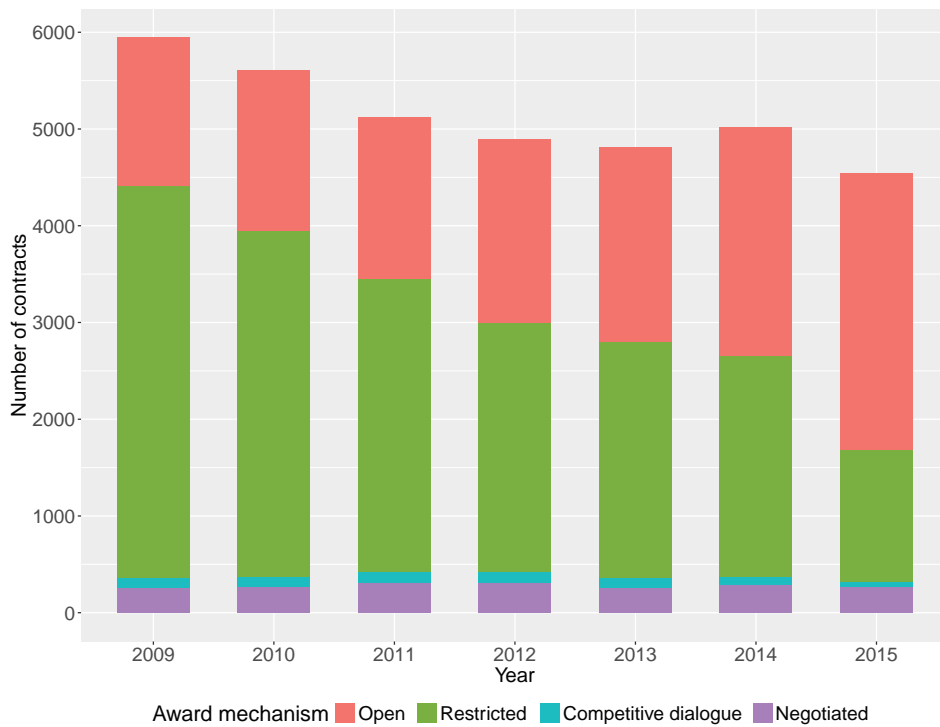


Figure 4.2: Number of CNs by Award Mechanism

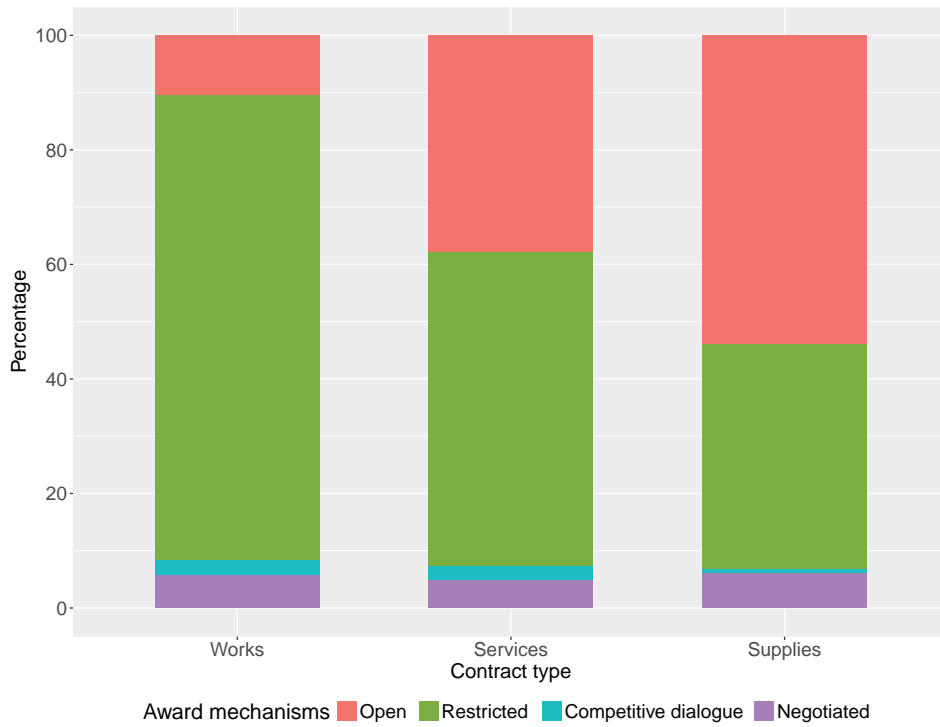


Figure 4.3: Distribution of Award Mechanism by Contract Type

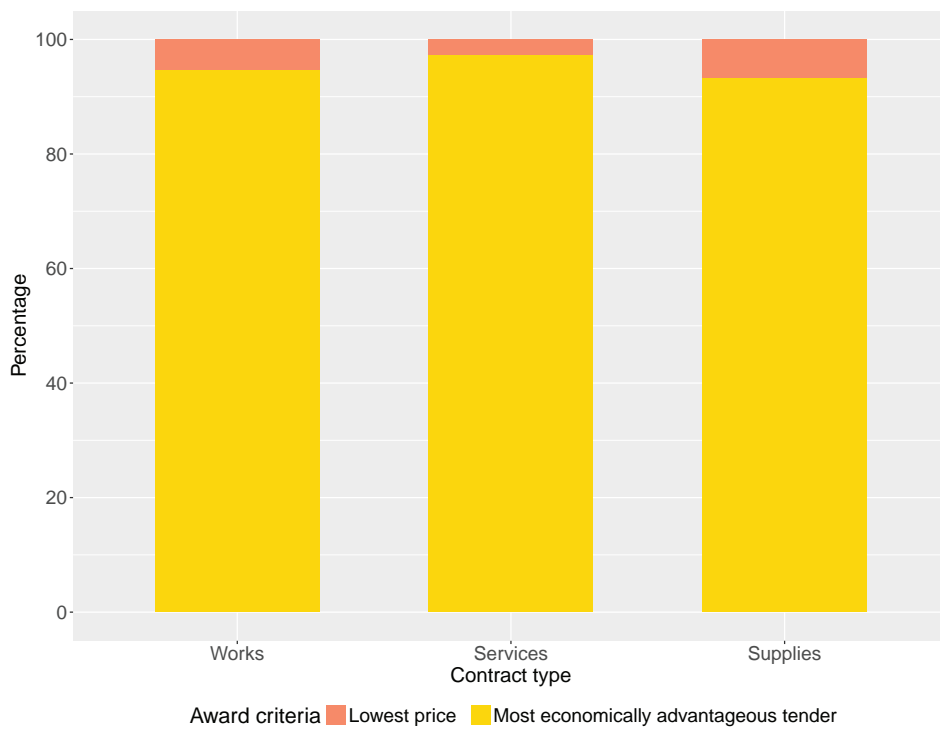


Figure 4.4: Distribution of Award Criteria by Contract Type

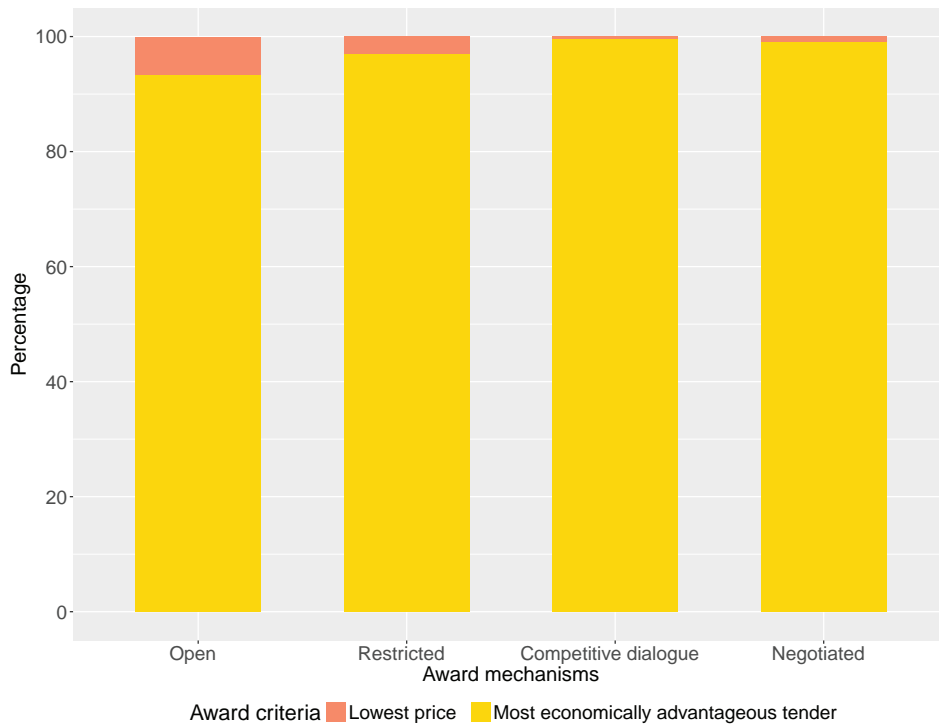


Figure 4.5: Distribution of Award Criteria by Award Mechanism

works contracts imply that attributes of these contracts may differ, so regressions for each contract type should be done separately.

Figure 4.5 depicts award criteria by award mechanism. It shows that the open procedure is the award mechanism most likely to be used in combination with the “lowest price” criterion, followed by the restricted procedure. This result, though preliminary, supports the suggestion from the theory that quality concerns and the use of negotiation should be positively correlated.

According to Figure 4.6, buyers with more experience tend to use the open procedure more often. This finding supports the argument that accumulating experience lowers administrative costs of auction and is in line with the results from [Bajari et al. \(2008\)](#) and [Chong et al. \(2014\)](#). However, the average buyer’s experience is higher for the negotiated procedure than for the restricted procedure.

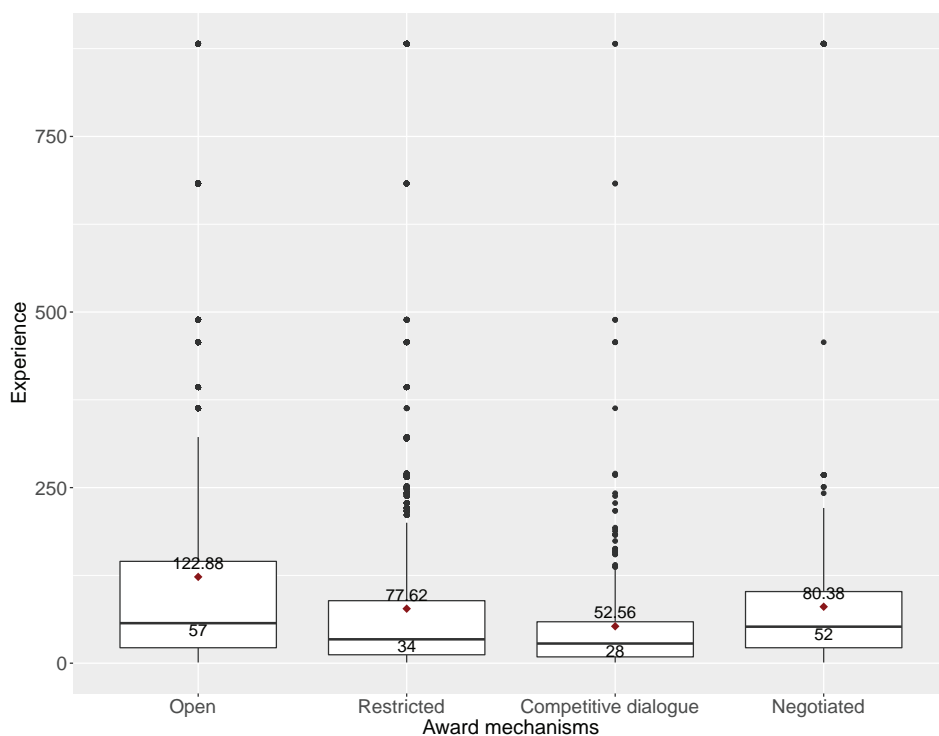


Figure 4.6: Buyers' Experience by Award Mechanism

Note. 1. This is a box-and-whisker plot. The lower bound of a rectangle is the 25th percentile, the upper bound the 75th percentile, and the horizontal line in the rectangle the median. The values of medians are marked below the median lines. The two vertical lines above and below each rectangle represent the range of observations that are within 1.5 times the interquartile range (the difference between 75th and 25th percentiles). The diamond point within each rectangle indicates the mean value, which is labelled above the point. 2. Experience is measured by the cumulative sum of contract notices (CNs) by each public authority.

4.4 Methodology

The choice of award mechanism is a question of probability, which can be evaluated with the logit model (or logistic model). The empirical analysis in this chapter uses three common logit models. This section firstly introduces the simplest logit model and then moves to the more complicated models.

Section 4.4.1 introduces the dichotomous logit model, which is suitable for a binary dependent variable. We use the dichotomous logit model to compare the choice of the open and restricted procedures. Section 4.4.2 introduces the multinomial logit model, which is appropriate when the dependent variable contains multiple categories. This model is used to compare the choice of the four benchmark award mechanisms. However,

the multinomial logit model imposes the assumption of *independence from irrelevant alternatives* (IIA). IIA may not be valid in the decision of using the four EU benchmark award mechanisms. Section 4.4.3 illustrates cases when IIA fails. The nested logit model partially relaxes the IIA assumption and may be more suitable than the multinomial logit model to examine the choice of the four EU benchmark award mechanisms. Section 4.4.4 discusses the techniques under the nested logit model.

4.4.1 Dichotomous Logit Model

Before turning to the dichotomous logit model, we consider the linear-probability model for dichotomous data. Given a procurement with two potential choices of award mechanism, auction and negotiation, a dummy variable for the choice of award mechanism Y can be coded as 1 for auction and 0 for negotiation. Suppose contract value X is a factor that affects the choice of award mechanism. The conditional probability π_i of using the auction for procurement i when $X = x_i$ is

$$\pi_i \equiv Pr(Y_i) \equiv Pr(Y = 1 | X = x_i) \quad (4.1)$$

and the conditional expectation $E(Y | x_i)$ is

$$E(Y | x_i) = \pi(1) + (1 - \pi_i)(0) = \pi_i. \quad (4.2)$$

If a linear-probability model is used to capture the dependency of Y on X , then

$$Y_i = \alpha + \beta X_i + \varepsilon_i \quad (4.3)$$

and

$$\pi_i = E(Y_i) = \alpha + \beta X_i, \quad (4.4)$$

where $\varepsilon_i \sim N(0, \sigma_\varepsilon^2)$, ε_i and $\varepsilon_{i'}$ are independent and identically distributed for $i \neq i'$, and X and ε are independent.

The linear-probability model is problematic because it cannot confine the probability π_i to the interval of $[0, 1]$. To overcome this problem, the cumulative probability distribution function of the logistic distribution

$$\Lambda(z) = \frac{1}{1 + e^{-z}} \quad (4.5)$$

can be used to transform π_i into the unit interval $[0, 1]$ and retain the linear structure. Hence, the linear dichotomous logit model is produced:

$$\pi_i = \Lambda(\alpha + \beta X_i) = \frac{1}{1 + \exp[-(\alpha + \beta X_i)]}. \quad (4.6)$$

Rearranging Equation 4.6 produces

$$\frac{\pi_i}{1 - \pi_i} = \exp(\alpha + \beta X_i). \quad (4.7)$$

Taking the natural logarithm of both sides of Equation 4.7, we have

$$\Lambda^{-1}(\pi) = \log_e \frac{\pi_i}{1 - \pi_i} = \alpha + \beta X_i. \quad (4.8)$$

The ratio $\frac{\pi_i}{1 - \pi_i}$ is the *odds* of auction (i.e. when $Y_i = 1$). The inverse transformation $\Lambda^{-1}(\pi) = \log_e \frac{\pi_i}{1 - \pi_i}$ is called the *logit* of π_i and would be interpreted as the *log-odds* when $Y_i = 1$. While the odds is bounded below by 0 and unbounded above, the logit is symmetric around 0 and unbounded both below and above. Increasing X by 1 increases the logit by β and multiplies the odds by e^β .

It is straightforward to include several explanatory variables in the dichotomous logit model. The logit model for multiple regression with k explanatory variables from X_1 to X_k is

$$\Lambda^{-1}(\pi) = \log_e \frac{\pi_i}{1 - \pi_i} = \alpha + \beta_1 X_{i1} + \beta_2 X_{i2} + \dots + \beta_k X_{ik}. \quad (4.9)$$

The normal distribution can be used to transform the linear-probability model into the linear probit model. Although the logit and probit models usually yield very similar

results, we use the logit model due to its two practical advantages. First, the logit model is simpler; second, the inverse linearising transformation for the logit model can be interpreted as log-odds, but the inverse transformation for the probit model is not directly interpretable (Fox, 2015).

4.4.2 Multinomial Logit Model

In this study, the type of award mechanism as a response variable contains four categories. To adapt to this attribute of multiple categories, we employ the *multivariate logistic distribution* to generalise the dichotomous logit model to the multinomial logit model (or polytomy logit model).

Suppose award mechanism Y includes m types: Y_i can be assigned with a value from 1 to m , depending on the type of award mechanism that the i th procurement uses. The values of Y are nominal and do not have ordinal properties. Let π_{ij} denote the probability that the i th procurement uses a type j award mechanism and let X_1 to X_k represent the potential explanatory variables. The multinomial logit model is expressed as:

$$\pi_{ij} = \frac{\exp(\gamma_{0j} + \gamma_{1j}X_{i1} + \dots + \gamma_{kj}X_{ik})}{1 + \sum_{l=1}^{m-1} \exp(\gamma_{0l} + \gamma_{1l}X_{i1} + \dots + \gamma_{kl}X_{ik})} \quad \text{for } j = 1, \dots, m-1 \quad (4.10)$$

and

$$\pi_{im} = 1 - \sum_{j=1}^m \pi_{ij} \quad (\text{for category } m) \quad (4.11)$$

Award mechanism m is chosen as the baseline category. Each of remaining $m-1$ award mechanisms has a set of parameters, $\gamma_{0j}, \gamma_{1j}, \dots, \gamma_{kj}$. The sum of the probability of all award mechanisms is 1:

$$\sum_{j=1}^m \pi_{ij} = 1.$$

The log-odds of award mechanism j versus the baseline category m can be deduced

from Equations 4.10 and 4.11:

$$\log_e \frac{\pi_{ij}}{\pi_{im}} = \gamma_{0j} + \gamma_{1j}X_{i1} + \dots + \gamma_{kj}X_{ik} \quad \text{for } j = 1, \dots, m-1. \quad (4.12)$$

The interpretation for coefficients $\gamma_{1j}, \dots, \gamma_{kj}$ is similar to that for β in the dichotomous logit model. The log-odds of category j and any category j' , except for baseline category m , can also be derived:

$$\begin{aligned} \log_e \frac{\pi_{ij}}{\pi_{ij'}} &= \log_e \frac{\pi_{ij}/\pi_{im}}{\pi_{ij'}/\pi_{im}} \\ &= \log_e \frac{\pi_{ij}}{\pi_{im}} - \log_e \frac{\pi_{ij'}}{\pi_{im}} \\ &= (\gamma_{0j} - \gamma_{0j'}) + (\gamma_{1j} - \gamma_{1j'})X_{i1} + \dots + (\gamma_{kj} - \gamma_{kj'})X_{ik} \end{aligned} \quad (4.13)$$

4.4.3 The IIA Assumption

The multinomial logit model relies on the assumption of independence from irrelevant alternatives (IIA), which states that the ratio of logit probabilities for any two alternatives does not depend on the availability or attributes of any other alternatives. The IIA assumption is appropriate in some cases (Cushing and Cushing, 2007, Luce, 2005). For example, retirees may consider only a few destinations where they would like to live, so their choice decision will not be significantly affected by changes in other destinations.

However, the IIA assumption is inappropriate in other cases (Chipman, 1960, Debreu, 1960). The famous red-bus-blue-bus problem illustrates a case when the IIA assumption is unrealistic. A commuter has to choose between going to work by car or by a blue bus. Suppose the initial probabilities of choosing a car (P_c) and choosing the blue bus (P_{bb}) are equal, so $P_c = P_{bb} = \frac{1}{2}$ and $P_c/P_{bb} = 1$. Suppose later a red bus is introduced and the red bus is identical to the blue bus except for colour. According to IIA, the ratio of probabilities of choosing a car and the blue bus remains at 1, i.e. $P_c/P_{bb} = 1$. However, if the traveller is rational, he would be indifferent to taking a blue bus or a red bus. The

new expected probability of taking a blue bus should equal to the expected probability of taking a red bus (P_{rb}), and the two probabilities should sum up to the original probability of taking the blue bus (before the red bus was introduced), thus $P_{bb} + P_{rd} = \frac{1}{2}$ and $P_{bb} = P_{rd} = \frac{1}{4}$. Because the probability of taking a car is unchanged, $P_c = \frac{1}{2}$, the new ratio of the probabilities of taking a car and taking the blue bus becomes $P_c/P_{bb} = 2$, rather than remaining constant at 1 as suggested by the IIA assumption.

In our case, suppose that the probabilities of choosing the open procedure, restricted procedure, negotiated procedure and competitive dialogue are respectively P_o, P_r, P_n and P_c and that $P_o = P_r = 0.4, P_n = 0.2, \frac{P_o}{P_n} = \frac{P_r}{P_n} = 2$ before competitive dialogue is introduced. If the IIA holds, the introduction of competitive dialogue affects the probabilities of using the former three award mechanisms proportionally. For example, a change to $P_o = P_r = 0.38, P_n = 0.14$, and $P_c = 0.1$ makes the value of $\frac{P_o}{P_n}$ and $\frac{P_r}{P_n}$ unchanged. If the changes in P_o, P_r and P_n are not proportional, IIA is violated. For example, when only the probability of the negotiated procedure is affected, $P_o = P_r = 0.4, P_n = 0.18, P_c = 0.02$ and $\frac{P_o}{P_n} = \frac{P_r}{P_n} = \frac{20}{9}$.

Because the negotiated procedure and competitive dialogue allow discussion and the open and restricted procedures do not, the introduction of competitive dialogue may affect only the use of the negotiated procedure. In this case, the nested logit model may be a replacement of the multinomial logit model.

4.4.4 Nested Logit Model

In the nested logit model, alternatives that share some properties are grouped into subsets, called nests. IIA holds within each nest, i.e. for any two alternatives in the same nest the ratio of probabilities is independent of the attributes or existence of all other alternatives. IIA does not hold in general for alternatives in different nests, i.e. for any two alternatives in different nests the ratio of probabilities can depend on the attributes of other alternatives in the two nests (Train, 2009). Thus, the nested logit model is suitable when the introduction of competitive dialogue affects only the probability of the

negotiated procedure.

The nested model is built on utility maximisation. Let the set of alternatives j be partitioned into K nonoverlapping subsets denoted by B_1, B_2, \dots, B_K . The utility that buyer n obtains from alternative j in nest B_k is denoted as $U_{nj} = V_{nj} + \varepsilon_{nj}$, where V_{nj} is observed by researchers and ε_{nj} is a random variable whose value is not observed by researchers. The object j will be chosen if and only if $U_{nj} > U_{ni}$ for $j \neq i$.

The probability that object j is chosen by individual i can be described as:

$$\begin{aligned} P_{nj} &= P(U_{nj} > U_{ni}) \\ &= P(V_{nj} + \varepsilon_{nj} > V_{ni} + \varepsilon_{ni}) \\ &= P(\varepsilon_{ni} - \varepsilon_{nj} < V_{nj} - V_{ni}), \end{aligned} \quad (4.14)$$

for all $j \neq i$. To solve Equation 4.14, a probability density function or cumulative density function must be imposed. The nested logit model is obtained by assuming that the vector of unobserved utility, $\varepsilon_n = \varepsilon_{n1}, \dots, \varepsilon_{nJ}$, has a cumulative distribution

$$\exp \left(- \sum_{k=1}^K \left(\sum_{j \in B_k} e^{-\varepsilon_{nj}/\lambda_k} \right)^{\lambda_k} \right), \quad (4.15)$$

where $Cov(\varepsilon_{nj}, \varepsilon_{nm}) = 0$ for any $j \in B_k$ and $m \in B_l$ with $l \neq k$. The parameter λ_k is a measure of the degree of independence in unobserved utility among the alternatives in nest k . A higher value of λ_k means greater independence. Combining this distribution and Equation 4.14 produces the choice probability for alternative $i \in B_k$:

$$P_{ni} = \frac{e^{V_{ni}/\lambda_k} \left(\sum_{j \in B_k} e^{V_{nj}/\lambda_k} \right)^{\lambda_k - 1}}{\sum_{l=1}^K \left(\sum_{j \in B_l} e^{V_{nj}/\lambda_k} \right)^{\lambda_l}}. \quad (4.16)$$

The probability ratio of individual n choosing between alternatives $i \in B_k$ and $m \in B_l$

is:

$$\frac{P_{ni}}{P_{nm}} = \frac{e^{V_{ni}/\lambda_k} (\sum_{j \in B_k} e^{V_{nj}/\lambda_k})^{\lambda_k - 1}}{e^{V_{nm}/\lambda_l} (\sum_{j \in B_l} e^{V_{nj}/\lambda_l})^{\lambda_l - 1}} \quad (4.17)$$

If alternatives i and m are in the same nest, i.e. $k = l$, then the terms in parentheses cancel out, so:

$$\frac{P_{ni}}{P_{nm}} = \frac{e^{V_{ni}/\lambda_k}}{e^{V_{nm}/\lambda_l}} \quad (4.18)$$

4.5 General Problems of the Models

Our models share the common problems of endogeneity and multicollinearity in the generalised linear models. This section introduces these two problems and potential remedies to reduce bias in the estimates.

Endogeneity occurs when the error term is correlated with any independent variables. Endogeneity may be caused by omitted variables, measurement error and simultaneity (i.e. reverse causality). The main source of endogeneity in this study is the omitted variables. Notably, we do not hold data on selection cost and the number of bidders. These two variables are related to contract complexity, a variable with available data. The error term captures the impacts of these two omitted variables, so the error term is correlated with contract complexity and causes endogeneity. Both the public data provider and the author have endeavoured to refine the data to keep measurement error in this study (particularly in the variables of contract value and duration) as low as possible. The number of bidders is the factor that is most likely to have a reverse causality with the choice of award mechanism, the dependent variable. Since it is an omitted variable, simultaneity is not a great concern in this study. Instrumental variable (IV) is a widely adopted remedy for endogeneity. An IV is correlated with the endogenous variable and uncorrelated with the error term. However, our dataset does not contain information to form appropriate IVs for the omitted variables.

Multicollinearity occurs when any of the independent variables are highly correlated. Although it is sensible to include several independent variables into one regression to examine their partial effects only when those variables are correlated. Very high correlation may cause high standard errors and unexpected signs in estimates. The problem of unreliable estimates can be greatly mitigated by increasing the sample size. Because our sample size is reasonably large, multicollinearity is unlikely to be a serious problem in this study.

Readers may feel free to skip the remainder of this section that mainly introduces the econometrics under endogeneity and multicollinearity. Section 4.5.1 discusses the econometrics under endogeneity in an order of omitted variables, measurement error, simultaneity and standard solutions. Section 4.5.2 discusses multicollinearity.

4.5.1 Endogeneity

To make the illustration of endogeneity easier, simplify the population model as

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + u, \quad (4.19)$$

where y refers to the log-odds of one of the award mechanisms to the baseline category, and x_1, x_2, \dots, x_k represent factors that may affect the choice of award mechanism.

One assumption for unbiased OLS estimations in multiple linear regressions is the zero conditional mean assumption that the error term has an expected value of zero regardless of values of independent variables, i.e. $E(u | x_1, x_2, \dots, x_k) = 0$. The necessary condition of the zero conditional mean assumption is that the expectation of the error term is zero and the independent variables are not correlated with the error term, that is $E(u) = 0$ and $Cov(x_j, u) = 0$ for $j = 1, 2, \dots, k$. The problem of endogeneity occurs when any independent variables are correlated with the error term. Endogeneity has three sources: omitted variable, measurement error and simultaneity.⁸

⁸References of endogeneity can be found in Verbeek (2008) and Wooldridge (2009, 2010)

4.5.1.1 Omitted Variables

Omitted variables are defined as variables that are not included as the independent variables in a regression model but are correlated with any of independent variables and the error term in the model. Omitted variables are usually due to ignorance or data unavailability. In a multiple regression case, omitted variables usually lead to bias in OLS estimators.

One remedy is to use a variable that is correlated with the omitted variable as a proxy variable in the OLS regression (plug-in solution). For example, if x_k is unobservable and x_k^* is used as the proxy variable for x_k , then the relationship between x_k and x is captured by

$$x_k = \delta_0 + \delta_k x_k^* + v_k. \quad (4.20)$$

The requirements for the plug-in solution to produce unbiased results are: 1) the error term u is uncorrelated with x_1, x_2, \dots, x_{k-1} and x_k and 2) the error term v_k is uncorrelated with x_1, x_2, \dots, x_{k-1} and x_k^* .

Many factors may influence the choice of award mechanism, but we can measure or find proxies for several of them.⁹ Omitted variables still cause endogeneity in the model. For example, as omitted variables, the cost of selection and number of bidders are likely to be correlated with proxies for complexity.

4.5.1.2 Measurement Error

Measurement errors exist when an imprecise observable measure is used to represent a variable of interest. [Dougherty \(2007\)](#) takes imperfect proxy variables as a cause of measurement error because the statistical structures of the measurement error problem are similar to the omitted variable-proxy problem. However, [Wooldridge \(2009\)](#) argues that these two problems are conceptually different:

⁹See Section [3.4](#) for a complete discussion of the influential factors.

“In the proxy variable case, we are looking for a variable that is somehow associated with the unobserved variable. In the measurement error case, the variable that we do not observe has a well-defined, quantitative meaning (such as a marginal tax rate or annual income, but our recorded measures of it may contain error. (Wooldridge, 2009, p.315)”

When the measurement error is in the dependent variable and is uncorrelated with independent variables, then the OLS estimators are unbiased and consistent; otherwise, the OLS estimators are biased and inconsistent. The dependent variable in this study is the award mechanism. Since the type of award mechanism is one of the most critical specifications for a contract, it is unlikely to be erroneous.

When the measurement error is in an independent variable, taking x_1^* as a measure of the unobserved explanatory variable x_1 , the measurement error in the population is $e_1 = x_1^* - x_1$. Assume zero mean of the measurement error, $E(e_1) = 0$. If the measurement error e_1 is uncorrelated with the observed measure x_1^* , then e_1 must be correlated with the unobserved variable x_1 . Replacing x_1 in the population model Equation 4.19 with $x_1 = x_1^* - e_1$ is:

$$y = \beta_0 + \beta_1 x_1^* + \beta_2 x_2 + \dots + \beta_k x_k + (u - \beta_1 e_1). \quad (4.21)$$

Because u and e_1 both have zero means and are uncorrelated with x_1^* , the composite error term $(u - \beta_1 e_1)$ also has a zero mean and is uncorrelated with x_1^* . Therefore, estimators in Equation 4.21 are unbiased. But the composite error variance in Equation 4.21, $Var(u - \beta_1 e_1) = \sigma_u^2 + \beta_1^2 \sigma_{e_1}^2$, is higher than the error variance σ_u^2 in the original population model.

A more common assumption is that the measurement error e_1 is uncorrelated with the unobserved independent variable x_1 (the classical errors-in-variables assumption). This assumption implies that the measurement error must be correlated with the observed measure x_1^* :

$$Cov(x_1^*, e_1) = E(x_1^* e_1) = E(x_1 e_1) + E(e_1^2) = 0 + \sigma_{e_1}^2 = \sigma_{e_1}^2. \quad (4.22)$$

For the modified model (Equation 4.21), the covariance between x_1^* and the composite error ($u - \beta_1 e_1$) is

$$Cov(x_1^*, u - \beta_1 e_1) = Cov(x_1^*, u) - Cov(x_1^*, \beta_1 e_1) = 0 - \beta_1 Cov(x_1^*, e_1) = -\beta_1 \sigma_{e_1}^2. \quad (4.23)$$

The correlation between x_1^* and the composite error ($u - \beta_1 e_1$) usually causes bias in all estimators, except in the special case that x_1 is uncorrelated with x_2, x_3, \dots, x_k .

This study may have a measurement error problem, especially for the variables of contract value and duration. Nevertheless, the EUODP (the data provider) and the author have put effort into refining data to keep measurement error in this study to as low a level as possible.

4.5.1.3 Simultaneity

Simultaneity describes a causal loop between the independent and dependent variables. Namely, not only does an independent variable affects the dependent variable, but also the dependent variable, in turn, affects the independent variable.

We demonstrate endogeneity due to simultaneity using the two-equation structural model with an endogenous variable in each equation:

$$y_1 = \beta_{10} + \alpha_1 y_2 + \beta_1 \mathbf{z}_1 + u_1 \quad (4.24)$$

and

$$y_2 = \beta_{20} + \alpha_2 y_1 + \beta_2 \mathbf{z}_2 + u_2. \quad (4.25)$$

Here y_1 and y_2 denote the endogenous variables; \mathbf{z}_1 represents a set of exogenous variables in Equation 4.24, \mathbf{z}_2 represents a set of exogenous variables in Equation 4.25, and u_1 and u_2 are the structural error terms. By definition, y_1 is correlated with u_1 and y_2 is correlated with u_2 ; \mathbf{z}_1 is uncorrelated with u_1 and \mathbf{z}_2 is uncorrelated with u_2 .

Replacing y_1 in Equation 4.25 with Equation 4.24 produces

$$(1 - \alpha_1\alpha_2)y_2 = (\beta_{20} + \alpha_2\beta_{10}) + (\alpha_2\beta_1z_1 + \beta_2z_2) + (\alpha_2u_1 + u_2). \quad (4.26)$$

If $\alpha_1\alpha_2 \neq 1$, then the above equation can be written as

$$y_2 = \pi_{20} + \pi_{21}z_1 + \pi_{22}z_2 + v_2, \quad (4.27)$$

where $\pi_{20} = \frac{\beta_{20} + \alpha_2\beta_{10}}{1 - \alpha_1\alpha_2}$, $\pi_{21} = \frac{\alpha_2\beta_1}{1 - \alpha_1\alpha_2}$, $\pi_{22} = \frac{\beta_2}{1 - \alpha_1\alpha_2}$, and $v_2 = \frac{\alpha_2u_1 + u_2}{1 - \alpha_1\alpha_2}$. Equation 4.27 is the reduced form equation for y_2 because y_2 is expressed by exogenous variables and the reduced form error v_2 . v_2 is correlated with u_1 because v_2 is a linear function of u_1 and u_2 . From Equation 4.27, it can be inferred that y_2 and u_1 are correlated through v_2 , so the OLS estimators for Equation 4.24 are biased and inconsistent except in special cases. The reduced form equation for y_1 is similar to the reduced form equation for y_2 . Similar proofs of endogeneity apply for Equation 4.25.

The number of bidders and award mechanism are the pair that most likely to have reverse causality. The benefits from auctions are most prominent when a large number of bidders exist, so anticipating a large number of bidders is likely to result in choosing an auction. Auctions require submission of complete bids to express interest to participate but negotiations do not have such a requirement. Higher participation costs at the early stage may keep some suppliers away from participating auctions. Since information from the contract notices does not contain the number of bidders, the number of bidders is an omitted variable rather than a source of simultaneity.

4.5.1.4 Proposed Solutions

Instrumental variable (IV) method is a popular solution for the endogeneity problem.

Supposing in a simple structural model

$$y = \beta_0 + \beta_1 x + u, \quad (4.28)$$

Because x and the error term u are correlated, the estimator of β_1 is inconsistent.

An observable variable z is an instrumental variable for x , if z satisfies two assumptions: 1) z is uncorrelated with u , i.e. $Cov(z, u) = 0$ and 2) z is correlated with x , i.e. $Cov(z, x) \neq 0$. The first assumption is untestable because the error term u is not observable. Its validity is usually checked by economic theory. The second assumption can be tested by regressing x on z . If the parameter of z is statistically different from zero, then the relationship $Cov(z, x) \neq 0$ holds.

Based on Equation 4.28, the covariance between z and y is

$$Cov(z, y) = \beta_1 Cov(z, x) + Cov(z, u). \quad (4.29)$$

Because $Cov(z, u) = 0$ and $Cov(z, x) \neq 0$, the parameter β_1 can be identified:

$$\beta_1 = \frac{Cov(z, y)}{Cov(z, x)}. \quad (4.30)$$

The IV method can be further developed into a two-stage least squares (2SLS) method if the number of exogenous variables that are not included in the structural model is greater than the number of endogenous explanatory variables in the structural model, and at the same time, at least one exogenous variable excluded from the structural model is correlated with each endogenous explanatory variable. Thus, the best IV estimators may be derived from the reduced form equation for the endogenous explanatory variables.¹⁰

In addition to the IV and the 2SLS approaches as the potential solutions for endogenous bias in general and proper proxy variables for omitted variable bias, the fixed

¹⁰However, the sufficient condition for identifying the parameters of the endogenous explanatory variables is more complicated. For more details of the 2SLS approach, see Chapter 15 and Chapter 16 in Wooldridge (2009) and Chapter 5 in Wooldridge (2010).

effects or first-differencing methods can be used to remove the unobserved effects from time-constant omitted variables in panel data analysis.¹¹

Endogeneity, mainly due to omitted variables, is a concern for this study. However, it is particularly challenging to identify proper IVs for those endogenous variables. This calls for publicising more detailed contract level data. Since pooled cross-sectional data are used in this study, the fixed effects and first-differencing methods are not applicable. Thus, with the currently available data, we have to conduct the analysis while acknowledging the potential endogeneity.

4.5.2 Multicollinearity

Multicollinearity occurs when two or more independent variables or combinations of independent variables are highly correlated and exhibit an approximately linear relationship. Technically, when the matrix defined by two variables is nearly not invertible, the correlation between these two variables is said to be “too high”.¹²

It should be underlined that multiple regression models allow correlations between the independent variables. Grouping several independent variables in one regression to examine their partial effects makes sense only when the researcher suspects that these variables are correlated. However, multicollinearity may cause unreliable estimators with high standard errors and unexpected sign or magnitude. A large number of observations with sufficient variation may help produce more reliable estimators when multicollinearity exists. A shortcut solution for multicollinearity is to drop one or more independent variables that are highly correlated.

Multicollinearity may be caused by two observable independent variables that share the same latent variable, for example, the contract value and the contract duration, which are proxies for complexity in this study. Multicollinearity may also result from a causal relationship between independent variables. For example, contract value may be highly

¹¹See Chapter 13 and 14 in [Wooldridge \(2009\)](#) for discussions on these methods

¹²Chapter 2 in [Verbeek \(2008\)](#) discusses multicollinearity.

correlated with quality concerns. Buyers are generally less worried about the quality of a contract with low valuation because a low value contract usually does not have sophisticated technical requirements. Overall, multicollinearity is unlikely to cause considerable problems in this study because our sample size is reasonably large.

4.6 Results

In this section, we present estimates of 1) a dichotomous logit model that compares the open procedure against the restricted procedure (Section 4.6.1) and 2) two multinomial logit models that respectively compare the negotiated procedure and competitive dialogue with the remaining procedures (Section 4.6.2). We run separate regressions for works, services and supply contracts. The Appendix provides results from two nested logit models that correspond to the multinomial logit models.

4.6.1 Open Procedure versus Restricted Procedure

Table 4.3 presents results that compare the open procedure to the restricted procedure, which is the baseline category. Two regressions are run for each contract type: one controls for year, region and the CPV, whereas the other does not.

The estimates for the traditional measures of complexity, i.e. log contract value and duration, and for the quality criterion dummy are conflicting across contract types. It seems that public authorities do not greatly differentiate between the open and restricted procedures too much with respect to contract complexity and quality concerns.

Contracts with a greater number of lots are more likely to use the open procedure. This confirms our second explanation about lots. The applicability of lots means that individual sub-contracts are likely to be clearly distinguished from one another. This lowers bidders' costs of preparing tendering documents and the public buyer's cost of screening bids. Therefore, benefits from the competitive pressure introduced by a large

number of bidders dominate the costs. As a result, the open procedure is preferred to the restricted procedure.

More experienced buyers tend to use the open procedure more frequently than the restricted procedure. This may be explained by the reduced administrative costs of conducting an open procedure due to accumulated experience.

4.6.2 Auctions versus Negotiations

Table 4.4 and Table 4.5 compare the four benchmark award mechanisms in the EU. Table 4.4 presents results from the multinomial logit model that uses the negotiated procedure as the baseline category. Table 4.5 summarises the results from the multinomial logit model with competitive dialogue as the baseline category. Two regressions are presented under each contract type. One of them controls for the year and region, and the other does not.¹³

Table 4.4 demonstrates strong and consistent estimates that contract value, contract duration and the quality criterion dummy are negatively related to using either the open or restricted procedure, compared to the negotiated procedure. This provides evidence that complexity and quality concerns play a role in the choice between a negotiated procedure and auctions (i.e. the open and restricted procedures). Divisibility into a greater number of lots suggests a higher probability of using auctions due to lower costs for both buyer and bidders.

More experienced buyers are more likely to use an open procedure than a negotiated procedure. Since experience may lower costs, this result supports the conclusion from [Bulow and Klemperer \(1996\)](#) that auctions produce a higher surplus to the buyer than negotiations when the marginal cost of the buyer is zero.

¹³We have tried to control for the CPV, but no estimates can be produced because the CPV introduces strong multicollinearity.

Table 4.3: Logit Regressions: Open Procedure versus Restricted Procedure (Baseline: Restricted Procedure)

	<i>Dependent variable:</i>					
	Works (1)	Works (2)	Services (3)	Services (4)	Supply (5)	Supply (6)
Intercept	0.863 (0.527)	3.712** (1.595)	1.143*** (0.154)	1.927 (1.342)	-0.352* (0.201)	0.560 (0.388)
Log contract value	-0.271*** (0.032)	-0.337*** (0.037)	-0.068*** (0.009)	-0.122*** (0.011)	0.061*** (0.013)	0.058*** (0.015)
Duration	0.012*** (0.002)	0.012*** (0.002)	-0.006*** (0.001)	-0.006*** (0.001)	-0.010*** (0.001)	-0.013*** (0.001)
No. of lots	0.028*** (0.009)	0.019* (0.010)	0.030*** (0.004)	0.018*** (0.004)	0.056*** (0.007)	0.030*** (0.007)
Quality criterion dummy	0.360 (0.237)	0.137 (0.260)	-1.031*** (0.091)	-0.665*** (0.108)	-0.768*** (0.092)	-0.325*** (0.104)
Log experience	0.171*** (0.035)	0.194*** (0.039)	0.188*** (0.010)	0.188*** (0.012)	0.196*** (0.015)	0.208*** (0.017)
Year	No	Yes	No	Yes	No	Yes
Region	No	Yes	No	Yes	No	Yes
CPV	No	Yes	No	Yes	No	Yes
Observations	4,112	4,112	19,696	19,696	9,489	9,489
R ²	0.040	0.160	0.027	0.172	0.042	0.175
Log Likelihood	-1,400.993	-1,226.628	-12,952.140	-11,028.540	-6,190.160	-5,329.690

Note: * p<0.1; ** p<0.05; *** p<0.01

Table 4.4: Multinomial Logit Regressions of Award Mechanism (Baseline: Negotiated Procedure)

	Dependent variable: Award mechanism					
	Works (1)	Works (2)	Services (3)	Services (4)	Supply (5)	Supply (6)
Open procedure						
Intercept	7.833*** (0.970)	8.366*** (1.014)	9.863*** (0.640)	9.705*** (0.647)	7.038*** (0.487)	7.545*** (0.516)
Log contract value	-0.458*** (0.056)	-0.534*** (0.058)	-0.320*** (0.019)	-0.328*** (0.019)	-0.249*** (0.024)	-0.274*** (0.025)
Duration	-0.002 (0.003)	-0.002 (0.003)	-0.014*** (0.001)	-0.014*** (0.001)	-0.022** (0.002)	-0.023** (0.002)
No. of lots	0.134*** (0.034)	0.139*** (0.036)	0.062*** (0.012)	0.059*** (0.012)	0.146*** (0.019)	0.138*** (0.020)
Quality criterion dummy	-0.257 (0.475)	-0.172 (0.486)	-2.814*** (0.582)	-2.829*** (0.583)	-1.739*** (0.341)	-1.695*** (0.346)
Log experience	0.098* (0.056)	0.099* (0.058)	0.018 (0.024)	0.017 (0.024)	0.280*** (0.029)	0.263*** (0.031)
Restricted procedure						
Intercept	6.988*** (0.856)	6.967*** (0.879)	8.736*** (0.638)	9.069*** (0.644)	7.486*** (0.493)	8.778*** (0.523)
Log contract value	-0.188*** (0.049)	-0.191*** (0.050)	-0.253*** (0.018)	-0.244*** (0.018)	-0.316*** (0.025)	-0.332*** (0.025)
Duration	-0.015*** (0.002)	-0.014*** (0.002)	-0.007*** (0.001)	-0.006*** (0.001)	-0.011*** (0.002)	-0.011*** (0.002)
No. of lots	0.107*** (0.033)	0.120*** (0.035)	0.032*** (0.012)	0.032*** (0.012)	0.091*** (0.020)	0.103*** (0.020)
Quality criterion dummy	-0.599 (0.423)	-0.274 (0.431)	-1.781*** (0.584)	-1.815*** (0.584)	-0.976*** (0.346)	-1.313*** (0.352)
Log experience	-0.074 (0.046)	-0.097** (0.047)	-0.173*** (0.023)	-0.177*** (0.024)	0.076** (0.029)	0.072** (0.031)
Competitive dialogue						
Intercept	-6.851*** (1.741)	-6.879*** (1.782)	-3.406*** (1.019)	-3.099*** (1.027)	-16.796 (2,412.552)	-15.836 (2,344.024)
Log contract value	0.351*** (0.088)	0.344*** (0.089)	0.216*** (0.030)	0.226*** (0.031)	-0.057 (0.066)	-0.069 (0.067)
Duration	-0.002 (0.004)	-0.002 (0.004)	0.015*** (0.002)	0.015*** (0.002)	0.017*** (0.004)	0.019*** (0.004)
No. of lots	-0.337*** (0.104)	-0.330*** (0.105)	-0.135*** (0.030)	-0.138*** (0.031)	-0.005 (0.061)	0.011 (0.061)
Quality criterion dummy	0.835 (1.091)	0.976 (1.099)	-0.463 (0.917)	-0.482 (0.917)	15.665 (2,412.552)	15.133 (2,344.023)
Log experience	-0.123 (0.076)	-0.145* (0.078)	-0.297*** (0.038)	-0.302*** (0.039)	-0.299*** (0.079)	-0.299*** (0.082)
Year	No	Yes	No	Yes	No	Yes
Region	No	Yes	No	Yes	No	Yes
Observations	4,492	4,492	21,254	21,254	10,190	10,190
R ²	0.057	0.111	0.051	0.112	0.057	0.133
Log Likelihood	-2,829.837	-2,667.609	-18,840.080	-17,635.950	-8,730.747	-8,029.515

Note: * p<0.1; ** p<0.05; *** p<0.01

Table 4.5: Multinomial Logit Regressions of Award Mechanism (Baseline: Competitive Dialogue)

	<i>Dependent variable: Award mechanism</i>					
	Works (1)	Works (2)	Services (3)	Services (4)	Supply (5)	Supply (6)
Open procedure						
Intercept	14.684*** (1.633)	15.245*** (1.680)	13.270*** (0.821)	12.804*** (0.829)	23.833 (2, 412.615)	23.381 (2, 343.994)
Log contract value	-0.809*** (0.082)	-0.878*** (0.084)	-0.535*** (0.027)	-0.554*** (0.027)	-0.192*** (0.064)	-0.205*** (0.065)
Duration	-0.001 (0.004)	-0.001 (0.004)	-0.028*** (0.002)	-0.029*** (0.002)	-0.040*** (0.004)	-0.042*** (0.004)
No. of lots	0.471*** (0.100)	0.469*** (0.100)	0.196*** (0.029)	0.197*** (0.029)	0.151** (0.059)	0.128** (0.058)
Quality criterion dummy	-1.092 (1.035)	-1.148 (1.044)	-2.351*** (0.717)	-2.347*** (0.718)	-17.405 (2, 412.615)	-16.828 (2, 343.994)
Log experience	0.222*** (0.072)	0.244*** (0.074)	0.314*** (0.033)	0.319*** (0.034)	0.578*** (0.076)	0.563*** (0.078)
Restricted procedure						
Intercept	13.839*** (1.562)	13.846*** (1.596)	12.143*** (0.817)	12.168*** (0.823)	24.282 (2, 412.615)	24.614 (2, 343.994)
Log contract value	-0.539*** (0.077)	-0.536*** (0.078)	-0.469*** (0.026)	-0.470*** (0.026)	-0.259*** (0.064)	-0.264*** (0.064)
Duration	-0.013*** (0.003)	-0.012*** (0.003)	-0.022*** (0.002)	-0.022*** (0.002)	-0.029*** (0.004)	-0.030*** (0.004)
No. of lots	0.444*** (0.100)	0.450*** (0.100)	0.167*** (0.029)	0.170*** (0.029)	0.096 (0.059)	0.093 (0.058)
Quality criterion dummy	-1.434 (1.012)	-1.251 (1.018)	-1.333* (0.718)	-1.333* (0.718)	-16.641 (2, 412.615)	-16.446 (2, 343.994)
Log experience	0.050 (0.064)	0.048 (0.065)	0.124*** (0.033)	0.125*** (0.033)	0.374*** (0.076)	0.371*** (0.078)
Negotiated procedure						
Intercept	6.851*** (1.741)	6.879*** (1.782)	3.406*** (1.019)	3.099*** (1.027)	16.796 (2, 412.615)	15.836 (2, 343.994)
Log contract value	-0.351*** (0.088)	-0.344*** (0.089)	-0.216*** (0.030)	-0.226*** (0.031)	0.057 (0.066)	0.069 (0.067)
Duration	0.002 (0.004)	0.002 (0.004)	-0.015*** (0.002)	-0.015*** (0.002)	-0.017*** (0.004)	-0.019*** (0.004)
No. of lots	0.337*** (0.104)	0.330*** (0.105)	0.135*** (0.030)	0.138*** (0.031)	0.005 (0.061)	-0.011 (0.061)
Quality criterion dummy	-0.835 (1.091)	-0.976 (1.099)	0.463 (0.917)	0.482 (0.917)	-15.665 (2, 412.615)	-15.133 (2, 343.994)
Log experience	0.123 (0.076)	0.145* (0.078)	0.297*** (0.038)	0.302*** (0.039)	0.299*** (0.079)	0.299*** (0.082)
Year	No	Yes	No	Yes	No	Yes
Region	No	Yes	No	Yes	No	Yes
Observations	4,492	4,492	21,254	21,254	10,190	10,190
R ²	0.057	0.111	0.051	0.112	0.057	0.133
Log Likelihood	-2,829.837	-2,667.609	-18,840.080	-17,635.950	-8,730.747	-8,029.515

Note: *p<0.1; **p<0.05; ***p<0.01

On the other hand, more experienced buyers are less likely to use a restricted procedure than a negotiated procedure. Although the restricted and negotiated procedures both limit the number of bidders, the effectiveness of the restricted procedure in extracting bidder's rent relies more on the strength of competition. As a public buyer becomes more experienced and more skillful in negotiation, its gains from negotiation increase. An experienced buyer may benefit more from a negotiated procedure than a restricted procedure.

All but one of the estimates in Table 4.5 comparing open or restricted procedures with competitive dialogue are similar and consistent with estimates in Table 4.4, when interpreting both the negotiated procedure and competitive dialogue as applications of negotiations.¹⁴

The exception is that more experienced buyers tend to use restricted procedures more often than competitive dialogue. While the restricted procedure contains a round of prequalification followed directly by competitive bidding, competitive dialogue follows a process of prequalification, negotiation and competitive bidding. Moreover, the required minimum number of bidder is five for the restricted procedure and three for competitive dialogue. It is likely that with lower administrative costs accompanied by more experience, the benefits from more bidders in the competitive bidding exceed the benefits from negotiation.

Lastly, we turn to the comparison between the negotiated procedure and competitive dialogue in Table 4.4.¹⁵ The estimates for the quality criterion dummy and for all complexity measures are not consistent across different contract types. This implies that public buyers may not distinguish these two award mechanisms when considering complexity and quality only. Buyer's experience is the only factor with consistent estimates

¹⁴Lack of variation is the reason that the model yields large standard errors in the quality criterion dummy estimates for the supply contracts. In few cases, competitive dialogue is applied simultaneously with the "lowest price" criterion (see Figure 4.5).

¹⁵Table 4.5 provides nearly identical estimates but opposite signs when comparing the negotiated procedure with competitive dialogue. This is because of the switch of the baseline category from the negotiated procedure to competitive dialogue. We can ignore the comparison between these two award mechanisms in Table 4.5 and focus on that in Table 4.4.

across contract types. More experience accumulated by a buyer is associated with a higher probability of using the negotiated procedure rather than competitive dialogue. Competitive dialogue differs from the negotiated procedure because it contains an additional competitive bidding stage. The results show that experienced buyers tend to put less value on competitive bidding in the competitive dialogue procedure. It is likely that competitive bidding in competitive dialogue involves only a small group of bidders, so the competitive pressure cannot force bidders to give up sufficient rents to induce the buyer to run this more complicated award mechanism.

As a robustness check, the Appendix presents results from the nested logit models that use the negotiated procedure or the competitive dialogue as the baseline category. The estimates from the nested logit models are generally consistent with the multinomial logit models.

4.7 Conclusions

This chapter has examined the choice in UK public procurement of whether to pre-select bidders in public procurement, and the further choice between the auction-based award mechanisms (i.e. open and restricted procedures) and the negotiation-based award mechanisms allowed under EU law (i.e. the negotiated procedure and competitive dialogue).

We learn from theory that quality concerns generally increase with contract complexity. A reputation mechanism, e.g. prequalification, can alleviate opportunistic behaviour that exploits contract incompleteness, which is often the case for complex contracts. Negotiations are better suited than auctions to complex contracts because they combine efforts from buyer and sellers to improve contract design and provide flexibility in unavoidable ex post renegotiation.

Our empirical results show that although the restricted procedure contains prequalifi-

cation and the open procedure does not, public buyers tend not to treat the two procedures differently when considering only quality concerns and complexity (Table 4.3). Nor do they tend to differentiate between the negotiated procedure and competitive dialogue (Table 4.4). It also turns out that public buyers take negotiation as a better approach than prequalification to tackle quality concerns and complexity (Table 4.4).

In addition, our results show evidence of two opposite impacts of buyer's experience. First, according to theory, more experience may put a buyer in a more advantageous position in negotiation and thus he is able to extract a higher surplus than a buyer with less experience. This view suggests that a more experienced buyer has a higher tendency to choose negotiation. This view is supported by the result from Table 4.4 that the log odds of the restricted procedure against the negotiated procedure decrease with the increase of buyer's experience.

Second, according to industry practitioners, greater experience enables buyers to reduce the administrative costs of conducting auctions involving a large group of bidders, so more experienced bidders are more likely to use auctions (Bajari et al., 2008). Our results show that increasing experience increases the probability of using the open procedure to the probability of using the negotiated procedure (Table 4.4) or competitive dialogue (Table 4.5).

Overall, this study suggests that the UK public procurement practice is generally consistent with the theoretical considerations on the optimal award mechanism choice. Negotiation is superior in cases of high complexity and quality concerns and auctions are preferred when contracts are simple and the cost of introducing an additional bidder is low.

The UK public authority may not be fully aware of the advantage of the restricted procedure over the open procedure when a contract is incomplete. Although the empirical results from Coviello et al. (2018) show that the restricted procedure does not worsen (and may even improve) various ex ante procurement outcomes (e.g. the number of bidders) or ex post procurement outcomes (e.g. time or cost overruns) when compared with the

open procedure, we find that the frequency of using the restricted procedure in the UK has declined in recent years.

[Siemonsma et al. \(2012\)](#) offer some evidence that competitive dialogue may provide value for PPP contracts in port development and operations, but the UK public authorities do not exhibit great preference for either competitive dialogue over the negotiated procedure or the reverse. The lower executive cost of running a negotiated procedure presumably makes the UK public authorities use negotiated procedures more often.

It is possible that some shortcomings in the restricted procedure and competitive dialogue have prevented public buyers from using these two procedures. Inspired by this, the next chapter explores the tendering period in different award mechanisms, which is a feature that has been explored by few studies.

Appendix: Results from the Nested Logit Regressions

This Appendix presents estimates from the nested logit models in Table 4.6 and Table 4.7. The results from the nested logit models are generally consistent with the results from the multinomial logit models (our main models).

Each table includes two regressions for each contract type. The second regressions for the works and services contracts control for year and region, while the corresponding first regressions do not. The quality criterion dummy and region cannot be included in the regression for supply contracts because they introduce high multicollinearity when compounded with competitive dialogue. Therefore, for supply contracts, one regression controls for the year but not the region and the other controls neither factors.

Table 4.6 contains results from using the negotiated procedure as the baseline, so it offers a robustness check for results from the multinomial model in Table 4.4. Table 4.7 provides results from using competitive dialogue as the baseline and thus it can be compared with Table 4.5.

Table 4.6: Nested Logit Regressions of Award Mechanism (Baseline: Negotiated Procedure)

	Dependent variable: Award mechanism					
	Works		Services		Supply	
	(1)	(2)	(3)	(4)	(5)	(6)
Open procedure						
Intercept	8.059*** (1.590)	7.674*** (1.205)	8.446*** (0.992)	9.631*** (0.682)	-24.466*** (3.701)	2.657** (1.235)
Log contract value	-0.644 (0.790)	-0.261 (0.274)	-0.537*** (0.068)	-0.336*** (0.028)	0.562*** (0.124)	-0.203*** (0.040)
Duration	0.006 (0.037)	-0.011 (0.009)	-0.042*** (0.007)	-0.015*** (0.002)	-0.110*** (0.011)	-0.086*** (0.005)
No. of lots	0.153* (0.088)	0.123*** (0.040)	0.174*** (0.032)	0.061*** (0.013)	0.515*** (0.067)	0.174*** (0.025)
Quality criterion dummy	-0.036 (1.188)	-0.265 (0.505)	-6.361*** (1.136)	-2.906*** (0.621)		
Log experience	0.222 (0.522)	-0.061 (0.162)	0.826*** (0.194)	0.035 (0.047)	2.387*** (0.248)	0.489*** (0.089)
Restricted procedure						
Intercept	6.572*** (1.868)	7.544*** (1.034)	1.022 (1.952)	8.900*** (0.744)	9.698*** (1.816)	7.349*** (0.571)
Log contract value	-0.161 (0.112)	-0.230*** (0.059)	-0.119*** (0.042)	-0.239*** (0.021)	-1.352*** (0.166)	-0.394*** (0.048)
Duration	-0.016*** (0.006)	-0.012*** (0.003)	0.009** (0.004)	-0.006*** (0.002)	0.088*** (0.013)	0.003 (0.006)
No. of lots	0.105*** (0.038)	0.122*** (0.039)	-0.046* (0.024)	0.030** (0.013)	-0.438*** (0.096)	0.047 (0.031)
Quality criterion dummy	-0.625 (0.432)	-0.275 (0.504)	1.643 (1.046)	-1.734*** (0.610)		
Log experience	-0.088 (0.072)	-0.079 (0.053)	-0.660*** (0.114)	-0.189*** (0.035)	-2.437*** (0.281)	-0.163 (0.101)
Competitive dialogue						
Intercept	-6.900*** (1.782)	-6.753*** (1.855)	-3.872*** (1.019)	-3.121*** (1.041)	1.118 (1.136)	-0.971 (1.143)
Log contract value	0.355*** (0.092)	0.336*** (0.098)	0.230*** (0.030)	0.227*** (0.031)	-0.184** (0.081)	-0.061 (0.079)
Duration	-0.002 (0.004)	-0.001 (0.004)	0.016*** (0.002)	0.015*** (0.002)	0.028*** (0.005)	0.020*** (0.005)
No. of lots	-0.338*** (0.106)	-0.328*** (0.111)	-0.147*** (0.020)	-0.139*** (0.020)	-0.064 (0.057)	-0.008 (0.059)
Quality criterion dummy	0.830 (1.121)	0.960 (1.183)	-0.096 (0.927)	-0.463 (0.937)		
Log experience	-0.125 (0.086)	-0.142 (0.093)	-0.358*** (0.041)	-0.305*** (0.041)	-0.554*** (0.122)	-0.331*** (0.125)
iv	1.801 (3.324)	0.091 (0.884)	7.755*** (1.644)	1.157*** (0.341)	22.821*** (3.044)	2.964*** (0.797)
Year	No	Yes	No	Yes	No	Yes
Region	No	Yes	No	Yes	No	No
Observations	4,492	4,492	21,254	21,254	10,190	10,190
R ²	0.057	0.111	0.052	0.112	0.058	0.082
Log Likelihood	-2,829.810	-2,667.048	-18,830.900	-17,635.830	-8,721.399	-8,498.502

Note: * p<0.1; ** p<0.05; *** p<0.01

Table 4.7: Nested Logit Regressions of Award Mechanism (Baseline: Competitive Dialogue)

	Dependent variable: Award mechanism					
	(1) Works	(2) Works	(3) Services	(4) Services	(5) Supply	(6) Supply
Open procedure						
Intercept	14.960*** (2.182)	14.447*** (1.820)	12.318*** (1.119)	12.752*** (0.851)	-25.584*** (4.073)	3.628*** (1.695)
Log contract value	-0.998 (0.796)	-0.592* (0.284)	-0.767*** (0.072)	-0.563*** (0.034)	0.746*** (0.159)	-0.142* (0.082)
Duration	0.008 (0.037)	-0.010 (0.010)	-0.059*** (0.008)	-0.030*** (0.003)	-0.138*** (0.013)	-0.056*** (0.007)
No. of lots	0.491*** (0.134)	0.452*** (0.107)	0.321*** (0.032)	0.200*** (0.018)	0.579*** (0.089)	0.182*** (0.059)
Quality criterion dummy	-0.866 (1.450)	-1.239 (1.077)	-6.265*** (1.159)	-2.443*** (0.757)		
Log experience	0.347 (0.525)	0.077 (0.176)	1.184*** (0.205)	0.340*** (0.058)	2.940*** (0.293)	0.820*** (0.155)
Restricted procedure						
Intercept	13.472*** (2.204)	14.344*** (1.748)	4.894** (2.077)	12.022*** (0.914)	8.580*** (1.875)	8.319*** (1.087)
Log contract value	-0.516*** (0.131)	-0.568*** (0.097)	-0.349*** (0.044)	-0.466*** (0.027)	-1.167*** (0.160)	-0.333*** (0.078)
Duration	-0.014** (0.006)	-0.011*** (0.004)	-0.007* (0.004)	-0.021*** (0.002)	0.060*** (0.012)	-0.018*** (0.006)
No. of lots	0.442*** (0.101)	0.451*** (0.106)	0.102*** (0.029)	0.169*** (0.017)	-0.374*** (0.101)	0.055 (0.058)
Quality criterion dummy	-1.455 (1.052)	-1.247 (1.075)	1.739 (1.187)	-1.271* (0.770)		
Log experience	0.037 (0.092)	0.063 (0.084)	-0.303*** (0.107)	0.116*** (0.039)	-1.884*** (0.280)	0.168 (0.141)
Negotiated procedure						
Intercept	6.900*** (1.782)	6.792*** (1.854)	3.872*** (1.019)	3.121*** (1.041)	-1.118 (1.136)	0.971 (1.143)
Log contract value	-0.355*** (0.092)	-0.337*** (0.098)	-0.230*** (0.030)	-0.227*** (0.031)	0.184** (0.081)	0.061 (0.079)
Duration	0.002 (0.004)	0.001 (0.004)	-0.016*** (0.002)	-0.015*** (0.002)	-0.028*** (0.005)	-0.020*** (0.005)
No. of lots	0.338*** (0.106)	0.329*** (0.111)	0.147*** (0.020)	0.139*** (0.020)	0.064 (0.057)	0.008 (0.059)
Quality criterion dummy	-0.830 (1.121)	-0.984 (1.183)	0.096 (0.927)	0.463 (0.937)		
Log experience	0.125 (0.086)	0.142 (0.093)	0.358*** (0.041)	0.305*** (0.041)	0.554*** (0.122)	0.331*** (0.125)
iv	1.801 (3.324)	0.071 (0.887)	7.755*** (1.644)	1.157*** (0.341)	22.821*** (3.044)	2.964*** (0.797)
Year	No	Yes	No	Yes	No	Yes
Region	No	Yes	No	Yes	No	No
Observations	4,492	4,492	21,254	21,254	10,190	10,190
R ²	0.057	0.111	0.052	0.112	0.058	0.082
Log Likelihood	-2,829.810	-2,667.030	-18,830.900	-17,635.830	-8,721.399	-8,498.502

Note: * p<0.1; ** p<0.05; *** p<0.01

Chapter 5

Study 2: Award Mechanism and Decision Speed in Public Procurement

5.1 Introduction

A notable amount of time in public procurement is spent on award decision making. From 2009 to 2015, the decision time for UK public contracts was on average six months. Almost half of the contracts were not awarded on the original schedule. For example, nine months of delay occurred during the award process of the UK public contract to widen highway M25 and it contributed to an overall project delay of 18 months. The overall delay of the project is estimated to increase the net present cost by £660 million, a 24% increase of the initial £2.7 billion total cost (UK National Audit Office, 2010).

This chapter explores how the choice of EU award mechanisms in the UK is related to the award decision speed. Specifically, this chapter tests the relationship between award mechanisms and three dimensions of decision speed: the duration of the award process, the probability of delaying the award and the duration of delay.

EU public procurement utilises four benchmark award mechanisms: the open procedure, the restricted procedure, the negotiated procedure and competitive dialogue.¹ The open and restricted procedures do not allow negotiations, the competitive dialogue allows negotiation at an early stage, and the negotiated procedure allows negotiation throughout the whole procedure.

Practitioners (e.g. Lynch, 2015 and Yescombe, 2007) and policymakers (e.g. UK Na-

¹See Section 2.2.1 for detail of the benchmark award mechanisms in the EU.

tional Audit Office, 2007) usually claim that negotiations slow down the decision speed in public procurement. However, to the best of our knowledge, this claim has not been empirically well-supported. Reeves et al. (2017) assert that they test the impact of competitive dialogue. However, they represent competitive dialogue by using a time dummy, which may be an inaccurate approach. Besides, they only compare competitive dialogue with the negotiated procedure.

Within this context, our contributions are twofold. First, we build upon theories in the strategic management and public procurement literatures to propose and test hypotheses regarding the link between the four EU benchmark award mechanisms and decision speed. Second, we provide new insights into the understanding of the tradeoffs between using different award mechanisms in public procurement practice. The knowledge might help public buyers choose a suitable award mechanism and propose a reasonable procurement schedule. In addition, the knowledge may help policymakers move forward in award mechanism design, as it uncovers some features that may slow down decision speed.

Given the economic and political significance of public projects (e.g. Loader, 2013, Pickard, 2017, Plimmer, 2016, Deloitte, 2016, and Uyarra and Flanagan, 2010), a relatively large body of literature examines the significance of different award mechanisms for realising the desired social benefits from public contracts (e.g. Bajari et al., 2008, Bulow and Klemperer, 1996, McAfee and McMillan, 1987a, Tadelis, 2012). While the direct monetary and quality impact are indeed crucial for public procurement, not many studies have investigated delivery time.

In particular, the public procurement literature has not yet explicitly tested the decision speed associated with various award mechanisms.² This is surprising because the strategic management literature lays considerable emphasis on the role of decision speed in determining the economic benefits associated with private firms (Baum and Wally, 2003, Eisenhardt, 1989, Forbes, 2005, Judge and Miller, 1991). The European Commission (2017a) comments that very lengthy procedures should be avoided because they are

²In this chapter, decision speed for public procurement contracts refers to the time elapsed from publication of a procurement opportunity (contract notice) to the award of contract.

expensive and cause uncertainty for both the public buyer and bidders. While acknowledging that both cost and time escalations imply inefficiencies in procurement and that the social welfare of public contract often depends on delivery time, the public procurement literature focuses on time spent by contractors, i.e. time after a contract is awarded, and largely ignores time spent on making award decisions (Gori et al., 2017, Guccio et al., 2012, Lewis and Bajari, 2011, Love et al., 2013).³ We have identified only two prior quantitative empirical studies on decision speed in public procurement: Reeves et al. (2017) and Reeves et al. (2015) focus on sectoral variations of decision speed for PPPs but do not relate their model specifications to theories of decision process.

The rest of this chapter is organised as follows. The next section explains the significance of decision speed and identifies the explanatory variables based on the theoretical framework from the strategic management literature. Section 5.3 proposes hypotheses and describes the data. Section 5.4 introduces the dichotomous logit model and survival analysis. These two methods form the split-population survival time model employed by our analysis. Section 5.5 discusses the results. Section 5.6 is the conclusion. The Appendices provide supplemental information for the survival analysis: the non-parametric methods in Appendix A and alternative hazard models in Appendix B.

5.2 Significance and Determinants of Decision Speed

This section draws the importance of decision speed and the determinants of decision speed from the strategic management literature. It extends the knowledge from the strategic management literature to the public procurement context because studies of decision speed are scarce in the public procurement literature.

³A larger number of studies from the project management and engineering literatures also focus on the time overrun after contract award (Ahsan and Gunawan, 2010, Assaf and Al-Hejji, 2006, Odeh and Battaineh, 2002, Sambasivan and Soon, 2007). Most of these studies are based on surveys collected from practitioners. While practitioners' hands-on experiences are invaluable, their perceptions may be subjectively biased.

Rajagopalan et al. (1993) take decision speed as one of the *process outcomes* in their integrative framework that summarises the strategic management literature on decision-making processes (see Figure 5.1 for a simplified version). The process outcomes are affected by three sets of antecedent factors (*environmental*, *organisational* and *decision-specific factors*) and *decision process characteristics*. In turn, the process outcomes affect the *economic outcomes* (e.g. firm performance), which is indirectly affected by the antecedent factors.⁴

The main interest of this study is in whether and how the award mechanism choice is related to the award decision speed in public procurement. The award mechanism choice determines many aspects of the decision process characteristic in a contract award decision. While the next section discusses the hypotheses regarding the relationship between the award mechanism choice and decision speed, this section reviews the importance of decision speed (Section 5.2.1) and the environmental, organisational and decision-specific factors in sequence. Since we take the environmental, organisational and decision-specific factors as control variables in the analysis, readers may wish to skim the subsections (Sections 5.2.2 to 5.2.6) about these factors.

We attempt to link the existing arguments in the strategic management literature to the context of award decision in public procurement. Corresponding factors in award decision-makings in public procurement can be identified according to the integrative framework of the strategic decision process by Rajagopalan et al. (1993). We identify the level of competition as an environmental factor; authority experience, authority type and whether it is an “on behalf” purchase as the organisational factors; contract complexity and quality concerns as decision-specific factors; and lastly, the type of award mechanism as a decision process characteristic.

⁴Papadakis et al. (1998) and Shepherd and Rudd (2014) also construct frameworks of the strategic decision making process.

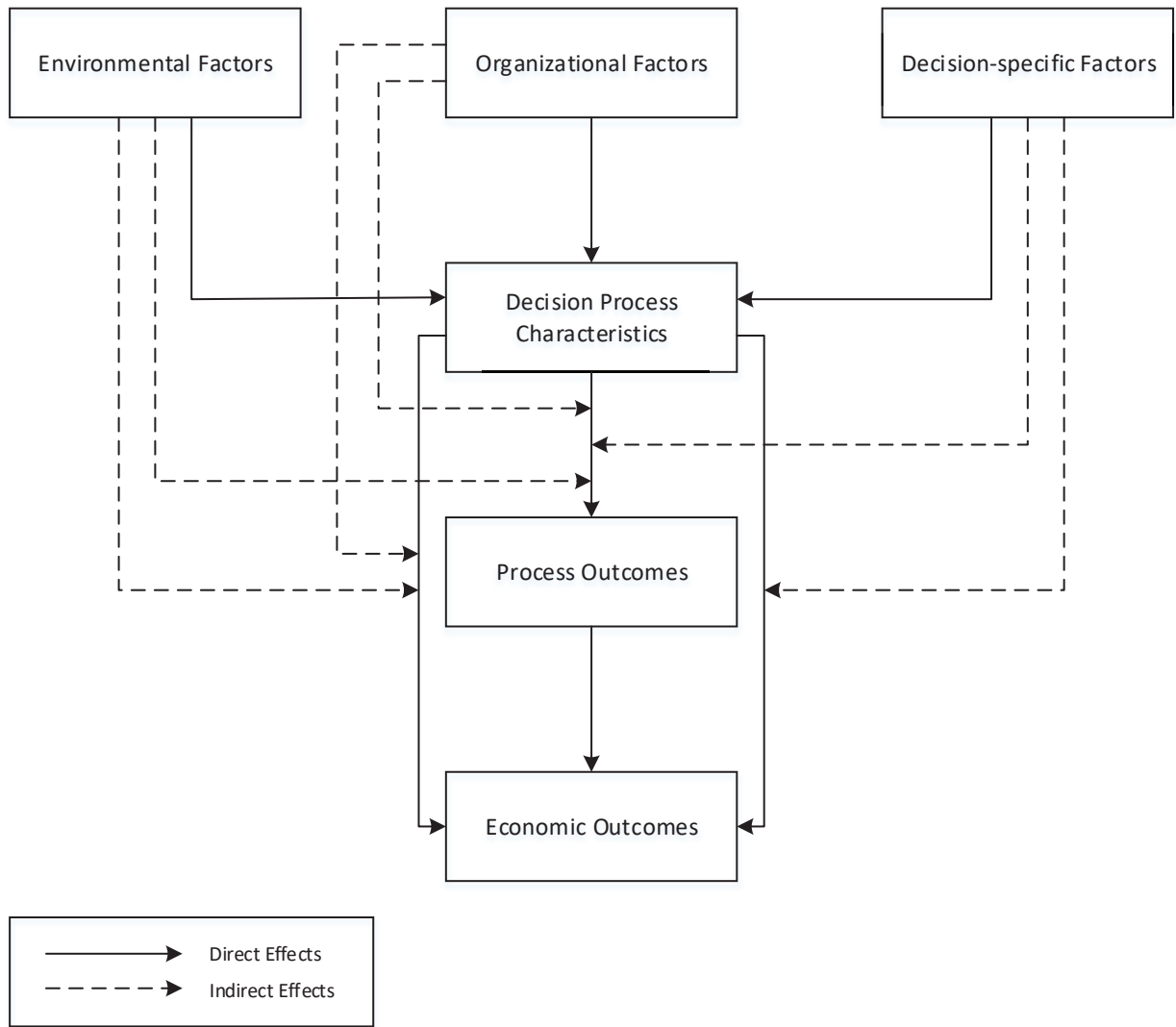


Figure 5.1: Strategic Decision Process: An Integrative Framework

Source: [Rajagopalan et al. \(1993\)](#)

5.2.1 Significance of Decision Speed

The strategic management literature refers decision speed to “how quickly organisations execute all aspects of the decision-making process, spanning from the initial consideration of alternative courses of action to the time at which a commitment to act is made” (Eisenhardt and Mintzberg et al. in Forbes, 2005, p. 355). This literature on decision speed focuses on private firms. It emphasises that decision speed can affect firm performance not only directly but also indirectly through strategic implications.

The relationship between decision speed and firm performance is most evident in a fast-moving environment (Elbanna and Child, 2007). In a dynamic environment that is characterised by unpredictability, firms that make faster decisions are likely to reap *first-mover advantages* by exploiting opportunities that elapse rapidly (D’Aveni et al., 2010, Gumpert and Stevenson, 1985, Makadok, 1998, Nadler and Tushman, 1999). Bourgeois and Eisenhardt (1988) and Eisenhardt (1989) start the study on the association between decision speed and firm performance. They identify positive relationships between decision speed and decision quality and between decision speed and firm performance in high-velocity (i.e. fast-moving) environments. Baum and Wally (2003) find empirical support that fast decision predicts growth and profit, and Judge and Miller (1991) find that a positive association between decision speed and firm performance exists only in high-velocity environments.

Admittedly, a side-effect of making fast decisions is to forgo the benefits of information that is disclosed slowly over time (Shankar et al., 1998). But as the circulation of information and information-processing efficiency are enhanced by advancing information technology, a slow decision-making process may not necessarily lead to more accurate decisions (Keen, 1988).

A more recent study on new ventures indicates that firms that make faster decisions are more likely to close (Forbes, 2005). This may be explained by the *speed trap* that over-emphasising on fast decision-making would mislead firms into a vicious cycle of less

attention to decision content and more critical issues to be decided (Perlow et al., 2002).

Decision speed has strategic implications that indirectly affect firm performance. Fast decision making accelerates the cognitive process and enhances learning because decision makers are obliged to be more deeply immersed in the decision environment (Eisenhardt, 1989), to more intensively develop and evaluate alternative choices (Anderson, 1983, Eisenhardt, 1989), and to more efficiently integrate information within time constraints (Hayes, 1981, Payne et al., 1988). Moreover, fast decision making may indicate proactive behaviour the management, which can enhance commitment from stakeholders, e.g. employees and potential investors (Langley, 1989). It nurtures a culture of action that applying knowledge into practice instead of over-emphasising the importance of planning (Pfeffer and Sutton, 2013).

A number of insights from the strategic management literature apply to public procurement. The concept of the *first mover advantage* and *speed trap* are relevant. A lengthy tendering period imposes high opportunity costs on bidders because they lose alternative trading opportunities (Ehrman and Peters, 1994). Since public buyers compete with each other for the best suppliers, those who make fast decisions are likely to get a larger number of bidders, which enhances competition and benefits the public buyers.

As time is also a cost to the public buyer, the downsides of delaying award decisions are self-evident (Van den Hurk and Verhoest, 2015). Time spent on an award decision is added to the overall time spent on delivery. Time overruns in award period affect post-award schedules because additional efforts by contractors are required to accelerate production and delivery arrangements in order to get back on schedule and adhere to the initial contract completion date (Lewis and Bajari, 2011). Otherwise, delays in delivering contracts will occur.⁵ Additional efforts are often compensated by extra payments. Therefore, an extended tendering period reduces social welfare by imposing a higher social cost or postponing user access to infrastructures or services (Lewis and Bajari, 2011, Reeves

⁵In their study on international development projects in Asia, Ahsan and Gunawan (2010) identify 88 out of 243 cases of delay in overall projects that can be ascribed to the lengthy evaluation in award mechanism or the award mechanism itself.

et al., 2015, 2017). However, making an award decision too fast may indicate insufficient care by the buyer in scrutinising bids.

Improvement of cognition and learning and enhancement of stakeholders' commitments are also relevant to public procurement. Like decision makers in firms, decision makers in public procurement can improve their cognitive and learning processes through the processing more information per unit of time. Making timely award decisions can signal that the public authority values punctuality. This may, in turn, strengthen contractors' commitment to carry out contracts on time.

However, the literature on decision speeds in the private sector offers no clues on how decision speed varies with award mechanisms, which determine various characteristics of the award decision process in public procurement.

5.2.2 Environmental Factor: Level of Competition

Theories in the strategic management and award mechanism design literatures jointly suggest that the level of competition affects award decision speed partially through the choice of award mechanism. According to the award mechanism literature, greater competition allows the award mechanism designer to extract more surplus (Bulow and Klemperer, 1996, Harris and Raviv, 1981, Holt, 1979). A greater level of competition generally means a larger number of bidders, allowing more alternatives to be considered by the contracting authority. Auctions are inherently able to incorporate more participants than negotiations.

In the strategic management literature, Eisenhardt (1989) argues that considering more alternatives at the same time accelerates cognitive processing and therefore, decision making speed. This argument is endorsed by empirical evidence from Anderson (1983) and Judge and Miller (1991) and laboratory experiment results from Schwenk (1983). An alternative viewpoint is that comparing and evaluating more alternatives require more time and slow down the pace of decision making (Fredrickson and Mitchell,

1984, Mintzberg et al., 1976, Schweiger et al., 1986).

5.2.3 Organisational Factor: Authority Experience

Experience is an intangible asset of human capital possessed by individuals that can facilitate strategically valuable behaviour, such as the procurement of resources (Becker, 1994, Hitt and Tyler, 1991, Pfeffer, 1994). It potentially affects both decision speed and choice of award mechanism.

Relevant experience is likely to accelerate decision making because people gather and process information more quickly. People with prior relevant experience are familiar with relevant information sources so they can gather information faster (Forbes, 2005). Second, people with prior relevant experience already possess a stock of knowledge which enables them to identify useful information more efficiently (Forbes, 2005). Lastly, because people with prior relevant experience know well about the decision process and data interpretation, they are likely to analyse information more swiftly (Lord and Maher, 1990).

Experience benefits public buyers in both auctions and negotiations (Bajari et al., 2008).⁶ On the one hand, the costs of implementing auctions are likely to decrease with experience. On the other hand, the more experienced buyer is more skillful in extracting rents in negotiations.

5.2.4 Organisational Factor: “On Behalf” Purchase

An “on behalf” procurement is conducted by a central purchasing body or by several buyers buying together. An on behalf procurement is an analogue to a decentralised decision making structure. In a decentralised structure, information is held separately. Vertical and/or horizontal interactions across units are more frequent in a decentralised

⁶It is also supported by empirical results from Chapter 4.

structure than in a centralised structure (Wally and Baum, 1994).

A centralised structure accelerates decision making. A centralised organisation concentrates information in a small group of decision makers who are less dependent on consultation (Eisenhardt, 1989, Galbraith, 1977). Besides, centralisation requires fewer interactions across different units and thus reduces the necessity of sharing information and mediating conflicts (Pfeffer, 1981, Shrivastava and Grant, 1985). Baum and Wally (2003), Eisenhardt (1989) and Wally and Baum (1994) show a positive relationship between decision speed and concentration in their empirical results. Using an agent-based simulation, Siggelkow and Rivkin (2005) suggest that decentralisation speeds up decision making in simple conditions, but in complex conditions when sophisticated coordination across different units is burdensome, centralisation accelerates decision making speed in the context of public procurement.

An on behalf purchase may also affect the choice of award mechanism. Such bulk purchase is more attractive to suppliers than purchase of smaller size because it is likely to generate a larger amount of absolute profit. Since the attractiveness of the offer is a factor that determines bargaining power, on behalf purchase may endow public buyers with higher bargaining power, which in favours public buyers in negotiations (Spaniel, 2014).

5.2.5 Organisational Factor: Authority Type

Whether local authorities or the central government conduct the procurement may affect award decision speed through their typical characteristics, e.g. access to information, organisation size, and flexibility of the organisational system.

Access to information. Access to complete information may boost decision makers' confidence and thus speed up decision making (Duhaime and Schwenk, 1985, Galbraith, 1977). Compared with the central government, local authorities lack human, financial and technical resources (Crook and Sverrisson, 1999, Smith, 1985). Lack of resources

may impede local authorities from getting complete information about the purchase and bidders' characteristics and thus slow down the award decision making.

Organisational size. Jin and Zou (2002) show some statistics of subnational and national government sizes of 17 industrial and 15 developing countries over the period from 1980 to 1994.⁷ They measure subnational and national government size by the proportion of a nation's GDP taken up by the total expenditure at the corresponding government level. In these countries, subnational governments on average account for 14.5% of GDP and national governments on average account for 32% of GDP in 1994. A larger organisation size indicates a more complex organisation structure (Pugh et al., 1968), which tends to slow strategic decision making (March et al., 1976). Studies on decision speed by Forbes (2005), Judge and Miller (1991) and Wally and Baum (1994) have controlled for organisation size.

Formalisation. Formalisation refers to rigidification and inflexibility of the system. Structural formalisation may slow down the decision making process by requiring collecting large amounts of data and analysing alternatives extremely thoroughly (Fredrickson and Mitchell, 1984) and by encouraging organisational inertia (Wally and Baum, 1994). Though simultaneously considering many alternatives may not slow the decision making speed (Eisenhardt, 1989, Judge and Miller, 1991), excessively evaluating the alternatives may do. Structural formalisation is one of the manifestations of comprehensiveness (Wally and Baum, 1994) and large organisations are more comprehensive in terms of the strategic decision making process than smaller organisations (Fredrickson and Iaquinto, 1989, Papadakis et al., 1998). Therefore, it can be expected that central government tends to be characterised by a higher level of formalisation, which is a feature that would decelerate the award decision process.

⁷The countries are: Argentina, Australia, Austria, Belgium, Bolivia, Brazil, Canada, Chile, Colombia, Denmark, France, Germany, Iceland, India, Indonesia, Iran, Ireland, Israel, Luxembourg, Malaysia, Mexico, Netherlands, Norway, Paraguay, South Africa, Spain, Sweden, Switzerland, Thailand, United Kingdom, United States and Zimbabwe.

5.2.6 Decision-Specific Factor: Complexity and Quality Concerns

Contract complexity and the accompanying quality concerns affect both decision speed and the award mechanism used. While [Holland \(2014\)](#) points out that complexity does not have a rigorous definition, the complexity of a contract may be defined as the effort required to provide a complete set of plans ([Tadelis, 2012](#)). Complex contracts contain dimensions that are difficult or even impossible to specify and are likely to give rise to higher quality concerns. They require more effort and therefore are more time-consuming to design.

Increasing complexity and quality call for interactions between the contracting authority and potential suppliers as well as greater discretionary power for the contracting authorities to restrict the number of providers to only the most competent ([Bajari and Tadelis, 2001](#), [Manelli and Vincent, 1995](#)). Negotiations facilitate communications to improve contract design and accommodate needs for ex post renegotiation ([Goldberg, 1977](#), [Tadelis and Bajari, 2006](#)). Compared with auctions, negotiations are more suitable for more complex contracts.

5.3 Hypotheses and Data

The last section introduces the significance of decision speed and the control variables. This section focuses on the independent variable of main interest – the choice of award mechanism, which is closely related to many decision process characteristics. It firstly discusses the views on the role of award mechanism in decision speed and proposes hypotheses accordingly (Section [5.3.1](#)), then describes decision speed by award mechanism classification using descriptive statistics (Section [5.3.2](#)) and the Kaplan-Meier Curve (Section [5.3.3](#)) and lastly explains the definitions of variables applied in later regressions using the dichotomous logit model and survival analysis (Section [5.3.4](#)).

This study takes the process outcomes (i.e. the log duration of award process, hazard

of award and probability delay) as the dependent variable and the choice of award mechanism as the main independent variable. In addition, it controls for some environmental, organisational and decision-specific factors.

5.3.1 Hypotheses about Award Mechanism

It seems that no theoretical studies have examined the relationship between award mechanism and decision speed. This may be because the relationship between award mechanism, which defines many aspects of process characteristics, and speed of decision making, which is one of the process outcomes, is regarded as self-evident ([Rajagopalan et al., 1993](#)).

Some practitioners and regulators blame negotiation for a lengthy procurement process and delays in contract awarding, but their claims have no credible empirical support – almost no study has comprehensively examined the link between award mechanism and award decision speed.

According to [Yescombe \(2007\)](#), PPP contracts often involve *very lengthy negotiations*. Without controlling other variables, [UK National Audit Office \(2007\)](#) explicitly takes negotiation as a cause of a lengthy award period. It states that:

...[T]endering period overall lasted an average of 34 months [for projects closed between 2004 and 2006]...- no better than the average for projects that closed between 2000 and 2003. ... However, we found that many of the reasons for long tendering periods. ... Within the overall tendering period, negotiations to finalise deals with a single preferred bidder have increased, lasting on average over a year and in some cases as long as five years. ([UK National Audit Office, 2007, p. 5](#))

[Lynch \(2015\)](#), an international procurement advisor, lists contract negotiations as one of the eight causes of delay in the procurement process for general public contracts.

As far as we know, [Reeves et al. \(2017\)](#) is the only prior quantitative study that tests the relationship between decision speed and award mechanism while controlling for other variables. They compare competitive dialogue and the negotiated procedure regarding the award decision speed of public-private partnership (PPP) contracts. Their results show that competitive dialogue, which is designed to limit the length of negotiation, corresponds to a longer overall tendering period. This contradicts the views that negotiations slow down award decision speed. However, they use a time dummy to account for competitive dialogue, defined by the year of its introduction, 2006. This dummy variable may not accurately affect the impact of the competitive dialogue because it captures too many additional factors, among which are included, the 2007–2008 financial crisis and the subsequent economic recovery.

We propose three hypotheses to test the general expectations of practitioners on the role of negotiation in decision speed:

Hypothesis 1. Award mechanisms with negotiation are associated with longer duration of the overall award process than award mechanisms without negotiation.

Hypothesis 2. Award mechanisms with negotiation are associated with a higher probability of delaying award than award mechanisms without negotiation.

Hypothesis 3. Award mechanisms with negotiation are associated with longer delays in awarding contracts than award mechanisms without negotiation.

5.3.2 Descriptive Statistics of Decision Speed

Our data include all UK public procurement contracts published in the Tenders Electronic Daily (TED) during the period 2009–2015. TED is the digital version of the Official Journal of the European Union, where public procurement contracts above EU thresholds must be advertised. The EU also encourages under-threshold contracts to be published in the TED. As a result, this database contains both above- and under-threshold contracts.

The data consist of two parts, contract notices (CNs) and contract award notices (CANs), linked by a common variable CAN ID. The data include 8,217 observations that have both parts and have the planned contract start date in the CN, t_{PS} . These observations also contain the CN dispatch date, t_{CN} , the end date of application, t_{EA} , and the date of contract award, t_{CA} . Most of the observations have information on contract characteristics such as the description of the target to be purchased, estimated value, award mechanism, and award criteria.

Referring back to Figure 2.1, the response period is calculated as the difference between t_{CN} and t_{EA} . A combination of the screening period and the standstill period is computed as the difference between t_{EA} and t_{CA} .

Table 5.1 Panel A gives descriptive statistics for the response period after removing observations with a response period of less than 10 days.⁸ Due to the small dispersion (and the relatively large data size), the narrow 95% confidence intervals indicate reliable estimates of the population means. The duration of the response periods generally comply with the EU requirement of the minimum response period: the response period for the open procedure is on average the longest, the response period for the accelerated procedures are on average the shortest, and those for the restricted, negotiated and competitive dialogue procedures are in between. There are no great differences in the duration of response period among the four EU benchmark award mechanisms and between the two accelerated procedures. Besides, the statistics indicate that the duration of the response period is roughly symmetrically distributed around the mean.

Panel B from Table 5.1 describes the duration of the screening period plus the standstill

⁸ According to the EU public procurement directive 2004/18/EC ([European Parliament and European Council, 2004](#)) Article 38, the minimum response period is 10 days for the accelerated restricted and accelerated negotiated procedures, 30 days for the restricted, negotiated and competitive dialogue procedures, and 40 days for the open procedure, considering all circumstances. It is fair to exclude values that are less than 10 days to ensure accuracy. Even for those contracts not subject to EU public procurement directives, a response period of less than 10 days is too short to fully inform all potential bidders and allow time for potential bidders to draft tenders or requests to participate. Unreported results show that the 1st percentile for all procedures except for the two accelerated procedures is greater than 10 days, which confirms that such a filtering rule retains no less than 99% of the original data for those procedures. No less than 95% of the original data for the accelerated restricted procedure are retained and no less than 75% of the original data for the accelerated negotiated procedure are retained.

period. The two periods are reported in combination because the cut-off date of the two periods (i.e. the date when an award decision notice is dispatched) is not available. Observations with a less than 10-day aggregate duration of the screening and standstill periods are excluded from this summary statistics because the legally required standstill period is no less than 10 days. Although the variation of the sample is relatively large, the ranges of the 95% confidence intervals are generally acceptable, which is owed to the reasonably large sample size. Since the means are larger than the corresponding medians, the distribution is positively skewed.

The average duration of screening bids and awarding contracts is about four months (126.21 days). Among the four benchmark award mechanisms, the competitive dialogue has the longest average duration and the open procedure has the shortest. This is within expectation because competitive dialogue is designed for the most complex contracts, while the open procedure is for simpler contracts. However, it is striking that the restricted procedure tends to have a longer average duration of screening and awarding contract than the negotiated procedure, suggested by the larger mean and quartile values of the restricted procedure. Moreover, the accelerated restricted procedure is also likely to be longer than the accelerated negotiated procedure. These results are at odds with the claim that the negotiation is responsible for lengthy screening periods.

Table 5.2 shows the chronological order of t_{CA} and t_{PS} . The values are calculated as the t_{CA} minus t_{PS} . A positive value captures the number of days of delay in contract award and a negative value represents the number of days of an early award.⁹ To avoid the significant impact of outliers and get relatively reliable estimates, the statistics are generated after trimming the sample by 25%. The table shows that more than 75% of contracts with the negotiated procedure and around 50% of contracts with the open, restricted, or competitive dialogue procedures were awarded before or on $t_{t_{PS}}$. The 75th percentile is 11.75 for the accelerated restricted procedure and zero for the accelerated

⁹This measure tends to underestimate the length of delay. When computing delays, the *actual* date of contract award (t_{CA}) should be compared the *planned* date of contract award, which is prior to the *planned* contract start date (t_{PS}). Because the *planned* date of contract award is not available, the *planned* contract start date is used as a replacement. To alleviate underestimation, we interpret a value of zero as an event of delay in later analyses.

negotiated procedure. This indicates that a higher proportion of contracts awarded with the accelerated restricted procedure were delayed than with the accelerated negotiated procedure.

Table 5.1: Duration of the Award Period (in Days)

Panel A: Response Period										
Award Mechanism	Obs.	Mean	CI (lower)	CI (upper)	S.D.	Min.	25th	50th	75th	Max.
Open	4021	44.73	44.33	45.12	12.75	10	40	45	49	410
Restricted	3228	36.77	36.32	37.22	12.99	10	31	35	40	398
Negotiated	415	38.2	35.84	40.57	24.51	10	30	35	38	396
Competitive dialogue	108	40.7	38.31	43.1	12.57	29	32	38	45	114
Accelerated restricted	362	19.19	18.3	20.08	8.58	10	14	17	22	71
Accelerated negotiated	47	17.32	14.6	20.04	9.25	10	11.5	15	18	52
Others	36	37.56	34.1	41.01	10.21	12	31.75	38	45.25	55
All	8217	39.91	39.59	40.23	14.82	10	32	40	46	410

Panel B: Screening Period plus Standstill Period										
Award Mechanism	Obs.	Mean	CI (lower)	CI (upper)	S.D.	Min.	25th	50th	75th	Max.
Open	3796	78.25	76.28	80.21	61.68	10	40	63	97	980
Restricted	3072	180.48	176.49	184.47	112.77	16	109	153	220	1213
Negotiated	375	125.03	113.31	136.74	115.37	16	61	92	142.5	830
Competitive dialogue	99	323.52	285.51	361.52	190.54	46	174	295	406.5	958
Accelerated restricted	337	116.67	105.95	127.40	100.09	10	56	86	144	711
Accelerated negotiated	42	56.90	42.81	71.00	45.23	10	36.5	45	63.75	278
Others	31	203.74	120.28	287.20	227.54	18	66.5	120	209	1001
All	7752	126.21	123.83	128.60	107.20	10	57	98	161	1213

Notes. 1. Response period: the difference in days between the date when the CN is dispatched and the end date of applications.

2. Screening period: the difference in days between the end date of applications and the date when the award decision notice is dispatched to all participants. Standstill period: the difference in days between the date when the award decision notice is dispatched and the date of contract award. The two periods are reported as a combination because the date that separates these two periods is unavailable.

3. "Award Mechanism" is based on information from CANs, which is the final award mechanism used. There are few cases in which the award mechanisms recorded in the CN and in the corresponding CAN differ.

4. "CI (lower)" and "CI (upper)" refer to the lower and upper bounds of the 95% confidence interval.

5. "Others" refers to a procedure without prior publication of a CN or a call for competition.

6. The sample is truncated by removing observations with a less-than-10-day response period for Panel A and by removing observations with a less-than-10-day aggregate duration of the screening period and the standstill period for Panel B. In practice both the response period and the standstill period should be at least 10 days.

Table 5.2: The Difference between the Actual Date of Contract Award and the Planned Contract Start Date (in Days)

Award Mechanism	Obs.	Mean	CI (lower)	CI (upper)	S.D.	Min.	25th	Median	75th	Max.
Open	2161	-1.36	-2.04	-0.67	16.25	-31	-13	-1	9	33
Restricted	1284	-2.21	-3.14	-1.28	16.97	-31	-16	-2	9	33
Negotiated	284	-5.21	-6.64	-3.79	12.19	-31	-14	0	0	31
Competitive dialogue	33	4.03	-1.97	10.03	16.93	-26	-8	0	17	32
Accelerated restricted	166	0.59	-2.01	3.2	17	-31	-11	0	11.75	33
Accelerated negotiated	39	-3	-5.67	-0.33	8.24	-28	-2.5	0	0	21
Others	13	-3.31	-11.59	4.98	13.71	-29	-9	0	0	17
All	3980	-1.81	-2.31	-1.3	16.24	-31	-14	-1	8	33

- Notes.* 1. “Award Mechanism” is based on information from CANs, which is the final award mechanism used. There are few cases in which the award mechanisms recorded in the CN and in the corresponding CAN differ.
2. “CI (lower)” and “CI (upper)” refer to the lower and upper bounds of the 95% confidence interval.
3. “Others” refers to a procedure without prior publication of a CN or a call for competition.
4. A positive figure in days means that the *actual* date of contract award was later than the *planned* contract start date, while a negative figure means that the *actual* date of contract award came before the *planned* contract start date. A positive figure is used as a measure of the number of days of delays in the contract award. This measure underestimates the length of delays in the contract award. When calculating the delays, the *actual* date of contract award should be compared with the *planned* date of contract award, which is prior to the *planned* contract start date. Because the *planned* date of contract award is not available, the *planned* contract start date is used as a replacement.
5. The sample is trimmed by 25% to remove the significant impact of outliers.

5.3.3 Kaplan-Meier Curve

This subsection provides Kaplan-Meier curves as a supplement to the descriptive statistics in the last subsection. The results from these two methods are consistent, i.e. the decision speed predicted by the negotiated procedure is slower than that predicted by the open procedure but is not slower (may even be faster than) that predicted by the restricted procedure. The Kaplan-Meier curve is a nonparametric technique in the survival analysis that is used for studies on event occurrence.

The survival analysis is suitable for this study because the interest of this study is when a contract is awarded. Section 5.4.2, Appendix A and Appendix B explain the survival analysis in detail. One advantage of nonparametric methods over parametric methods is that that no assumptions about the distribution of event times are required in the former.

Our data are closer to continuous-time type because they are recorded using a fine-grained time metric of days. The attribute of continuous-time allows us to adopt the Kaplan-Meier method to estimate the survival function and display the estimates using the Kaplan-Meier curve.¹⁰

Figure 5.2 presents the Kaplan-Meier curves for all contracts in the dataset and takes t_{CN} as the beginning of time. Information about the overall duration of the award process can be inferred from this figure. The percentage survival rate at time point t stands for the proportion of contracts that are not awarded by time point t . At any given time, the open procedure has the lowest percentage survival rate. The negotiated procedure has a lower percentage survival rate than both the restricted procedure and competitive dialogue until after 400 days of t_{CN} , when the curves for the negotiated and restricted procedures converge. The median lifetime is lowest for the open procedure (around 100

¹⁰See Appendix A for an introduction of nonparametric methods to describe event occurrence data. The Kaplan-Meier method is more accurate and less affected by subjective judgement than the other two nonparametric methods for describing continuous-time data. We do not provide the life table estimated by the Kaplan-Meier method because the thousands of time intervals resulting from thousands of events make the table too long to present.

days), second lowest for the negotiated procedure (around 137 days), followed by a median lifetime of about 190 days for the restricted procedure and about 330 days for competitive dialogue. Figure 5.2 suggests that the average overall duration of the award process for the negotiated procedure is longer than that for the open procedure but shorter than for the restricted procedure and competitive dialogue.

Figure 5.3 plots the Kaplan-Meier curves for contracts with delayed awards and takes t_{PS} as the beginning of time. This figure reflects the duration of delay. Once the delay of award occurs, the percentage survival rate is the lowest for the negotiated procedure in the very early stage of delay. The survival rate for the negotiated procedure has a sharp decline to 40% not long after t_{PS} when the survival rates for the remaining procedures are still quite high. This suggests that for the negotiated procedure 60% of contracts that were not awarded before the planned contract start date were awarded shortly after the planned contract start date. The survival curve for the negotiated and open procedures intersect at around 17% after 100th days of delay when the survival rates for the restricted procedure and competitive dialogue are just below 40%. This shows that the proportion of contracts that were awarded within 100th days of delay was higher for contracts with negotiated or open procedure (83%) than for contracts with the restricted procedure or competitive dialogue (60%).

5.3.4 Variable Definition

This subsection introduces the variables used in the regressions. A summary of the variables is exhibited in Table 5.3. The dependent variable varies according to the models used to analyse the award decision speed. The *log duration of award process* is the dependent variable in the OLS model. It is the natural logarithm of the number of days between the date when the CN was dispatched and the date of award. In the Cox model, the dependent variable is the instantaneous *hazard of awarding a contract* at a particular time t , on the condition that the contract is not awarded before time t . The logit model takes the *probability of delaying contract award* as the dependent variable. The probability

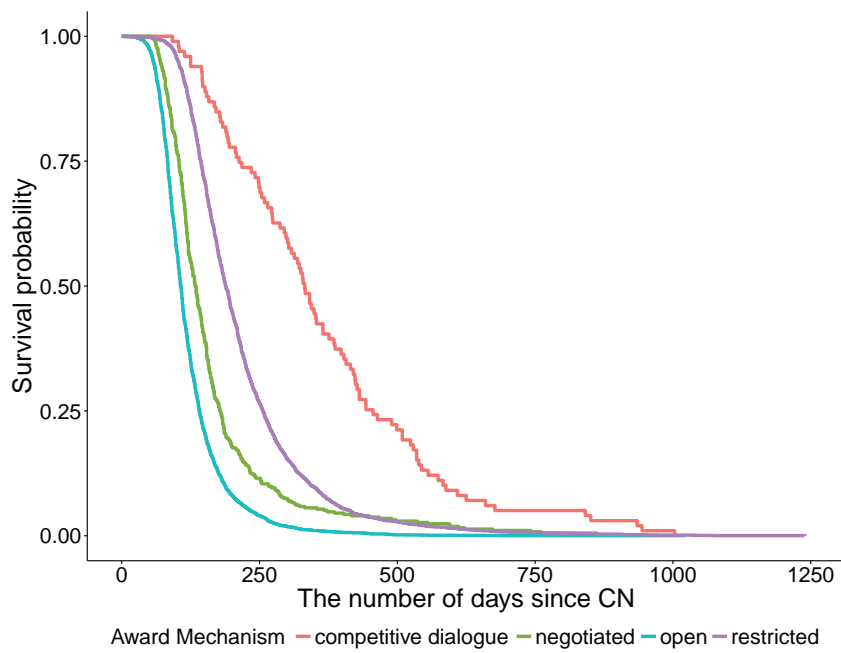


Figure 5.2: Kaplan-Meier Curves for All Contracts

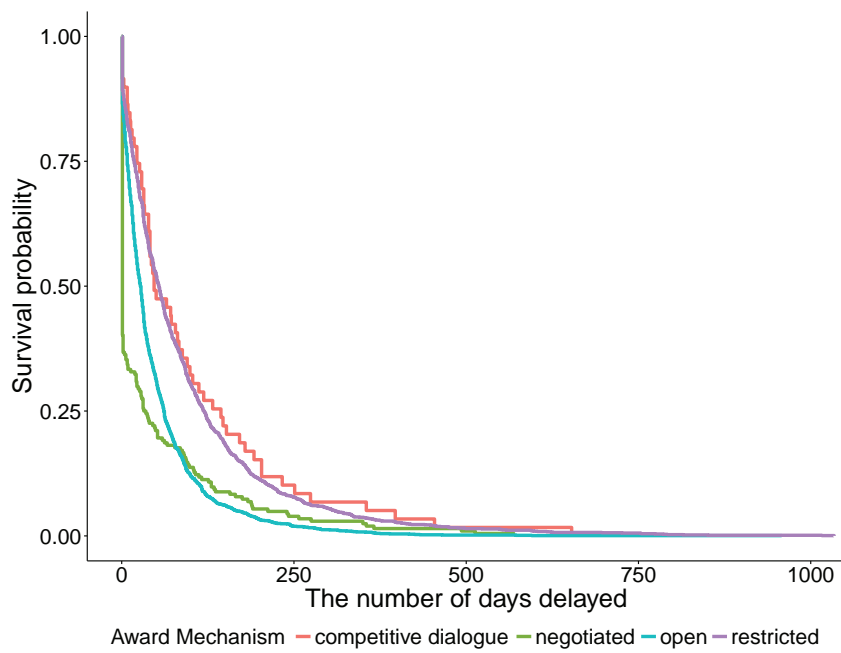


Figure 5.3: Kaplan-Meier Curves for Contracts with Delayed Award

of delaying contract award is the final cumulative outcome of the instantaneous hazard of awarding contracts.

The explanatory variables included in the regressions are identified according to the discussion in Section 5.2. The *type of award mechanism*, as a decision process characteristic, is the explanatory variable of main interest.¹¹ As a categorical variable, it contains four values in the main regressions: the open, restricted and negotiated procedures and competitive dialogue.

Variables classified as environmental, organisational and decision-specific factors are possible confounders (i.e. variables that affect both the explanatory variable of interest and dependent variable). These confounders are likely to be associated with type of award mechanism, probability of delay and duration of delay, so they are controlled for to reduce bias in the estimates for award mechanisms.

The environmental factors include *response period*, which is the difference in days between the date when the CN was dispatched and the end date of application; and a *lots dummy*, which is a binary variable where a value of 1 indicating that a contract is split into multiple lots and a value of 0 for a contract does not use any lots. The response period is used to account for competition. A longer response period exposes a procurement request to more suppliers, so it is likely that more suppliers will bid.¹² The lots dummy is an indicator of both the level of competition and the complexity of a contract. Lots decompose a large contract into smaller sub-contracts. It is likely that more suppliers are able to deliver a sub-contract than to deliver the overall contract. Moreover, the divisibility indicates that responsibilities in sub-contracts can be clearly separated, so the overall contract becomes simpler.

¹¹Gori et al. (2017) control for award mechanism in their analysis of the duration of delay in completing public works contracts for local governments.

¹²Kenny and Crisman (2016) and Knack et al. (2017) provide empirical evidence that the number of bidders is positively correlated with contract advertising.

Table 5.3: Variable Definition

Dimension	Variable	Definition
Process outcomes	Log duration of award process	The dependent variable in OLS regressions. The natural logarithm of the number of days between the date when the CN was dispatched and the date of award.
	Hazard of award	The dependent variable in Cox PH regressions. The conditional probability that a contract is awarded at time t (given that the contract is not awarded before time t)
	Probability of delay	The dependent variable in logit regressions. The probability of delaying a contract award.
Decision process characteristics	Award mechanism	Types of award mechanism. Four values (the open procedure, restricted procedure, negotiated procedure and competitive dialogue) are included in the main regressions.
Environmental factors	Response period	The length of time between the date when the CN was dispatched and the end date of application. A measure of competition.
	Lots dummy	Equals to 1 when a contract is divided into multiple lots and 0 when lots are not used. It is a measure of competition and can also be viewed as a measure of contract complexity perceived by the public authority.
Organisational factors	Sum of contracts	Equals to the cumulative sum of CNs issued by a public buyer. A measure of procurement experience.
	On behalf dummy	Equals to 1 if the procurement is conducted by a central purchasing body or by several buyers buying together, and 0 if not.
	Authority type	Type of the contracting authority.
Decision-specific factors	Log contract value	The natural logarithm of the contract value stated in the CAN. A measure of complexity.
	Contract duration	The estimated duration of contract stated in the CN.
	Quality criterion dummy	Equals to 1 for "most economically advantageous tender" and 0 for "lowest price". A measure of quality concerns.
	Planned award period	The difference between the date of dispatching CN and the planned contract start date.
	Contract type	Type of contract. Contains three values: works, supply and services.
	CPV code	Common Procurement Vocabulary. Used to further classify what is to be purchased.

We identify the sum of contract, on behalf dummy and authority type as organisational factors for an award decision in public procurement. The *sum of contract*, as a measure of authority experience, is the cumulative sum of CNs issued by a public buyer. [Bajari et al. \(2008\)](#), [Chong et al. \(2012, 2014\)](#) and [Gori et al. \(2017\)](#) adopt the similar measure of procurement experience of public buyers. Since experience is tied to individuals rather than to an institution as a whole, employee mobility should admittedly be considered in measuring the experience of an institution like a contracting authority. But it is likely that more than one person within a contracting authority has been involved in previous procurement and it is unlikely that all staffs with previous experience resign at the same time. Furthermore, it is often the case that staff are required to give a notice period before leaving the office so that they can hand over their work and transmit their experience to their successors. As a result, it is credible to take procurement experience of a public authority as a continuously accumulated factor over time.

The variable *on behalf dummy* indicates whether the procurement is conducted by a central purchasing body (including the cases when several buyers buy collectively). The value is 1 for collective purchasing and 0 otherwise. *Authority type* is a categorical variable with 12 values, among which are the local authorities and central government.¹³

Data for several decision-specific factors are available. *Contract value* is the contract value stated in the CAN and *contract duration* is the duration of the contract stated in CN. They are frequently used as proxies of contract complexity in analyses of procurement ([Bajari et al., 2008](#), [Chong et al., 2012, 2014](#), [Gori et al., 2017](#)). Because contract value is positively skewed, the natural logarithm of contract value is used in the regressions.

We use contract values from CANs rather than estimated contract values from the CNs. The estimated contract value is worked out by contracting authorities based on the fundamentals of a procurement. The contract value is the outcome based on the fundamentals of the procurement and the interactions between the contracting authority

¹³The 12 values are: central government; armed forces; local authorities; water, energy, transport and telecommunications sectors; European Union institution/agency; other international organisation; body governed by public law; other; not applicable; national or federal agency/office; regional or local agency/office; and not specified.

and bidders, such as competition, private information and outside opportunities. Since the interactions help both the contracting authority and the winning bidder better understand the contract, contract value may more accurately reflect the real level of contract complexity than the estimated value.

The *quality criterion dummy* is a proxy for quality concerns as a decision-specific factor. It is a binary variable, equal to 1 for using award criteria of “most economically advantageous tender” and 0 for “lowest price”.¹⁴

The *planned award period* is calculated as the difference between the date of dispatching CN, t_{CN} , and the planned contract start date, t_{PS} . We expect this variable to reflect the level of complexity, the buyer’s confidence or competence, the urgency of the procurement, or any combination of these four factors. This measure seems have not been used by previous studies.

Additional decision-specific factors are *contract type* and *common procurement vocabulary (CPV)*. Contract type defines the nature of a contract in three categories: works, supply and services contracts. The CPV is an eight-digit code that further specifies the goods or services purchased. In a CPV code, the latter digits describe the procurement in greater detail. The first two digits indicate which of the 45 divisions (e.g. other transport and equipment) a procurement belongs to, the third digit specifies the group (e.g. ships and boats), the following digit shows the class (e.g. ships), the next digit codes the category (e.g. ships and similar vessels for the transport of persons or goods), and the last three digits reveal the sub-category (e.g. ferry boat).¹⁵

The *year* when the CN is issued and the *region* where the contracting authority is located are controlled for to capture less observable factors that could be responsible for the probability or duration of delay in awarding contracts.¹⁶

¹⁴The other attainable variable about criteria is the weight allocated to price in bid evaluation. This variable is not introduced in the regressions, because it is not representative of all contracts. Criteria weights are available only when the value of the criteria dummy is the “most economically advantageous tender”.

¹⁵See the “Guide to the Common Procurement Vocabulary (CPV)” by [European Commission \(2008\)](#) for details.

¹⁶We have run regressions that control for monthly fixed effects. The monthly fixed effects are not

5.4 Estimation Methodology

The estimates reported here use both the OLS regressions and the split-population survival time model to assess the impact of award mechanism on the timing of contract award. This section explains the econometrics underlying the split-population survival time model. [Schmidt and Witte \(1989\)](#) originally use the split-population survival time model to predict whether an individual returns to prison after a certain period of release. The model consists of two parts: (1) a logit model that estimates the probability of delay for all contracts; (2) a Cox proportional hazard model (Cox PH model) that assesses the hazard of award for contracts with delayed award only, from which the duration of delay can be inferred. We also estimate a Cox PH model with data for all contracts, irrespective of whether there are delays in awards or not. Estimates from this additional Cox PH model are linked to the overall duration of the award process.

This section describes the logit model (Section [5.4.1](#)), reviews the Cox PH model within the background of survival analysis (Section [5.4.2](#)) and integrates the logit model and the Cox PH model as the split-population survival time model (Section [5.4.3](#)).

5.4.1 Dichotomous Logit Model

We estimate the probability of delaying award, π , by the logit model, which is a generalised linear model with the logistic distribution. Detailed introduction of the logit model can be found in [Kleinbaum and Klein \(2010\)](#) and [Train \(2009\)](#).

Regarding the probability of delaying award, contracts fall into two categories: those that are awarded ahead of the scheduled contract start date ($D = 0$) and those that are awarded on or after the scheduled contract start date, i.e. with delayed award ($D = 1$). π is a probability that $D = 1$ conditional on explanatory variables X_1, X_2, \dots, X_k and is confined by the range from 0 to 1 inclusive:

significant, so *month* is not included in the model as an explanatory variable.

$$\pi \equiv Pr(D = 1 \mid X_1, X_2, \dots, X_k) \in [0, 1]. \quad (5.1)$$

The logistic distribution $\Lambda(z) = \frac{1}{1+e^{-z}}$, which is bounded by 0 and 1, is used to fit a nonlinear function to the data:

$$\pi = \frac{1}{1 + e^{-\left(\alpha + \sum_{i=1}^k \beta_i X_i\right)}}. \quad (5.2)$$

Rearranging Equation 5.2 arrives at the log odds of delay:

$$\log_e \left(\frac{\pi}{1 - \pi} \right) = \alpha + \sum_{i=1}^k \beta_i X_i. \quad (5.3)$$

The coefficient β_i for X_i measures the effect of one unit change in X_i on the log odds of delay. A positive (negative) β_i suggests that a rise in X_i increases (decreases) the probability of delay.

5.4.2 Survival Analysis

Survival analysis (also known as duration analysis) evaluates questions about the “occurrence and timing of events” (Singer and Willett, 2003, p. 303). This study is concerned about the timing of awarding a contract, so survival analysis fits the purpose of this study. Specifically, we use a Cox PH model to estimate the impact of award mechanism on the hazard of awarding a contract. We provide a comprehensive introduction to the essentials of survival analysis before introducing the Cox PH model.

Based on Singer and Willett (2003) and Kleinbaum and Klein (2012), we firstly review the three elements of a time-to-event analysis and then introduce the Cox PH model, a semiparametric method. In addition, Appendix A introduces alternative nonparametric methods (including the Kaplan-Meier method) and their underlying econometrics; Ap-

pendix B illustrates alternative hazard models and justifies the use of the Cox PH model in this study.

5.4.2.1 Basic Elements of Event Occurrence

The *target event*, the *beginning of time* and the *metric for clocking time* are the three fundamental elements shared by all research questions about time-to-event occurrence (Singer and Willett, 2003). Here we introduce the three elements as well as the concept of “censored data” which is a common issue in survival analysis studies.

The *target event* is the event whose the occurrence is analysed. It is frequently referred to as the “failure event”, because many events of interest are negative experiences under epidemiologic and medical research, such as death, disease incidence and relapse of using drugs. However, the target event is not necessarily negative. It can be positive events such as “the time to get a job after graduation” in social science studies. In our case, the target event is “a contract being awarded”. The date of event occurrence is recorded as the *award date*.

The *beginning of time* is the starting point of the measurement window when all individuals are at risk of target event but no one has experienced it. Survival time is counted from the beginning of time to the occurrence of the target event. There may be more than one choice of the beginning of time, but the choice must be justified by the purpose of the study. For example, either a person’s age or his tenure on the job may be a predictor of a decision to leave the job. In this case, either the “date of birth” or the “first date of employment” is the beginning of time.

In this study, for the Cox PH model that assesses the overall duration of the award process, we choose the time when a CN is dispatched, denoted as t_{CN} , as the starting point. Alternatively, people may be tempted to choose the end date of application, denoted as t_{EA} . Their reason is that t_{EA} marks the start of the screening period, in which bids are evaluated. However, t_{CN} is superior to t_{EA} as a candidate for the starting time of

the award period when considering the impact of award mechanism. As illustrated in Figure 2.1, the type of award mechanism determines the schedule of the procurement after the publication of the CN. The type of award mechanism makes a difference in not only whether negotiations are allowed during the screening period but also the minimum duration of the response period, whether requests to participate or tenders are submitted during the response period, and whether a prequalification stage is required. As a result, the award process should include the response period.

As the second part of the split-population model, the Cox PH model for the duration of delaying award takes the planned contract start date stated in the CN as the starting point to count the number of days of delay. It should be noted that this model applies to only those contracts with delayed awards.

The *metric for clocking time* is a unit to record time. It can be as fine as *seconds* or *days* or as coarse as *semesters*, *months* or even *years* depending on the data collecting mechanism. Since more precise measurement preserves more information than less precise measurement, time should be recorded in the most precise units possible. The time metric for data analysis and the time metric for data collection can be different. Rounding is not allowed when transforming a more precise time metric into a coarser one; otherwise, the hazard estimate may be biased. Hazard depends on the length of the time interval. Rounding produces a rougher time measurement and increases the number of ties in a certain time interval. For this study, time is recorded the number of *days*.

Censoring occurs whenever an individual's event time is unobserved. There are three reasons for this: (1) the target event never takes place; (2) the target event took place outside the follow-up time window; (3) an individual is lost to follow-up during the study period. Censoring provides partial information about individual survival time, but the exact survival time is unknown. Right-censoring and left-censoring are two basic types of censoring. Right-censoring is when the event occurrence is not observed during the study time window, so the actual survival time is no less than the observed survival time. Left-censoring occurs when it is known that the event took place between time 0 and t

but the exact time of the event is unknown. For an observation that is left-censored at time t , the actual survival time is no more than the observed survival time t . Right- and left-censoring can co-exist in a single subject and lead to interval-censored data.

The validity of survival analysis relies on the assumption of noninformative censoring. The noninformative censoring assumption states that censoring mechanism is unrelated to the time-to-event distribution. In other words, censoring does not indicate either target event occurrence or the risk of target event occurrence. By contrast, informative censoring relates to the event occurrence. It may make the non-censored group unrepresentative of the censored group and lead to a biased estimate of hazard. Noninformative censoring is often true when censoring is independent or random.¹⁷

Our data are right-censored and are representative only for contracts that were successfully awarded. We produce this dataset by merging CN and CAN data through matching the *future CAN ID* for CN data and the *CAN ID* for the CAN data. Although we are unable to estimate the number of awards that failed during the period from 2009 to 2015, the [European Commission \(2017b\)](#) estimates that 10% of lots were not awarded in 2016. Public buyers deal with these failed awards by not publishing anything, advertising a cancellation notice or releasing a CAN with no winner and no value. Because we exclude CANs with no value in data cleaning, our analyses do not contain unsuccessful contracts.

Our data do not capture all contracts that were awarded. In our dataset, 7,870 out of the 78,277 CNs have their corresponding CANs. For contracts that were awarded but do not have a published CAN, we do not know when they were awarded or whether their awards were delayed. Observations with no corresponding CANs are discarded because no information (not even a vague range) of the time to target event is available.

Reasons (2) and (3) (see above) should mainly account for the unobserved event time and right-censoring in this study. In the case of reason (2), a contract with its CN published in late 2015 is more likely to be right-censored because its CAN is unlikely to be

¹⁷The concepts of noninformative censoring, independent and random slightly differ from each other. Chapter 1 of [Kleinbaum and Klein \(2012\)](#) compares these three concepts in details.

also published in 2015, which is the end of our observing time. For reason (3), contracts with a value below the EU public procurement threshold are more likely to be right-censored. Public buyers with these contracts may not bother to publish CANs because they are not legally bound to do so. None of the two reasons should have any implications that the hazard of award of the right-censored observations differs significantly from the hazard of award of the observations without censoring.

5.4.2.2 Cox PH Model

We adopt the Cox proportional hazard model (Cox PH model) developed by [Cox \(1992\)](#) to estimate the hazard of award. It is a popular model for estimating continuous-time hazard. The logarithm of the hazard of award is treated as the dependent variable. The model consists of a baseline function, $\log h_0(t_j)$, which is the baseline log hazard in instant j when all predictors are 0, and a weighted linear combination of predictors:

$$\log h(t_{ij}) = \log h_0(t_j) + \sum_{i=1}^k \beta_i X_i. \quad (5.4)$$

The antilog form of the model is

$$h(t_{ij}) = h_0(t_j) e^{\left(\sum_{i=1}^k \beta_i X_i \right)}. \quad (5.5)$$

The Cox PH model makes no assumption about the distribution of the baseline hazard, so it cannot be used to estimate the hazard function. However, the beauty of the model lies in the fact that it can assess the impact of changes in the explanatory variables while avoiding unrealistic assumptions about hazard distribution. Holding other explanatory variables constant, the hazard ratio compares estimated hazards when $X_1 = c + 1$ and

when $X_1 = c$, where c is a constant:

$$\text{Hazard ratio} = \frac{h_0(t_j)e^{\left[\beta_1(c+1) + \sum_{i=2}^k \beta_i X_i\right]}}{h_0(t_j)e^{\left[\beta_1 c + \sum_{i=2}^k \beta_i X_i\right]}} = e^{\beta_1}. \quad (5.6)$$

Therefore, the coefficient β_i for X_i measures the effect of one unit change in X_i on the hazard ratio. A positive (negative) β_i suggests that a rise in X_i is associated with a higher (lower) hazard.

5.4.3 Split-Population Survival Time Model

The split-population survival time model developed by (Schmidt and Witte, 1989) combines the logit and hazard models. It has the following structure:

$$h(t) = Pr(D = 1 | X_1, X_2, \dots, X_k) \times h^*(t | D = 1, X_1^*, X_2^*, \dots, X_k^*), \quad (5.7)$$

where the hazard $h(t)$ is the probability that a contract with delayed award is awarded exactly at time t , $Pr(D = 1)$ is the probability of delay, and $h^*(t)$ is the conditional hazard of award that exists only when $D = 1$. We estimate $Pr(D = 1)$ by a logit model based on covariates X_1, X_2, \dots, X_k and $h^*(t)$ by a Cox PH model based on covariates $X_1^*, X_2^*, \dots, X_k^*$.

We could assume that $Pr(D = 1)$ and $h^*(t)$ are independently affected by different factors. But in our case, it is unreasonable to believe that the probability of delaying award and the probability of award are affected by different factors. Therefore X_1, X_2, \dots, X_k and $X_1^*, X_2^*, \dots, X_k^*$ are identical in our case and our split-population model can be simplified into:

$$h(t) = Pr(D = 1 | X_1, X_2, \dots, X_k) \times h^*(t | D = 1, X_1, X_2, \dots, X_k). \quad (5.8)$$

Gori et al. (2017) adopt a split-population survival time model with a similar structure in their analysis on delaying completion of works contracts for Italian public procurement.

5.5 Results

5.5.1 Main Estimates

Table 5.4 shows the estimates for the duration of the overall award process with all contracts using an OLS model (column (1)) and a Cox PH model (column (2)) and the estimates for the two parts of the split-population survival time model (columns (3) and (4)). The negotiated procedure is the baseline category. Estimates for the remaining award mechanisms reflect their difference from the negotiated procedure.¹⁸

The OLS estimates show that, compared with the negotiated procedure, the open procedure is associated with a shorter overall award process, while the restricted procedure and competitive dialogue correspond to a longer overall award process. These results are supported by the Cox PH model in column (2), It shows that compared with the negotiated procedure, the open procedure has a higher hazard of award and the restricted procedure and competitive dialogue have a lower hazard of award.

Compared with the negotiated procedure, column (3) shows that the open procedure tends to have a lower probability of delay, while the restricted procedure and competitive dialogue are associated with a higher probability of delay. The insignificant estimates for the restricted procedure indicate that the probabilities of delay for the restricted procedure and the negotiated procedure do not differ greatly.

The Cox PH model in columns (4) evaluates hazard when the award process is operated with time-overruns. The duration of delay can be inferred because the beginning of time is the date when delay started. Compared with contracts using the negotiated procedure, contracts with the restricted procedure and competitive dialogue have a lower

¹⁸We have run regressions using the award mechanism as the only explanatory variable and adding different combinations of the environmental, organisational and decision-specific factors as the control variables. The vast majority of estimates are consistent and similar in sign and significance across these regressions. The regressions in Table 5.4 are the preferred specifications, taking into account the number of confounders that they control for, the sample size after controlling the confounders, and the fitness or the explanatory power shown by the test statistics.

probability of being awarded at any instant, which indicates a longer duration of delay on average. These two estimates are statistically significant. The difference between the open procedure and the negotiated procedure is not significant.

To facilitate comparison between the negotiated procedure with other three benchmark award mechanisms, the hazard ratio of each award mechanism to the negotiated procedure is calculated, using the estimates from columns (2) and (4). The hazard ratios and the corresponding 95% confidence intervals are presented in Table 5.5. For example, during the entire award process, the estimated hazard of award for the restricted procedure is on average 34% ($= 100\% \times (0.660 - 1)$) lower than for the negotiated procedure; after delays have occurred, the estimated hazard of award for the restricted procedure is on average 30.9% ($= 100\% \times (0.691 - 1)$) lower than for the negotiated procedure. The upper boundaries of the 0.95 confidence intervals are lower than one. This indicates that the hazards of award for the restricted procedure are unlikely to be higher than for the negotiated procedure. The two hazards of award for the open procedure are estimated to be 1.61 times and 1.15 times those for the negotiated procedure. However, once delay occurs, the hazard of award for the open procedure may not necessarily be higher than for the negotiated procedure, because the lower boundary of the 95% interval (0.826) is less than one.

The results offer evidence that the restricted procedure has a longer overall duration of award process and a longer duration of delay than the negotiated procedure while the probability of delay for the two award mechanisms do not differ significantly. These findings undermine *Hypotheses 1, 2 and 3*. Next, we compare the accelerated restricted procedure and the accelerated negotiated procedure to further check these findings.

Table 5.4: Coefficient Estimates

	<i>OLS</i> (all contracts) Log duration of award process (1)	<i>Cox PH hazards model</i> for the duration of award process (all contracts) Hazard of award (2)	<i>Logistic</i> (all contracts) Prob. of delay (3)	<i>Cox PH hazards model</i> for the duration of delay (contracts with delayed award only) Hazard of award (4)
Open procedure	-0.318*** (0.044)	0.476*** (0.112)	-0.878*** (0.259)	0.140 (0.169)
Restricted procedure	0.102** (0.044)	-0.415*** (0.111)	0.305 (0.261)	-0.370** (0.162)
Competitive dialogue	0.217*** (0.063)	-0.418*** (0.160)	1.875*** (0.405)	-0.407* (0.223)
Response period	0.003*** (0.0004)	-0.007*** (0.001)	0.002 (0.002)	-0.002 (0.002)
Lots dummy	0.071*** (0.013)	-0.114*** (0.034)	0.290*** (0.077)	-0.030 (0.049)
Sum of contracts	0.0002*** (0.00004)	-0.0004*** (0.0001)	0.001*** (0.0002)	-0.0005*** (0.0001)
On behalf dummy	-0.028** (0.014)	0.086** (0.036)	0.033 (0.083)	0.245*** (0.052)
Log contract value	0.018*** (0.003)	-0.037*** (0.007)	0.053*** (0.018)	-0.024** (0.010)
Contract duration	0.00003*** (0.00001)	-0.0001** (0.00002)	0.0002*** (0.0001)	-0.0001* (0.00003)
Quality criterion dummy	0.077*** (0.021)	-0.228*** (0.056)	0.269** (0.128)	-0.252*** (0.087)
Planned award period	0.002*** (0.0001)	-0.004*** (0.0002)	-0.014*** (0.001)	0.001*** (0.0004)
Constant	4.400*** (0.183)		1.392*** (0.646)	
Year fixed effects	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes
Authority type	Yes	Yes	Yes	Yes
Contract type	Yes	Yes	Yes	Yes
CPV code	Yes	Yes	Yes	Yes
Observations	5,093	5,093	5,093	2,432
R ²	0.550	0.430		0.162
Log Likelihood		-36,953.250	-2,855.317	-16,318.760
Akaike Inf. Crit.		74056.500	5,862.634	32785.520

*p<0.1; **p<0.05; ***p<0.01

Notes. 1. The baseline category of award mechanism is the negotiated procedure, so the coefficients for the open, restricted and competitive dialogue procedures show the difference between these three procedures and the negotiated procedure. 2. CPV code: the first two digits of CPV codes are used as a categorical variable in the logit and Cox models because the resulted AIC statistics are lower than when the first three digits of the CPV codes are applied. The first three digits of the CPV codes enter in the OLS model because they lead to a higher R-squared. The applications of the first two or first three digits produce similar magnitude, sign and significance for estimates of other variables in the models.

Table 5.5: Hazard Ratios of Alternative Award Mechanisms to the Negotiated Procedure

	Cox model for duration of award process			Cox model for duration of delay		
	exp(coef)	lower .95	upper .95	exp(coef)	lower .95	upper .95
Open procedure	1.610	1.293	2.003	1.150	0.826	1.601
Restricted procedure	0.660	0.532	0.820	0.691	0.502	0.950
Competitive dialogue	0.659	0.481	0.901	0.666	0.430	1.031

5.5.2 Additional Tests

We learn from the Kaplan-Meier Curves that the hazard of award is lower for the accelerated restricted procedure than that the accelerated negotiated procedure. In both the Kaplan-Meier Curves that describe the award process of all contracts (Figure 5.4) and the award process after delay occurs (Figure 5.5), the lines for the accelerated negotiated procedure always lie beneath those for the accelerated restricted procedure and reach 0% more quickly.

The accelerated negotiated procedure is taken as the baseline category in the parametric estimates (Table 5.6). No significant difference is found in the estimates for the two accelerated procedures.

5.5.3 Interpretation of Confounders

Table 5.4 also reflects features of control variables that are of interest. Estimates for the response period and lots dummy show that a greater number of bidders implies a longer overall award process (columns (1) and (2)), a higher probability of delay (column 3) and a longer duration of delay (column 4). Estimates for the log contract value, contract duration and quality criterion dummy suggest that complex contracts and higher concerns about quality are significantly associated with a longer overall award process, a higher probability of delay and a longer duration of delay.¹⁹

¹⁹Reeves et al. (2015) find that the length of the overall process is positively but not strongly associated with the capital value of PPP projects.

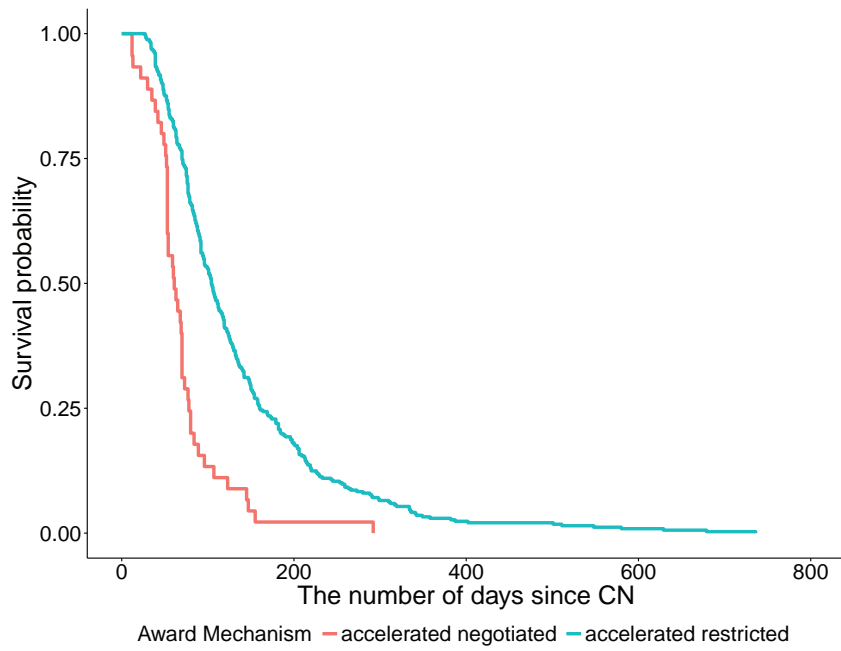


Figure 5.4: Kaplan-Meier Curves for All Contracts (Accelerated Procedures)

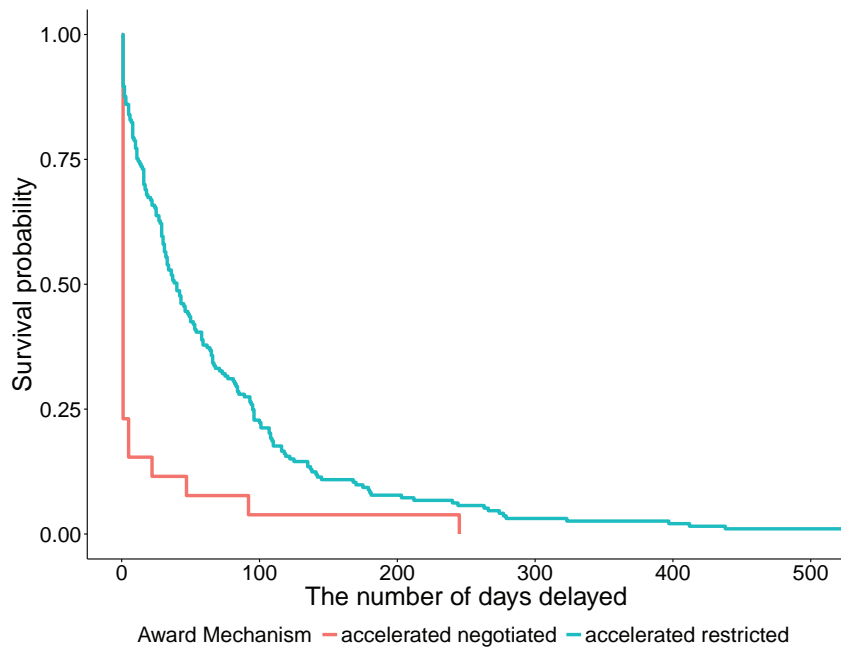


Figure 5.5: Kaplan-Meier Curves for Contracts with Delayed Award (Accelerated Procedures)

Table 5.6: Coefficient Estimates for Accelerated Procedures

	Log duration of award process		Hazard of award		Prob. of delay		Hazard of award	
	<i>OLS</i> (all contracts) (1)	<i>Cox prop. hazards</i> (all contracts) (2)	<i>Cox prop. hazards</i> (all contracts) (3)	<i>logistic</i> (all contracts) (4)	<i>Cox prop. hazards</i> (contracts with delayed award only) (5)	<i>Cox prop. hazards</i> (contracts with delayed award only) (6)	<i>Cox prop. hazards</i> (contracts with delayed award only) (7)	<i>Cox prop. hazards</i> (contracts with delayed award only) (8)
Accelerated restricted procedure	-0.091 (0.175)	-0.148 (0.409)	-0.918 (1.500)	-0.918 (1.500)	-0.961 (0.607)	-0.961 (0.607)	-0.961 (0.607)	-0.961 (0.607)
Response period	0.013*** (0.005)	-0.028** (0.013)	0.046 (0.032)	0.046 (0.032)	-0.012 (0.019)	-0.012 (0.019)	-0.012 (0.019)	-0.012 (0.019)
Lots dummy	0.059 (0.103)	0.180 (0.229)	-0.241 (0.671)	-0.241 (0.671)	0.502 (0.399)	0.502 (0.399)	0.502 (0.399)	0.502 (0.399)
Sum of contracts	0.001* (0.0005)	-0.003*** (0.001)	0.011*** (0.004)	0.011*** (0.004)	0.0001 (0.001)	0.0001 (0.001)	0.0001 (0.001)	0.0001 (0.001)
On behalf dummy	0.094 (0.103)	-0.150 (0.251)	0.205 (0.730)	0.205 (0.730)	0.049 (0.459)	0.049 (0.459)	0.049 (0.459)	0.049 (0.459)
Log contract value	0.052 (0.032)	-0.173*** (0.057)	0.165 (0.166)	0.165 (0.166)	-0.232*** (0.085)	-0.232*** (0.085)	-0.232*** (0.085)	-0.232*** (0.085)
Contract duration	-0.0001* (0.0001)	0.0001 (0.0001)	-0.0005 (0.0004)	-0.0005 (0.0004)	-0.0002 (0.0002)	-0.0002 (0.0002)	-0.0002 (0.0002)	-0.0002 (0.0002)
Quality criterion dummy	0.093 (0.194)	-0.676* (0.359)	-1.471 (1.656)	-1.471 (1.656)	-1.264* (0.668)	-1.264* (0.668)	-1.264* (0.668)	-1.264* (0.668)
Planned award period	0.004*** (0.001)	-0.009*** (0.002)	-0.018*** (0.006)	-0.018*** (0.006)	-0.001 (0.003)	-0.001 (0.003)	-0.001 (0.003)	-0.001 (0.003)
Constant	3.826*** (0.765)		-22.160 (6,836.756)	-22.160 (6,836.756)				
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Authority type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Contract type	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CPV code	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	246	246	246	246	135	135	135	135
R ²	0.765	0.598			0.537	0.537	0.537	0.537
Log Likelihood		-999.992			-69.928	-69.928	-69.928	-69.928
Akaike Inf. Crit.					253.855	253.855	253.855	253.855

Note: *p<0.1; **p<0.05; ***p<0.01

Notes. The accelerated negotiated procedure is the baseline category. The coefficient for the accelerated restricted procedure shows the difference when comparing the accelerated restricted procedure with the accelerated negotiated procedure.

Centralised purchasing is likely to have a quicker award process. This prediction is in accordance with the theoretical implication of a centralised decision making structure.

A counterintuitive finding is that more experience (measured by the sum of contracts) corresponds to a longer award process, a higher probability of delay and a longer duration of delay. Experience may foster both actual capability and self-belief. However, an individual may become over-confident when self-belief is disproportionately higher than actual capability. Over-confidence makes people set a tight deadline that is unlikely to be met. Moreover, over-confident people may devote insufficient effort to their work. The estimates for experience suggest that UK public authorities may become over-confident as they gain increasing experience with the negative impact of over-confidence dominating the positive impact of more developed skills on decision speed.

The negative relationship between the planned award period and the probability of delay support the speculation about over-confidence and competence. When a buyer sets a more flexible deadline of award, time-overruns occur less frequently and the duration of delay becomes shorter. The planned award period also reflects competence, as it is positively related to the duration of the overall award process. It is unlikely that the planned award period represents the level of complexity because it has a negative correlation with the probability of delay, while the traditional complexity measures (i.e. contract value and duration) and quality concerns are positively correlated with the probability of delay. The planned award period may also reflect the urgency of procurement because the result shows that a shorter planned award period corresponds to a shorter award period.

5.6 Conclusions

Practitioners (e.g. [Lynch, 2015](#) and [Yescombe, 2007](#)) and policymakers (e.g. [UK National Audit Office, 2007](#)) tend to blame negotiation for a lengthy award process and delays in contract award, but their claims are not supported by robust empirical evidence. This is a motivation for the examination here of the relationship between award mech-

anisms and decision speed in awarding UK public contracts. The empirical modelling utilises the logit model and survival analysis, which are two complementary methods for event analysis. We refer to the strategic management literature in identifying explanatory variables and examine multiple factors in addition to the award mechanism.

Our results show that negotiations do not appear to slow down decision speed. Although the negotiated procedure and competitive dialogue both contain negotiation and competitive dialogue is less tolerant of negotiation than the negotiated procedure, the latter performs better than competitive dialogue regarding decision speed. With respect to award decision speed and the probability of delay, the negotiated procedure dominates the restricted procedure (which does not allow any negotiation) while the restricted procedure outperforms the competitive dialogue. We also highlight that the open procedure (which does not allow negotiation either) is the most efficient award mechanism in both saving time and preventing award delays.

According to our descriptive statistics, the award process (the total duration of the response period, screening period and standstill period) is on average 122.98 days for the open procedure, 217.25 days for the restricted procedure, 163.23 days for the negotiated procedure, and 364.22 days for competitive dialogue (Table 5.1). More than 75% of contracts with the negotiated procedure were awarded before or on the planned contract start date, whereas the number is 50% for contracts awarded through the open procedure, restricted procedure or competitive dialogue (Table 5.2).

When controlling for other determinants of decision speed, the more sophisticated models in Table 5.4 generate results consistent with the descriptive statistics. The open procedure is on average associated with the shortest duration of the overall award process and the shortest duration of delay, followed by the negotiated procedure, the restricted procedure and competitive dialogue. The probability of delay for the open procedure tends to be the lowest followed again by the negotiated procedure, the restricted procedure and competitive dialogue.

Results in Table 5.4 also imply that including more bidders, as suggested by a longer

response period and the use of lots (and therefore considering more alternatives) may slow down the award process. We show strong evidence that greater complexity and higher quality concerns may reduce the award decision speed. We suggest public buyers allocate more time to the overall award process when they intend to split a contract into subcontracts or to advertise the planned procurement for a long time or when they anticipate complex contracts.

Moreover, it is suspected that over-confidence grows with increasing experience and imposes a negative impact on decision speed. The empirical models show that more experience corresponds to a longer award process, a higher probability of delay and a longer duration of delay. Competence, which is also likely to increase with accumulating experience, would exhibit the opposite correlations with these decision speed measures. It is a caveat that more experienced public buyers should be cautious about being over-confident.

This study reveals several issues for future studies on decision speed in awarding public contracts. First, this study analyses contracts that were successfully awarded but what are the factors that lead to failure in awarding contracts? Second, the restricted procedure differs from the open procedure by allowing for an additional prequalification and differs from the negotiated procedure by not allowing for negotiation. However, the restricted procedure underperforms the open procedure and the negotiated procedure. It would be interesting to investigate the cause of this phenomenon. Lastly, compared with the negotiated procedure, competitive dialogue replace negotiations in the final stage with competitive bidding. The purpose of this change is to curb endless haggling in negotiation. However, why is it the case that competitive dialogue is on average lengthier than the negotiated procedure?

Appendix A: Non-parametric Methods to Describe Event Occurrence Data

Appendix A introduces the life table and its components, which are fundamental nonparametric techniques to describe event occurrence data. Methods to construct a life table for discrete- and continuous-time event occurrence data are discussed in sequence. This appendix is based on [Singer and Willett \(2003\)](#) and [Kleinbaum and Klein \(2012\)](#).

A.1 Life Table

The life table is a fundamental tool for describing both discrete- and continuous-time data. The hazard function, the survival function and the median lifetime are the three essential components of a life table. The methods to estimate the hazard and survival functions are relatively straightforward for discrete-time data. For continuous-time data the estimation is more complicated. The approaches include the grouped strategies represented by the discrete-time method and the actuarial method and ungrouped strategy represented by the Kaplan-Meier method.

To construct a life table and to estimate the hazard function, survival function and median lifetime, we need information on the time intervals, the number of individuals in the risk set at the beginning of each time interval, the number of events during each time interval and the number of censored observations during each time interval. The time interval is the key to hazard estimation. Hazard is a conditional probability of event occurrence defined within a specific time interval. Whenever stating a hazard, the time interval of the hazard must be provided. In a life table, the lengths of all time intervals need not be the same. The intervals in later stages may be greater to accommodate sufficiently large risk sets.

The risk set is a collection of individuals who have not encountered the target event by the beginning of the current time interval and who are at risk of experiencing the

target event during the current time interval. In most studies, including this one, data are right-censored. The right-censored observations are those that have not encountered the target event during the observed time and that are not tracked thereafter.

A.2 Methods for Discrete-Time Data

When describing discrete-time data, the widths of time intervals are determined subjectively and are subject to constraints of the metric for time recording. The width of the time interval can be the same as the metric for time recording or be coarser than the recording metric.

The discrete hazard rate is defined as the conditional probability that individual i experience the event in interval j , on condition that the individual has not experienced the event in any past interval. Mathematically, the statement is expressed as

$$h(t_{ij}) = Pr [T_i = j | T_i \geq j], \quad (5.9)$$

where T indicates event time and t is an arbitrary division of time. The estimate of the discrete time hazard in interval j is computed as the number of events that took place in interval j divided by the number of individuals at risk during interval j :

$$\hat{h}(t_j) = \frac{n \text{ events}_j}{n \text{ at risk}_j}. \quad (5.10)$$

Hereafter, n stands for “the number of individuals”. Since the discrete-time hazard is a probability, it is bounded between 0 and 1 inclusively.

The survival probability for discrete-time data is the probability that individual i survives past interval j :

$$S(t_{ij}) = Pr [T_i > j]. \quad (5.11)$$

If the data are not right-censored, the estimates of survival probability at the end of interval j can be expressed as the number of individuals who have not experience the

event by the end of interval j divided by the number of individuals in the risk set at the starting point of the study time window:

$$\hat{S}(t_j) = \frac{n \text{ who have not experienced the event by the end of interval } j}{n \text{ at the starting point}}. \quad (5.12)$$

If the right-censoring appears in interval k , Equation 5.12 cannot be used to estimate the survival probability from interval k onwards (including interval k). The reason is that the event times of the censored individuals are unknown. This problem can be circumvented by applying the formula below:

$$\hat{S}(t_j) = \hat{S}(t_{j-1}) [1 - \hat{h}(t_j)]. \quad (5.13)$$

The estimated survival probability in interval j is the product of the estimated survival probability in the previous interval and the difference between one and the estimated hazard probability in interval j . The formula can be rewritten as:

$$\hat{S}(t_j) = [1 - \hat{h}(t_1)] [1 - \hat{h}(t_2)] \dots [1 - \hat{h}(t_j)]. \quad (5.14)$$

The median lifetime can be estimated by linear interpolation using the two sample survival probabilities that are immediately adjacent to 0.5 (Miller, 1981). Denote p as the lower bound of interval m which has a sample survival probability $\hat{S}(t_m)$ just above 0.5 and q as the lower bound of interval $m + 1$ which has a sample survival probability $\hat{S}(t_{m+1})$ just below 0.5 (q is the upper bound of interval m), then

$$\text{Estimated median lifetime} = p + \left[\frac{\hat{S}(t_m) - 0.5}{\hat{S}(t_m) - \hat{S}(t_{m+1})} \right] (q - p) \quad (5.15)$$

A.3 Comparing Discrete- and Continuous-Time Hazard and Survival Functions

Continuous-time data can be taken as the limit of discrete-time data by assuming that each interval becomes infinitesimal, giving innumerable continuous instants t_1, t_2, \dots, t_j . As each interval approaches 0, the probability that an event is observed at a particular instant and the probability of ties also infinitely approaches 0.

Letting T_i represents the event time for individual i , individual i 's the hazard at time t_j is:

$$h(t_{ij}) = \lim_{\Delta t \rightarrow 0} \left\{ \frac{\Pr [T_i \text{ is in the interval}(t_j, t_j + \Delta t) | T_i \geq t_j]}{\Delta t} \right\}. \quad (5.16)$$

In contrasting to discrete-time hazard, which is a conditional probability, the continuous-time hazard is a rate. A hazard rate is obtained by dividing a given hazard probability by a period of time. While a hazard probability is bounded by 0 and 1 inclusively, a hazard rate has a lower limit of 0 and has no upper limit.

The definition of the survival function in continuous time is similar to that in discrete time (Equation 5.12), but the survival probability is defined at an instant of time t_j instead of over a period of time, interval j :

$$S(t_{ij}) = \Pr [T_i > t_j]. \quad (5.17)$$

A.4 Methods for Continuous-Time Data

This section introduces the grouped and ungrouped approaches to describe continuous-time data. The grouped estimation strategies include the discrete-time method and the actuarial method. They allow dividing continuous time into arbitrary time intervals. The ungrouped strategy, i.e. the Kaplan-Meier method, is superior to grouped strategies

because it constructs time intervals using the actual event times. We also introduce the cumulative hazard function which overcomes the limitation of the continuous-time hazard function.

Discrete-time method. The discrete-time method to describe continuous-time data shares an identical computational algorithm with the method to describe discrete-time data. The discrete-time method evolves from the definition of discrete-time hazard. Here we denote the discrete-time hazard as $\hat{p}(t_j)$ to distinguish it from the continuous-time hazard rate.

$$\hat{p}(t_j) = \frac{n \text{ events}_j}{n \text{ at risk}_j}. \quad (5.18)$$

$\hat{p}(t_j)$ is a conditional probability of event occurrence in interval j .

Denoting $width_j$ as the width of interval j , then the continuous-time hazard rate, $\hat{h}(t_j)$, which is expressed in per unit of time, is:

$$\hat{h}(t_j) = \frac{\hat{p}(t_j)}{width_j}. \quad (5.19)$$

The estimated continuous-time survival probability at the end of interval j is:

$$\hat{S}(t_j) = [1 - \hat{p}(t_1)] [1 - \hat{p}(t_2)] \dots [1 - \hat{p}(t_j)]. \quad (5.20)$$

The discrete-time method assumes that all events and censoring take place at the endpoint of each interval.

Actuarial method. The actuarial method (also known as the life-table method) is similar to the discrete-time method. However, it posits different assumptions about event occurrence and censoring. It assumes that events and censoring occur randomly and evenly in each interval. For the survival function, the number of individuals at risk of

surviving *past* the end of interval j is:

$$n' \text{ at risk}_j = n \text{ at risk}_j - \frac{n \text{ censored}_j}{2}. \quad (5.21)$$

The estimated continuous-time survival probability under the actuarial method is obtained by replacing $n \text{ at risk}_j$ with $n' \text{ at risk}_j$ in equation 5.18 and applying this equation into equation 5.20.

For the hazard function, the number of individuals at risk of event occurrence *during* the interval j is:

$$n'' \text{ at risk}_j = n \text{ at risk}_j - \frac{n \text{ censored}_j}{2} - \frac{n \text{ events}_j}{2}. \quad (5.22)$$

This demonstrates that both the occurring events and censoring would diminish the risk set. The actuarial estimator of the continuous-time hazard rate is produced by replacing $n \text{ at risk}_j$ with $n'' \text{ at risk}_j$ in Equation 5.18 and applying this equation into Equation 5.19.

Kaplan-Meier method. The Kaplan-Meier method (also known as the product-limit method) develops the discrete-time method by breaking down the observed time horizon into intervals using the actual event time so that each interval contains only one observed event. Each interval is closed at the left and open at the right. The first interval starts from time interval 0 and ends at the first event time. For the subsequent intervals, the upper limit is one observed event time, and the lower limit is the immediate next observed event time. If a censoring and an observed event time coincide, the Kaplan-Meier method assumes that the event occurred ahead of censoring and includes the tied censored observation and the observed event in the same time interval. The Kaplan-Meier hazard and survival functions are estimated by applying Equations 5.18, 5.19 and 5.20 in the discrete-time method.

The hazard function is not as informative for continuous-time data as for discrete-time data. The hazard estimates derived by the grouped methods depend on an artificial time

intervals and may be too coarse to reveal more detailed insights. The hazard estimates from the Kaplan-Meier method are not directly comparable with one another because the width of each interval varies greatly.

The cumulative hazard function aggregates the hazard over time and is not subject to either of the two problems mentioned above. The cumulative hazard function is the integral of the hazard function between integration limits of t_0 and t_j :

$$H(t_{ij}) = \int_{t_0}^{t_j} h(t_{ij}) dt_{ij}. \quad (5.23)$$

Since a hazard function is the first derivative of its cumulative hazard function, the level of unique risk at each instant can be deduced by examining the shape of the cumulative hazard function. For instance, the slope of the cumulative hazard function is constant.

Appendix B: Hazard Models

As a supplement to Section 5.4.2, this appendix introduces the hazard models that explore whether and how the risk of event occurrence can be predicted by or attributed to particular factors. We start from the simpler discrete-time hazard model and move to the Cox (semi-parametric) and parametric models for continuous-time data. After introducing of these models, we justify the use of the Cox proportional hazard model in this study. Appendix B is based on [Singer and Willett \(2003\)](#) and [Kleinbaum and Klein \(2012\)](#).

The models are presented in the context of public procurement, which takes *awarding a contract* as the event of interest, the *dispatch date of CN* denoted by t_{CN} as the beginning of time, and *days* as the metric of time. For the simplicity of demonstration, a dummy variable X_1 indicating the type of award mechanism is introduced as the single substantive predictor in the models ($X_1 = 0$ for the negotiated procedure and $X_1 = 1$ for the remaining procedures). Additional time variant and invariant substantive predictors can be added

into the models easily.

B.1 Discrete-Time Hazard Models

The basic discrete-time hazard model transforms the hazard function using a logit (log odds) link, which is the natural logarithm of odds:

$$\text{logit} = \log_e(\text{odds}) = \log_e \left(\frac{\text{probability}}{1 - \text{probability}} \right). \quad (5.24)$$

Such transformation addresses the bounded nature of the discrete-time hazard, which must lie between 0 and 1.

The hazard for contract i to be awarded in interval j is denoted as $h(t_{ij})$. Use $D_{1ij}, D_{2ij}, \dots, D_{Jij}$ to represent J intervals that consist of the observation period. Each time indicator D_{Jij} takes the value 1 for the interval it represents and 0 for other intervals. The discrete-time hazard model is written as:

$$\text{logit } h(t_{ij}) = [\alpha_1 D_{1ij} + \alpha_2 D_{2ij} + \dots + \alpha_J D_{Jij}] + \beta_1 X_{1ij}. \quad (5.25)$$

Each intercept parameter α_J represents the baseline logit hazard in interval J . The slope parameter β_1 assesses the per unit partial effect of the change in predictor X_1 , i.e. the difference between using and not using the negotiated procedure. The shapes of the logit hazard functions for contracts with and without the negotiated procedure are identical because they both are based on the baseline logit hazard with an additive value $\beta_1 X_{1ij}$.

The basic discrete-time hazard model postulates the *proportional odds assumption*. Since $\text{odds} = e^{\text{logit}}$, the estimated odds ratio of non-negotiated procedure ($X_{1ij} = 1$) to negotiated procedure ($X_{1ij} = 0$) for interval j is:

$$\text{Estimated odds ratio for interval } j = \frac{e^{\hat{\alpha}_j D_j + \beta_1}}{e^{\hat{\alpha}_j D_j}} = e^{\beta_1}, \quad (5.26)$$

which is independent of time. The hazard function can be obtained by applying the

inverse transformation *probability* = $\frac{1}{1+e^{-\log it}}$:

$$h(t_{ij}) = \frac{1}{1 + e^{-\{\alpha_1 D_{1ij} + \alpha_2 D_{2ij} + \dots + \alpha_J D_{Jij}\} + \beta_1 X_{1ij}}}. \quad (5.27)$$

An alternative transformation link to overcome theoretically impossible fitted hazard values (those below 0 or above 1) for discrete-time data is the complementary log-log transformation, often denoted as *clog – log*:

$$clog - log = \log(-\log(1 - probability)). \quad (5.28)$$

The general model using the clog-log link is:

$$clog - log h(t_{ij}) = [\alpha_1 D_{1ij} + \alpha_2 D_{2ij} + \dots + \alpha_J D_{Jij}] + \beta_1 X_{1ij}. \quad (5.29)$$

The inverse transformation is *probability* = $1 - e^{(-e^{(clog-log)})}$. Unlike the logit model, the clog-log model proposes the *proportional hazards assumption* that the hazards ratio of non-negotiated procedures ($X_{1ij} = 1$) to the negotiated procedure ($X_{1ij} = 0$) for interval j is e^{β_1} , which is time invariant.

Compared with the logit model, the clog-log model is most helpful when the data are truly continuous-time but measured in discrete-time (Hosmer et al., 2013, Prentice and Gloeckler, 1978). If data are truly discrete time, then the clog-log transformation offers no advantages over the simpler logit transformation. However, the Cox regression model for continuous data (which is discussed in Appendix B.2) and the clog-log model share the proportional hazard assumption. This identical assumption makes the clog-log model a discrete analogue of the Cox regression model (Allison, 1982).

B.2 Semi-parametric Cox Regression Model

The Cox proportional hazard model (Cox PH model) initiated by Cox (1992) is a popular model for continuous-time survival analysis. Unlike a probability that is bounded

between 0 and 1, the continuous-time hazard is a rate that is greater than 0. The Cox PH model uses the *logarithm*, which is defined over values greater than 0, as the transformation link. The model consists of a baseline function, $\log h_0(t_j)$, which is the baseline log hazard when all predictors are 0, and a weighted linear combination of predictors. A Cox PH model with a single predictor is

$$\log h(t_{ij}) = \log h_0(t_j) + \beta_1 X_{1ij}. \quad (5.30)$$

and the antilog form of the model is

$$h(t_{ij}) = h_0(t_j) e^{\beta_1 X_{1ij}} \quad (5.31)$$

The Cox PH model imposes no assumption about the distribution of event occurrence over time. In this sense, the Cox PH model is not strictly parametric. It generalises the Kaplan-Meier approach and relies on only the ranks of observed event times ([Kalbfleisch and Prentice, 2011](#)). Therefore, the baseline hazard and survival functions are not specified.

The Cox PH model is also not strictly nonparametric. It is better to label the model as “semi-parametric”. The model involves parametric assumptions that establish links between predictors and hazard. Among those assumptions, the most notable is the *proportional hazards assumption*, which states that the per unit effect of each predictor on the baseline hazard function remains the same over time. The hazard ratio comparing the estimated hazards when $X_1 = c$ and when $X_1 = c + 1$, where c is a constant, is always e^{β_1} :

$$\text{Hazard ratio} = \frac{h_0(t_j) e^{\beta_1(c+1)}}{h_0(t_j) e^{\beta_1 c}} = e^{\beta_1}. \quad (5.32)$$

Estimates from the Cox PH model are not reliable if the proportional hazards assumption is not met. A caveat for using the Cox PH model is to evaluate the proportional hazards assumption. It is worth noting that the proportional hazards assumption can

be relaxed and the Cox PH model can be extended to data in which the proportionality assumption does not hold. When a predictor violates the proportional hazard assumption, there are two standard solutions for acknowledging the multiple baseline hazard functions: (1) to apply a stratified model that uses the predictor to define multiple strata if the predictor is not of research interest; (2) to fit a model that includes the interaction between the predictor and time if the predictor is of research interest.

Making no assumptions about the distribution of the baseline hazard function involves tradeoffs. The Cox regression provides no estimate of the hazard function. However, this cost is bearable as the effects of predictors on the hazard function rather than the hazard function are of primary interest for most studies. The Cox regression model can be used to evaluate the effects of predictors on the hazard rate without invoking unrealistic assumptions on the distribution of the baseline hazard function.

The shape of the baseline hazard function $h_0(t_j)$ is in effect irrelevant because $h_0(t_j)$ is eliminated in the partial likelihood estimation process to estimate the coefficients of predictors. Contract i 's contribution to the partial likelihood at t_{ij}^* is $\frac{h(t_{ij}^*)}{\sum_{\text{risk set at } t_{ij}^*} h(t_{ij}^*)}$. The partial likelihood represents the probability of observing the actual event data as a function of unknown population parameters. The partial likelihood can be obtained by multiplying all the contributions of all contracts:

$$\begin{aligned}
 \text{Partial likelihood} &= \prod_{\text{noncensored individuals}} \frac{h(t_{ij}^*)}{\sum_{\text{risk set at } t_{ij}^*} h(t_{ij}^*)} \\
 &= \prod_{\text{noncensored individuals}} \frac{h_0(t_j) e^{\beta_1 X_{1ij}}}{\sum_{\text{risk set at } t_{ij}^*} h_0(t_j) e^{\beta_1 X_{1ij}}} \\
 &= \prod_{\text{noncensored individuals}} \frac{e^{\beta_1 X_{1ij}}}{\sum_{\text{risk set at } t_{ij}^*} e^{\beta_1 X_{1ij}}}.
 \end{aligned} \tag{5.33}$$

Equation 5.33 shows that the baseline hazard function $h_0(t_j)$ has been taken into account, but its effect is cancelled out.

B.3 Parametric Continuous-Time Hazard Model

Unlike the Cox regression model, which imposes no assumption about the distribution of hazard, the parametric models assume that the hazard follows some family of distributions. The popular distributions for parametric survival models are the Weibull, the exponential (which is a special case of Weibull), the log-logistic, the log-normal, and the generalised gamma. Because this research uses only the Cox PH model, we do not go further about the parametric models.²⁰

B.4 Justification for Using the Cox PH Model

The discrete-time hazard model is not ideal for this study because the data are recorded using a fine-grained time metric of *days* and should be taken as continuous-time data. We adopt the Cox model instead of the parametric models because we are not concerned about estimating the absolute level of hazard. By doing so, we avoid making assumptions about the shape of the hazard functions and are still able to estimate the relationship between the hazard and different factors.

The Schoenfeld residual (Schoenfeld, 1982) is used to test the appropriateness of the proportional hazard assumption. A Schoenfeld residual for a predictor, X , is computed as the difference between contract i 's value of X and the expected value of X among other contracts that are in the risk set when i experiences the event:

$$\hat{S}_i(X) = x_i - \text{expected}_i(X). \quad (5.34)$$

If the proportional hazards assumption holds, the Schoenfeld residuals are unrelated to time so that a plot of Schoenfeld residual against time should be generally horizontal and reveal no consistent trend. Because these features are true for both our Cox PH models for the duration of delay and the overall award process, the proportional hazards assumption

²⁰Details of the parametric models are covered in Chapter 7 by Kleinbaum and Klein (2012).

is likely to hold in our models. Therefore, we stay with the Cox PH models and do not relax the proportional hazards assumption.

Chapter 6

Study 3: Discretion, Corruption and Competition in Public Procurement: a Cross-country Analysis

6.1 Introduction

This chapter explores the association between discretion, corruption and competition in EU public procurement contracts. According to the World Bank, the annual bribe costs over the globe is \$1.5 trillion, which is equivalent to around 2% of the global GDP.¹

Corruption is a principal-agent problem (Celentani and Ganuza, 2002, Lambert-Mogiliansky and Sonin, 2006, Rose-Ackerman, 1975). Procuring authorities (i.e. contracting authorities or public buyers) appoint internal officials or external companies as procuring agents to select contractors. Corruption occurs when a procuring agent misuses its discretion in exchange for bribe payment rather than acting on behalf of the interest of the procuring authority. Previous chapters assume that the procuring agent's interest is in line with the procuring authority and do not differentiate the procuring agent from the procuring authority because the principal-agent problem is not a focus in these chapters. This chapter treats the procuring authority and agent as different subjects.

A well-established theoretical literature indicates that causation goes both ways between corruption and competition. Bliss and Di Tella (1997), Burguet and Che (2004), Compte et al. (2005) and Romer (1994) examine how corruption affects competition; Ades and Di Tella (1999), Bliss and Di Tella (1997), Celentani and Ganuza (2002) and Shleifer and Vishny (1993) analyse how competition affects corruption. Most relevant empirical

¹See the World Bank website <http://www.worldbank.org/en/topic/governance/brief/anti-corruption>.

studies focus instead on how corruption affects economic growth and investment (Mauro, 1995, Méndez and Sepúlveda, 2006, Méon and Sekkat, 2005). Coviello et al. (2018) and Knack et al. (2017) are among the very few empirical papers that have systematically explored the relationship between corruption and competition in the context of public procurement.

Public procurement may be particularly revealing about the economic impact of corruption. On the one hand, the choice of an award mechanism that allows high discretion (e.g. negotiation, prequalification or debarment, and scoring auctions) may be an indicator that the procuring agent is not acting solely to obtain best value for money in public procurement. On the other hand, to mitigate corruption, regulators are likely to impose more rigid award mechanisms (e.g. price-only auctions) (Chong et al., 2012).

This study makes the following contributions. First, based on the *revenue equivalence theorem* and the extensive form game, we model a mechanism of the interaction between discretion and corruption, which in turn drives honest bidders out. Although many studies on discretion or corruption have described this link between discretion and corruption, few formal models exist. Second, this study augments the recently growing literature on procurement outcomes (Albano et al., 2017, Baldi et al., 2016, Coviello et al., 2018, Hyttinen et al., 2018, Lewis and Bajari, 2011, Spagnolo, 2012). Using data for the 28 EU member countries, Iceland and Norway over the period 2012–2015, we conduct a systematic study on the links between discretion, corruption and competition in EU public procurement. We separately analyse discretion and corruption levels by measuring discretion with award mechanism and a quality criterion dummy and measuring corruption with a corruption perception index (CPI). While many studies on procurement outcomes proxy discretion by award mechanisms, we find that only Coviello et al. (2018) and Knack et al. (2017) have considered discretion and corruption simultaneously. Third, we compare the four benchmark award mechanisms in the EU public procurement and their links to procurement outcomes (e.g. the number of bidders and rebates).

The remainder of this chapter is organised as follows. Section 6.2 is a review of relevant

literature of corruption separate and in addition to the literature of award mechanism in Chapter 3. Section 6.3 proposes a game theory model that shows the links between discretion, corruption and competition. Section 6.4 puts forward the hypotheses and describes the data. Section 6.5 presents the results. Section 6.6 is the conclusion. The Appendix discusses the presentation of an extensive-form game and the distinctions between the imperfect information game and the incomplete information game.

6.2 General Consideration and Literature Review

This section is a literature review on corruption and competition that is linked and additional to the literature review on award mechanism in Chapter 3. Section 6.2.1 discusses the general terms why we expect a relationship between award mechanism and corruption. It explains how award mechanisms allow for various levels of discretion and thus various possibility of corruption and why corruption is inherently difficult to research.

The subsequent subsections review the factors that may interact with or influence competition in public procurement. Section 6.2.2 explains when and why discretion for procuring agent should be allowed. Section 6.2.3 discusses how corruption is related to competition. Section 6.2.4 discusses other determinants of competition and thus provides clues of the variables that we should control for in the empirical analysis. Readers may wish to skip Section 6.2.4.

The discussions in Sections 6.2.2, 6.2.3 and 6.2.4 show that influential factors on competition (i.e. the number of participants and price) include discretion of the procuring agent, corruption, contract complexity, demand, transparency and collusion, market openness, and legal origin. The discussions highlight discretion and corruption as important interacting factors. These two intertwined factors closely link not only to the competition but also to many of the other factors.

6.2.1 Award Mechanisms with Considerations of Corruption

Award mechanisms can be designed to combat corruptions, but they can also be channels for corruption. In public procurement, the award procedure may contain a pre-selection process, which allows discretion of the procuring agent. The EU allows four benchmark award mechanisms: the open, restricted, negotiated and competitive dialogue procedures.² All these benchmark award mechanisms, except for the open procedure, contain a process of pre-selection. The pre-selection entitles the procuring agent to apply additional (subjective) selection criteria, which are supposed to be tailored to the unique requirements of the purchase, to exclude bidders with(out) certain attributes and to limit the number of bidders.

Negotiations offer additional room for discretion. The negotiated procedure and the competitive dialogue allow negotiations on non-verifiable quality aspects. Corruption may still be possible even in cases of the open and restricted procedures where there is no negotiation if the award criteria are not purely price-based. The procuring agents have discretion in scoring auctions, which takes into account more subjective criteria than price, such as supplier reputation and technical design. In these cases, the procuring agents can tilt the award criteria towards the subjective criteria and put less weight on price.

A biased procuring agent may exert his discretion in favour of the groups that have close relationships with him in exchange for monetary or non-monetary benefits paid in advance, on the spot or in the future. As this chapter argues, whichever the form of benefits that the procuring agent receives and whenever the benefits are received, the economic consequences of fraudulent conduct on procurement are the same: the competitive environment is compromised and a bidder who has offered any benefits to the procuring agent is more likely to win the contract; the public buyer pays a higher price for worse quality.

Although it is a widely accepted idea that corruption adversely affects the entry and

²See Chapter 2 for detailed comparison of these four benchmark award mechanisms.

therefore the contract rebates, little direct empirical evidence has been offered. This is because corruption, as a hidden action, is inherently difficult to measure. Instead, the literature inclines to uncover the relationship between procurement outcome and discretion, which is usually measured by award mechanisms ([Baldi et al., 2016](#), [Lewis and Bajari, 2011](#), [Spagnolo, 2012](#)).

6.2.2 Discretion

Rule-based award mechanisms (e.g. price-only auctions) usually include a large number of bidders to strengthen competition. However, [Samuelson \(1985\)](#) demonstrates that when there are entry costs and the number of bidders becomes very large, it is likely that an additional bidder brings little or no social welfare because the probability that an additional bidder shares the similar profile with an existing bidder becomes higher. In the meanwhile, more bidders incur bid preparation costs and opportunity costs. As a result, the discretion to limit the number of bidders may improve the net social welfare.

When the contract is complex, the advantages of discretion over rule-based award mechanism are greater. Even when quality is verifiable, it may be expensive for the public buyer to specify the award rules and the costs of screening bids is high. When quality cannot be easily verified, pure price competition cannot attract competent bidders ([Tadelis and Bajari, 2006](#)). More competent bidders usually have more opportunities and can acquire a better rate of return from alternative businesses, so they are likely to withdraw from fierce price competition, which they deem to be unprofitable. In this latter case, pure price competition chooses a winner who asks for the lowest price but provides the lowest level of non-contractible quality ([Bajari and Tadelis, 2001](#), [Manelli and Vincent, 1995](#)).

These quality concerns often justify the discretionary power of procuring agents in awarding contracts ([Compte et al., 2005](#)). To limit participation by prequalifying bidders would motivate bidders to work towards higher quality, even when the quality is non-contractible ([Albano et al., 2017](#), [Branco, 1997](#), [Che, 1993](#), [Cripps and Ireland, 1994](#),

Spagnolo, 2012). In addition, negotiation with a limited number of reputable bidders fosters understanding of a complex contract and improves contract design (Bajari and Tadelis, 2001, Manelli and Vincent, 1995). Also, negotiation is compatible with the cost-plus compensation rule, which accommodates ex post renegotiation well.³

The benefits introduced by the discretionary power are not without costs. Abuse of discretion induces *corruption* (i.e. exchanging a biased decision for bribes) which is often accompanied by *collusion* between suppliers (Burguet and Che, 2004, Compte et al., 2005, Lambert-Mogiliansky and Sonin, 2006).

6.2.3 Corruption and Competition

Corruption of public officials does not appear as a central topic of academic study until the late twentieth century. It emerged as a political or philosophical concept and was later coded in laws and was subsequently and successively analysed by sociologists, anthropologists and economists (Williams, 2000).⁴

Rose-Ackerman (1975) started the modern research into the economics of corruption by discussing penalties to dispel incentives of firms to offer bribes and incentives of public officials to accept bribes. Rose-Ackerman (1978) is among the first studies that link corruption with competition. In her case of distributing a scarce government good when inter-official (political) competition is possible, she contends that the existence of a small number of honest officials forces all public officials to behave honestly.

Corruption can be considered as a cost of doing business. For suppliers, corruption is similar to tariff and non-tariff barriers, tax rate, restrictions on ownership and regulation requirements in the sense that they all reduce the revenue stream and discourages firms from making an initial fixed investment (Evenett and Hoekman, 2005, Romer, 1994).

³See Section 3.4.2 for detailed discussion of the relationship between award mechanism and compensation rules.

⁴Williams (2000) keeps track of the development of studies in corruption. It is a collection that contains selected papers since 1961 and consists of four volumes entitled “Explaining Corruption”, “Corruption in the Developing World”, “Corruption in the Developed World” and “Controlling Corruption”.

Shleifer and Vishny (1993) take bribes as an analogue of tax which is a markup on price but show that uncoordinated bribe taking schemes are much more costly than taxation.

In addition to the relationship between corruption and competition, the literature also examines how administrative decentralisation is related to corruption (Fan et al., 2009, Fisman and Gatti, 2002, Lessmann and Markwardt, 2010, Rose-Ackerman, 1975, Shleifer and Vishny, 1993) and how corruption facilitates collusion (Compte et al., 2005, Lambert-Mogiliansky and Sonin, 2006).

The consensus of the literature is that two-way causality exists in the relationship between corruption and competition. The theoretical impact of corruption on competition almost uniformly refers to competition among bidders. Corruption suppresses the number of potential bidders by affecting the amount of gains and it softens price competition. By contrast, the effects of competition on corruption arise for several reasons. The rest of this section reviews the literature on how corruption influences competition and the literature on the impacts of different competitions among bidders, contracting authorities, and government servants on corruption.

6.2.3.1 Corruption as a Determinant of Competition

Corruption is a principal-agent problem (Celentani and Ganuza, 2002, Lambert-Mogiliansky and Sonin, 2006, Rose-Ackerman, 1975). An agent is hired to operate on behalf of a government or non-government organisation to make decisions. However, the procuring agent's discretionary power nurtures corruption, which would never be an issue without delegation (Burguet and Che, 2004, Rose-Ackerman, 1975). A corrupted agent places his own interest ahead of the interest of the organisation when he exchanges discretion for bribes. Corruption may take place in the cases of dispensing government goods, such as construction licences (Shleifer and Vishny, 1993), and purchasing goods and services, i.e. public procurement (Celentani and Ganuza, 2002, Compte et al., 2005).

Without corruption and under perfect information, a procurement contract is awarded

to an efficient firm that offers the best price-quality combination (Burguet and Che, 2004, Compte et al., 2005). With corruption, the efficient allocation is compromised. Inefficient firms get a higher chance to win on favourable terms at the cost of public buyers. This is the case whether contract and bribe competitions take place sequentially or simultaneously.⁵ Bribe competition can affect the participation of the bidders (and therefore the identity of the winner) and the extent of competition (and thus the terms of the contracts) (Rose-Ackerman, 1975).

Price and quality are two fundamental elements of a procurement contract. A procuring agent may favour a briber by accepting the briber's bid with a higher price or poorer quality than the best possible price-quality combination. Allowing price to change for a given quality is essentially the same as allowing quality to change for a given price (though varying quality for a given price is a more complicated case to analyse) (Rose-Ackerman, 1975).

In the context of procurement, for suppliers, paying bribes is a cost in addition to the cost of production and overhead costs. It is likely to have impacts on competition from two aspects. First, grafts (i.e. the expected bribe payment) may reduce the number of participants. Graft acts as a tax on ex post profits and the diminished profitability makes it less attractive to make initial fixed cost investment and pay for overhead costs (Bliss and Di Tella, 1997, Romer, 1994). This is especially likely to expel small and medium sized enterprises (SMEs) because SMEs tend to have fewer resources to establish a connection with the procuring agent and make initial investments (Davoodi and Tanzi, 2002). According to Bliss and Di Tella (1997), corruption generates surpluses from cost structure of firms. Because efficient firms have a greater surplus than inefficient firms do, a corrupt procuring agent has an incentive to drive out inefficient firms so that it can milk more bribes from efficient firms. Moreover, corruption can aggravate the opaqueness of the selection process, which in turn hampers the ability of bidders, especially foreign

⁵Compte et al. (2005) analyse the effect of corruption on competition in procurement in a situation when contract competition is followed by a bribery competition, the winner of which is given a chance to modify its initial bid and undercut its rivals. Burguet and Che (2004) show that procuring agent is biased towards the bribe competition winner in tender assessment when bidders are in a competition that evaluates prices, quality and bribes simultaneously.

bidders, to bid ([Evenett and Hoekman, 2005](#)).

The second impact of corruption is to soften price competition. Firms with a close connection with the procuring agent often hope to gain protection in public procurement and discourage competition ([Della Porta and Vannucci, 1999](#)). With protection, a seller would bid at a higher price so that his increased cost due to bribe would be compensated by the higher payment ([Burguet and Che, 2004](#)). However, this compensation transfers cost from the briber to the public buyer. [Compte et al. \(2005\)](#) show that in procurement where the firm offering the highest bribe can be allowed to resubmit its bid, the competing firms share a joint interest to set initial offer prices to a high level. Such collusion between competing firms inflates the price by more than the amount of bribe received by the procuring agent.

If the the procuring agent's discretionary power is limited, the existence of honest efficient firms may restore price competition ([Burguet and Che, 2004](#), [Compte et al., 2005](#)). To win a contract, an honest efficient firm has to compete with bribe payers by offering a sufficiently low price in order to overcome its comparative disadvantage in bribe competition. The sufficiently low price is high enough to make the efficient firm stay profitable but low enough to leave no profits for less-efficient firms who have a higher tendency to bribe procuring agents.

However, when the government agent has substantial discretionary power (awarding a contract to a firm who did not offer the lowest price), more cost-efficient firms face a lower probability of winning ([Burguet and Che, 2004](#)). To secure a win without paying bribes, a firm has to bid at a price that is unprofitable ([Compte et al., 2005](#)). Indeed, a more efficient firm can choose to outbribe inefficient firms, but outbribing would not ensure a more efficient firm to win all offers ([Burguet and Che, 2004](#)). Less efficient firms could response by randomising the bribes to make it very costly (if not impossible) for the more efficient firms to be an ever-victorious winner.

One should note that a more efficient firm can also benefit from the softened price competition by colluding with less efficient firms ([Burguet and Che, 2004](#)). In this case,

when the procuring agent has large discretionary power, corruption facilitates collusion. The more efficient firm remains in the market but it no longer hardens price competition.

In sum, corruption as an additional transaction cost affects competition through three paths. First, a bidder who may act dishonestly and will internalise its cost of the bribe is discouraged from entering the tender because they expect lower net profits after paying bribes (Bliss and Di Tella, 1997, Davoodi and Tanzi, 2002, Romer, 1994, Rose-Ackerman, 1975). Second, a corrupt procuring agent is motivated to drive inefficient bidders out so that it can ask for higher bribes from more efficient bidders who tend to have a larger surplus (Bliss and Di Tella, 1997). Third, bidders build the costs of bribe into their bids, which inflates the price paid by the public buyer (Burguet and Che, 2004, Compte et al., 2005). The direct impact through the first and second path is shrinking the number of bidders.⁶ The direct impact through the third path is softening price competition.

6.2.3.2 Competition as a Determinant of Corruption

Competition (in this context of competition as a determinant of corruption) has several meanings. It can refer to competition among bidders, to inter-jurisdictional competition among different authorities and to competition for the position of procuring agent. Here we briefly review how these three forms of competitions affect corruption.

The theoretical impact of competition of bidders on corruption is inconclusive. Bliss and Di Tella (1997) propose that the equilibrium number of firms and the level of the graft are endogenously determined by what they call *deep competition parameters* such as overheads costs and fixed costs of suppliers. According to them, an increase in the deep competition parameters has uncertain effects on the level of graft per firm. Increasing competition drives out the least efficient firms and makes the remaining firms more profitable. Therefore, the remaining firms are more able to pay bribes. However, when the competition becomes very intensified, only a small proportion of firms remain

⁶The revenue equivalence theorem (see Section 3.4.1) show that a reduction in the number of bidders will ultimately increase the prices charged by the remaining bidders if the remaining bidders expect such reduction in the number of participants.

and those firms are likely to have similar production functions with close overhead costs. None of the remaining firms may meet additional graft request. [Ades and Di Tella \(1999\)](#) emphasise the interaction of bidders' competition with public sectors' incentive scheme. Softer competition leaves firms with higher rents, which induce the procuring agent to manipulate the selection to obtain bribes. However, in the meanwhile, the public sector has a higher incentive to strengthen supervision on the procuring agent and to increase penalties for corruptive conducts.

Increased inter-jurisdictional competition predicts lower levels of corruption across localities. [Rose-Ackerman \(1978\)](#) proposes that when allocating a scarce resource, the existence of a few honest procuring agents who refuse to accept bribes rebuilds honesty in all bureaucracies because applicants have alternative choices if they are asked to pay bribes. [Brennan and Buchanan \(1980\)](#) note the similarities between inter-jurisdictional competition and competition in the product market and argue that the competition reduces the room for rent extraction by procuring agents. [Shleifer and Vishny \(1993\)](#) compare joint monopoly (i.e. centralised or cooperated) corruption, independent monopolistic corruption and competitive corruption and demonstrate that the level of bribes is the lowest in the third case, where competition between bureaucracies drives bribe levels to zero.

[Celentani and Ganuza \(2002\)](#) discuss the cases when increased competition for the position of procuring agent may lead to a higher probability of corruption and when it may have no impact on corruption. Public sectors rely on the expertise of procuring agents to verify quality and feasibility. It is likely that the increased competition for the position leads to employing procuring agents with higher ability. More capable procuring agents have a lower marginal cost of evaluating bids and verifying the surplus retained by bidders. With better knowledge of bidders' production functions, procuring agents are able to extract a greater proportion of surplus through corruption so the probability of corruption is higher. The probability of corruption and level of the bribe may also be higher if the increased competition implies a lower wage differential between more capable and less capable procuring agents.⁷ In this case, procuring agents may have

⁷[Ades and Di Tella \(1999\)](#) summarise that businesspeople hold a point of view that to raise the wages

an incentive to make up for the relatively low wage through receiving bribes. However, when the competition causes wage differentials, the procuring agents become less prone to corruption. Once the criminal malfeasance is exposed, the guilty procuring agent is punished through dismissal. Deprivation of job and loss of wages are potential costs of corruptive actions (Treisman, 2000). Higher salaries suggest a higher cost of misconducts and are more likely to align procuring agents' behaviour with the objectives of the public sector (Becker and Stigler, 1974).

6.2.4 Other Determinants of Competition in Public Procurement

In addition to corruption, contract specific factors, e.g. complexity and demand, and macro factors, e.g. information barriers, market openness and a nation's legal framework, also affect competition in public procurement. This subsection reviews research on these additional determinants of competition.

This literature review helps identify control variables in our empirical regressions. It also further highlights the important roles of discretion and corruption in competition by showing the links between discretion, corruption and these other factors. Readers may skip the detail in the remainder of this subsection.

6.2.4.1 Complexity

More complex contracts are likely to have more non-contractible qualitative considerations (Tadelis and Bajari, 2006). Bidders incur more costs to evaluate the profitability to carry out a complex contract and to prepare tendering documents, i.e. high entry costs. The entry costs are a component of the total costs. Bidders will keep entering into the competition until the intensified competition drives their expected profit down to their expected costs (French and McCormick, 1984).

of public officials is likely to dismiss the incentives of corruption.

Fewer bidders may compete for a complex contract when the contract is awarded through a rule-based award mechanism (e.g. the open procedure). Since bidders have to clearly specify many potential scenarios, it is very burdensome for them to prepare the tendering documents (Hyytinen et al., 2018).

6.2.4.2 Demand

Demand influences the attractiveness of contract to the suppliers (Caldwell et al., 2005). More bidders will compete for a contract with potentially large demand.⁸ If the public buyers do not coordinate their demand, e.g. conducting many separate one-off purchases, the transaction costs for both the public buyer and suppliers are higher.

Public contracts would attract more suppliers if public buyers can reduce fluctuations in demand and to set up a responsible budget schedule (Caldwell et al., 2005). However, the spending scheme in some areas has been observed to be cyclical (Bayens and Martell, 2007). The budget is often loose at the beginning of a fiscal year, becomes tight to prevent over-spending during the year and ends up with a “panic” spending in the year-end in order to exhaust the budget allocated for a certain fiscal year.

6.2.4.3 Information Barriers

Procurement information is transmitted between different public sectors and between public sectors and potential suppliers. Timely and accurate information makes a difference in competition.

Transparency refers to how easily potential bidders can access and understand what is going on about a contract (Amaral et al., 2009). Transparency in public procurement is featured with a clear definition of award criteria and accurate and easily accessible records

⁸For example, based on Japanese data, the empirical results by Hattori (2010) indicate that electricity suppliers are more likely to competing for contracts in large city areas, which are supposed to have higher electricity demand.

of the award process. Opaque procurement practice may arise from administrative inefficiencies, such as not making the necessary investment in developing a transparent procurement regime, favouritism to domestic firms, or rent-seeking and corruption ([Evenett and Hoekman, 2005](#)).

Transparency does not have a clear-cut impact on competition. On the one hand, non-transparency discourages potential suppliers from bidding because the contract is surrounded by greater uncertainties ([Amaral et al., 2009](#), [Evenett and Hoekman, 2005](#)). On the other hand, publicising bidders' identities and their price signals may facilitate collusion, whereas full opaqueness that leaks no information about bidders' identification and signals would effectively prevent collusion ([Albano, Buccirossi, Spagnolo and Zanza, 2006](#), [Stigler, 1964](#)). Bidders in a collusive cartel bid cooperatively so as to undermine the competition.

Public authorities cannot adopt a fully opaque procurement process, because they are accountable to the general public ([Lengwiler and Wolfstetter, 2006](#)).⁹ Based on a regression discontinuity design analysis on Italian procurement auctions, [Coviello and Mariniello \(2014\)](#) find that the increased publicity requirement attracts more participation and leaves less economic rent for the winning supplier.

E-procurement, which applies e-commerce in procurement, helps communication between public buyers and suppliers. Purchasing goods and services online increases the accuracy and timeliness of information. It also reduces the time-consuming administrative paperwork ([Dimitri et al., 2006](#), [Jullien, 2006](#)).

Cross-departmental dialogues between public buyers also benefit information transmission ([Caldwell et al., 2005](#)). Establishing regular conversation channels facilitates public authorities to exchange procurement information in time. Moreover, cross-departmental dialogue contributes to cooperation that smooths demand across public sectors.

⁹[Amaral et al. \(2009\)](#) discuss several empirical studies that highlight transparent procedures adopted by procuring authorities.

6.2.4.4 Market Openness

The literature of market openness discusses the favouritism to domestic firms under different market structures. [Trionfetti \(2000\)](#) provides a concise theoretical review with illustrations on two market structures: the constant returns to scale and perfect competition paradigm and the increasing returns to scale and monopolistic competition paradigm. There are two forms of discriminations that affect foreign firms' participation in the domestic market: 1) an outright restriction or a ban on purchases from foreign suppliers and 2) adding a price preference margin to foreign goods and services ([Evenett and Hoekman, 2005](#), [Trionfetti, 2000](#)). Although an explicit ban on foreign suppliers is rare, it is a widely existing *de facto* practice ([Trionfetti, 2000](#)).

The impact of discriminatory policy on trade against foreign suppliers is conditional on the relative size of government demand and domestic output ([Evenett and Hoekman, 2005](#), [Trionfetti, 2000](#)). A ban on public procurement from foreign suppliers does not affect equilibrium price, the volume of trade, or domestic output when domestic output is more than the government demand and less than the total domestic demand ([Baldwin, 1970, 1984](#), [Evenett and Hoekman, 2005](#), [Trionfetti, 2000](#)). This is because foreign supply, though not taken up by domestic government demand, is met by domestic private demand. When government demand is greater than domestic supply at a unanimous world price, exclusion of foreign supplier would lead to a fall in total import and, in the short run, a higher domestic price ([Baldwin, 1970, 1984](#), [Evenett and Hoekman, 2005](#), [Trionfetti, 2000](#)). In the long run, the price inflation disappears because the increased profit induces new domestic entry in the industry until the domestic price equals the world price ([Evenett and Hoekman, 2005](#)).

[Evenett and Hoekman \(2005\)](#) elaborate the case of price discrimination under free trade. Price discrimination that favours domestic firms adds a percentage inflation factor $\rho\%$ to the price of foreign goods, P_f . Thus, the buyer compares the *preference inflated price* of foreign goods, $(1 + \rho)P_f$, and the actual price of domestic goods, P_d . When government demand is less than or equal to domestic supply, imposing price discrimination

has no impact on prices, imports, domestic output or national welfare. While the public sector shifts from the foreign supply to the domestic supply, the released foreign supply is met by domestic private buyers. Those domestic private buyers will purchase from foreign suppliers at P_f . When government demand is greater than domestic supply, the short-run and long-run impacts of price discrimination are complicated. However, the price discrimination will at least drive out a proportion of foreign suppliers.

[Ades and Di Tella \(1999\)](#) and [Laffont and N'Guessan \(1999\)](#) use the ratio between imports and GDP as one of the independent variables to predict corruption. [Ades and Di Tella \(1999\)](#) find that countries with a higher share of imports in GDP correspond to a lower level of perceived corruption, but results from [Laffont and N'Guessan \(1999\)](#) show that greater openness of economy does not always indicate a lower level of perceived corruption.

6.2.4.5 Legal System

A substantial literature has been developed in the past decades regarding the implications of different legal systems to the economic outcomes ([La Porta et al., 2008](#)).¹⁰ The legal theories emphasise two interrelated channels: the political channel and the adaptability channel.

The political channel describes how the protection of private property rights affects financial development ([Glaeser and Shleifer, 2002](#), [La Porta et al., 1999](#)). In history, compared with the French and German civil laws, the English common law was more concerned about confining the king's power over the adjudication of private properties. This was because the English monarch was quite powerful. By contrast, the French and German civil law entitled the crown greater power in order to stabilise the country ([Hayek,](#)

¹⁰The legal origin is correlated with financial development ([La Porta et al., 1997, 1998](#), [Levine, 1998, 1999](#)), ownership concentrations ([La Porta et al., 2002](#)), the burden of entry regulations ([Djankov et al., 2002](#)), firms' debt maturity and access to external finance ([Demirgüç-Kunt and Maksimovic, 1998, 1999](#)), capital allocation across firms and industries ([Beck and Levine, 2002](#), [Claessens and Laeven, 2003](#), [Wurgler, 2000](#)), informational efficiency of stock price ([Morck et al., 2000](#)), and financial crisis ([Johnson et al., 2000](#)).

2013). The legal traditions of the civil laws are biased towards the power of the state and focused less on the rights of individual investors (Mahoney, 2001). Overall, the state has greater controls of the judiciary and the private property right are less protected under the civil law than under the common law (Glaeser and Shleifer, 2002).

The adaptability channel suggests that legal systems, e.g. the common law, that depend on jurisprudence (i.e. legal provisions created by judges in the process of case settlement) adapt to the current condition more quickly than legal systems, e.g. the civil law, that rely on statutory law modifications. Bailey and Rubin (1994), Priest (1977) and Rubin (1977, 1982) contend that the substantial discretionary power of judges makes it possible to challenge inefficient laws through case-by-case discussions and to replace inefficient provisions with more efficient ones. However, some people cast doubt on the argument for evolution towards more efficient law. Blume and Rubinfeld (1982) argue that keeping legislations consistent with rapidly changing social, economic and technological conditions incurs transition costs. They show that the legal system may not necessarily be efficient over time due to the unwillingness to bear the transition costs of approaching a more efficient legal system.

It is difficult to separate the political and adaptability channels entirely although they emphasise different aspects. The political channel focuses on the power of the state and the adaptability channel focuses on the ability of the legal system to adapt to changing conditions. It is less likely to realise jurisprudence in a legal system in which the government controls judiciary than in a legal system in which the judiciary is entitled to greater independence (Glaeser and Shleifer, 2002). These two channels imply that the common law system is likely to be more effective than the civil law system in combating corruption (David and Brierley, 1978, La Porta et al., 1999).

6.3 The Model

The last section shows that the literature takes discretion and corruption as two distinct interacting factors that are closely related to competition. The purpose of this section is to present a model that establishes the connections between discretion, corruption, and the entry of honest bidders. The model contributes to the literature by demonstrating a mechanism that shows the interaction between discretion and corruption. It is a mechanism that many studies have verbally argued for but few studies offer formal models as supporting evidence.

To allow for endogenous corruption decisions, this section models the procurement process as an extensive-form game, which consists of a sequence of possible moves by players.¹¹ The amount of bid is derived from the *revenue equivalence theorem* that expresses the value of bids by the number of bidders and bidders' true valuations (Myerson, 1981, Riley and Samuelson, 1981, Vickrey, 1961, 1962). With this expression of bid, we are able to link the procuring agent's discretion with bidders' expected profits and the procuring agent's expected corruptive gain.

This section treats both dishonest conducts for monetary and non-monetary bribes as equivalent. A non-monetary benefit has a monetary equivalent value. Following Rose-Ackerman (1975), we keep quality offered by each bidder at the same level and allow changes in price.

The model is based on the following assumptions, which are inherited from the literature on the *revenue equivalence theorem*¹²:

1. Bidders' type (based on bidders' true costs of delivery) is drawn from a distribution, the cumulative distribution function of which is strictly increasing and continuous;
2. Risk neutrality holds for each bidder and procuring agent;

¹¹The Appendix reviews the basics of the extensive-form game.

¹²Section 3.4.1 reviews the literature on the revenue equivalence theorem in detail.

3. The contract must be awarded to one of the bidders; when there is no bribe transfer, the bidder with the highest type (i.e. delivering the contract at the lowest cost) wins; when there is bribe transfer, the bidder who offers the bribe wins;
4. The expected payoff for the bidder with the lowest type is zero.

The *revenue equivalence theorem* was initially discussed in a single-seller-many-buyer context. It states that in a case of N bidders whose types are drawn from a uniform distribution defined over an interval $[\underline{v}, \bar{v}]$, the Nash equilibrium is that each bidder bids $\frac{N-1}{N}v_i$, where v_i is bidder i 's actual valuation. $\frac{N-1}{N}$ is called the bid shading factor, which represents the fraction that a bidder is willing to pay out from his actual valuation and is defined over $(0,1)$. As the number of buyers increases, the bid shading factor increases from nearly zero to one and each buyer bids closer to his true valuation.

The bid shading factor in a single-buyer-many-seller context, i.e. procurement, follows a logic similar to the one in the single-seller-many-buyer context. The presence of more number of sellers makes bidder i bid an amount b_i that is closer to his true valuation, i.e. cost of delivery c_i . The bid shading factor is a decreasing function with respect to the number of bidders. As the number of sellers increases, the bid shading factor $\frac{b_i}{c_i}$ decreases from some high level to one. The bid shading factor with one buyer and N sellers can be represented by $\frac{N+k}{N}$, where k is a constant greater than 0 that measures the markup over c_i and $\lim_{N \rightarrow +\infty} \frac{N+k}{N} = 1$. The equilibrium offering price by seller i is $\frac{N+k}{N}c_i$.

Expressing bids by the bid shading factor, this section constructs a model on the extensive form game when the procuring agent has a high discretionary power of restricting the final participants and a potentially dishonest bidder exists. It shows that the dishonest bidder may align his interest with the interest of the procuring agent by offering a bribe. The expected profit of the dishonest bidder and the expected gain of the procuring agent would increase if the procuring agent accepts the bribe and retains a fewer number of final bidders. The honest bidder cannot win when corruption takes place. Therefore, the honest bidders have lower expected payoffs of bidding and are less likely to participate when the procuring agent's discretionary power of restricting the final participants is high

and a bidder may bribe the procuring agent, i.e. when the likelihood of corruption is high. Also, the honest bidders are more likely to opt out when the participation costs (e.g. costs of preparing tendering documents or opportunity costs) are high.

The model is a partial analysis that assumes the probability of detecting the corruption and the intensity of punishment for corruption are static and independent from the amount of bribe. In reality, both the probability of detection and intensity of punishment are likely to increase as the amount of bribe goes up. However, we may expect that these two numbers stay stable or increase marginally at low levels, so the expected illegal gains of both the procuring agent and the dishonest bidder do not dramatically decrease. The conclusion from this model should still hold in this case.

In the rest of this section, Section 6.3.1 describes the model in the simplest case that involves two players; Section 6.3.2 extends the model to a case with three players and Section 6.3.3 generalises the conclusion from the case with three players to a case with multiple players.

6.3.1 Case 1: A Game of a Potentially Dishonest Bidder and a Potentially Dishonest Procuring Agent

We start with a simple procurement in a world with only a bidder i , B_i and a procuring agent, G (see Figure 6.1). At the initial stage, B_i has to choose whether to bid for the contract (E) or not (O). The bidder and procuring agent may act dishonestly under certain circumstances. Having entered the procurement, the bidder may offer a bribe (B) or act honestly (H). The procuring agent may accept a bribe (a) or refuse a bribe (h). The procuring agent knows whether the bidder chooses to participate in the procurement and whether any bidder offers a bribe. However, the bidder knows nothing about whether the procuring agent would accept a bribe. Because B_i is the only bidder, he will win the contract as long as he bids for it.

B_i has two information sets and four pure strategies, i.e. $S_{B_i} = \{EB, EH, OB, OH\}$.

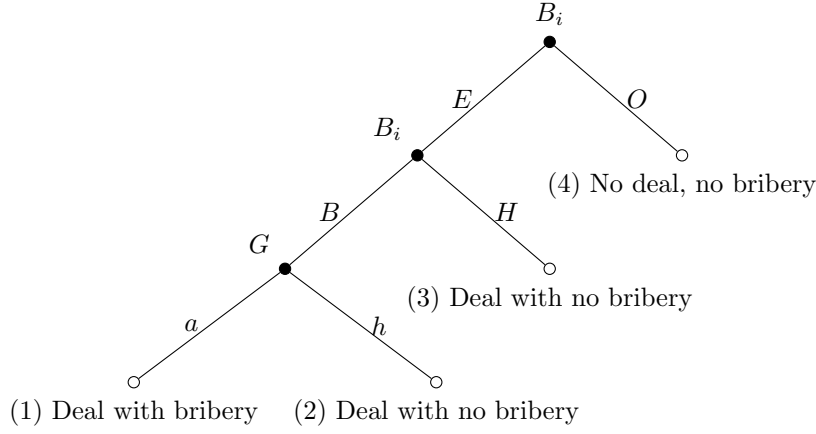


Figure 6.1: A Procurement with a Potentially Dishonest Bidder and a Potentially Dishonest Procuring Agent

The procuring agent has one information set and two pure strategies, i.e. $S_G = \{a, h\}$. Different combinations of pure strategies of B_i and the procuring agent arrive at different outcomes of trading. For example, a strategy pair of (EB, h) leads the procurement to a transaction without bribery transfer, i.e. terminal node (2).

For B_i , preparing the tendering documents incurs a cost of p_i and offering a bribe has a monetary cost of b . Let θ be the probability that corruption is detected, the monetary equivalent penalty to B_i is t and the monetary equivalent penalty to the procuring agent is m . Since B_i is the only bidder, the bid shading factor is $\frac{1+k}{1} = 1 + k$. B_i will offer a price of $(1 + k)c_i$, where c_i is his cost for delivering the contract.

Proposition 1. In a world with a bidder and an procuring agent, if $kc_i > p_i$, the outcome is a deal with no bribery; if $kc_i < p_i$, the bidder will not participate and no deal will take place. A deal with bribery will never take place.

The matrix form of the game and the payoff of each party are shown in Figure 6.2. Each cell shows one pair of payoff. For each pair of payoffs, the payoff of B_i is on the left side and the payoff of the procuring agent is on the right side. For instance, a strategy pair of (EB, a) is concluded as a deal with bribery (terminal node (1)). In this case, B_i has an expected payoff of $kc_i - p_i - b - \theta t$ ($= (1 + k)c_i - c_i - p_i - b - \theta t$) and the procuring agent has an expected payoff of $b - \theta m$.

		Procuring Agent	
		a	h
B_i	EB	$kc_i - p_i - b - \theta t, b - \theta m$	$kc_i - p_i, 0$
	EH	$kc_i - p_i, 0$	$kc_i - p_i, 0$
	OB	$0, 0$	$0, 0$
	OH	$0, 0$	$0, 0$

Figure 6.2: Expected Payoffs of a Procurement with a Potentially Dishonest Bidder and a Potentially Dishonest Procuring Agent

Notes. Each cell shows one pair of payoffs. For each pair of payoffs, the payoff of B_i is on the left side and the payoff of the procuring agent is on the right side.

It is for sure that $kc_i - p_i$ is no less than $kc_i - p_i - b - \theta t$, so EH dominates EB for B_i . Therefore, as long as $kc_i - p_i$ is greater than 0, EH is the best response for B_i once he chooses to participate, regardless of the strategy chosen by the procuring agent, i.e. B_i will bid for the contract and does not offer any bribe. When $kc_i - p_i$ is less than 0, the best response for B_i is not to participate.

6.3.2 Case 2: A Game of a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder

Having discussed the procurement in a world with one potentially dishonest bidder and one potentially dishonest procuring agent in Section 6.3.1, we introduce an honest bidder into the world. We assume the costs of offering a bribe vary across bidders. The honest bidder is the extreme case where this cost is infinitely high and discourages him from offering any bribes.

Figure 6.3 is a game tree that depicts this extensive form game with a potentially dishonest bidder i , B_i , a potentially dishonest procuring agent G and an honest bidder j , B_j . At the beginning, the potentially dishonest bidder and the honest bidder have to decide to compete for the contract (E) or not participate (O). Neither of bidders knows whether the other has chosen to participate. Once B_i chooses E , he needs to decide whether to bribe the procuring agent (B) or not (H). The procuring agent would choose

to accept (a) or decline a bribe (h). The choice of the procuring agent is unknown to either of the bidders. The procuring agent knows which bidder has chosen to bid for the contract and whether B_i offers a bribe. Let the perceived probability for B_i to enter the competition be α and to bribe be γ , the perceived probability for B_j to participate in the competition be β , and the perceived probability for G to accept a bribe be λ .

Without loss of generality, we can expect that λ is an increasing function with the procuring agent's expected payoff from taking bribes, $E(\pi_G)$. If the procuring agent does not accept any bribe, he has a payoff of zero. If he accepts a bribe that is offered to him, he faces an expected payoff function

$$E(\pi_G) = b - \theta m. \quad (6.1)$$

Therefore, it can be inferred that λ increases with b .

Lemma 1. λ increases with b .

B_i has two information sets and four pure strategies, i.e. $S_{B_i} = \{EB, EH, OB, OH\}$. The procuring agent has two information sets and four pure strategies, i.e. $S_G = \{aa, ah, ha, hh\}$. B_j has one information set and two pure strategies, i.e. $S_{B_j} = \{E, O\}$. Combinations of these pure strategies lead the game to eight terminal nodes. For example, a combination of (EB, aa, O) ends up with terminal node (4): the contract is awarded to B_i after he bribes the procuring agent, while B_j opts out.

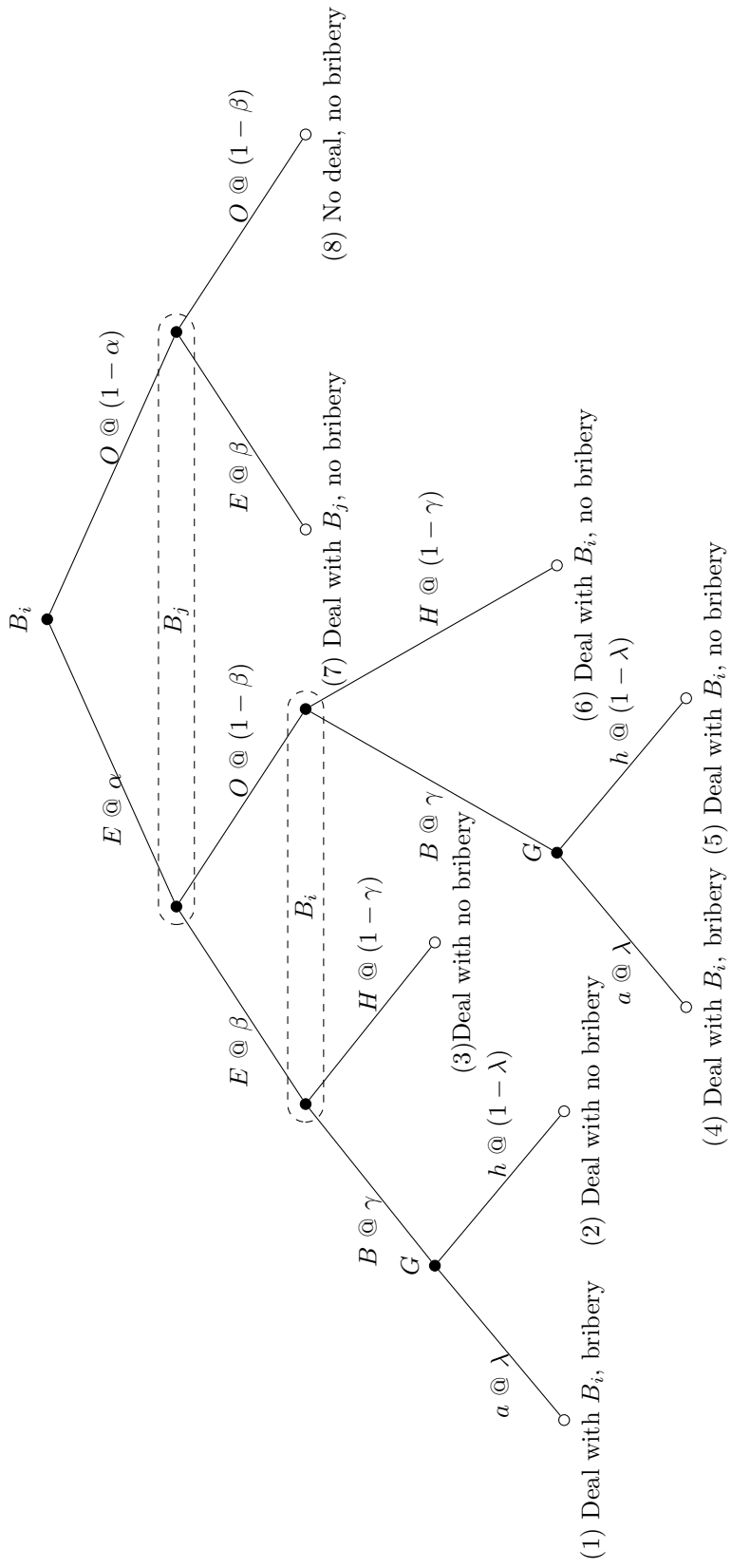


Figure 6.3: A Procurement with a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder

Let $1 - \mu$ be the probability that B_i wins, μ be the probability that B_j wins at each terminal node, and N be the total number of bidders. Let n be the number of bidders who are not considered by the procuring agent if he accepts the bribe from B_i . Since B_i knows n , he would ask for a price that is $\frac{(N-n)+k}{N-n}$ times of his delivery cost c_i . The general expected payoff function for B_i at each terminal node is expressed as a probability weighted average

$$\begin{aligned} E(\pi_{B_i}) &= (1 - \mu) \left[\frac{(N - n) + k}{N - n} c_i - c_i - p_i - b - \theta t \right] + \mu(-p_i) \\ &= (1 - \mu) \left[\frac{k}{N - n} c_i - b - \theta t \right] - p_i. \end{aligned} \quad (6.2)$$

Rearranging Equation 6.2, we can find that the maximum possible amount of b is confined by

$$\frac{k}{N - n} c_i - \theta t - \frac{E(\pi_{B_i}) + p_i}{1 - \mu}. \quad (6.3)$$

Therefore, b is likely to increase with n . Combining this inference with Lemma 1, we can further infer that λ increases with n .

Lemma 2. λ increases with n .

If B_i has successfully paid the bribe, B_i knows that he will certainly win. For B_i , the game is reduced to a game with only two players: B_i and the procuring agent. In this case, $(1 - \mu) = 1$, $n = N - 1$ and B_i will ask for $(1 + k)c_i$. The expected payoff function for B_i is $kc_i - p_i - b - \theta t$. If B_i does not offer a bribe or the procuring agent does not accept a bribe, then $n = 0, b = 0, \theta = 0$ and $(1 - \mu)$ is a variable between 0 and 1 (inclusive). The expected payoff function for B_i is $(1 - \mu)\frac{k}{N}c_i - p_i$.

B_j knows only the total number of N bidders and does not know n or whether his bid will be discarded without being evaluated. He would ask for a price of $\frac{N+k}{N}c_j$ and incur a preparation cost of p_i .

When B_j chooses to participate, the general expected payoff function for B_j at each

terminal node is

$$\begin{aligned}
 E(\pi_{B_j}) &= \mu \left(\frac{N+k}{N} c_j - c_j - p_j \right) + (1-\mu)(-p_j) \\
 &= \mu \frac{k}{N} c_j - p_j.
 \end{aligned} \tag{6.4}$$

If B_i successfully paid a bribe, then $\mu = 0$ and B_j has a payoff of $-p_j$. If a bribe is not offered or not accepted, the expected payoff of B_j is $\mu \frac{k}{N} c_j - p_j$.

Figure 6.4 is the payoff matrix when $N = 2$ and B_j chooses to bid for the contract. Figure 6.5 is the payoff matrix when $N = 2$ and B_j chooses to not to bid for the contract. Among the three payoff functions in each cell, the payoff function on the left is for B_i , the one in the middle for the procuring agent and the one on the right for B_j . In a combination of strategies (EB, ah, E) , EB means that B_i enters the competition and bribes the procuring agent, E stands for that B_j chooses to enter the competition, and ah represents that the procuring agent chooses to accept a bribe when both bidders i and j bid for the contract and that the procuring agent would behave honestly when B_i bids for the contract but B_j does not. A combination of strategies (EB, ah, E) leads to terminal node (1): B_i wins the contract with bribery.

		Procuring agent			
		aa	ah	ha	hh
EB	$k c_i - p_i - b - \theta t, b - \theta m, -p_j$	$k c_i - p_i - b - \theta t, b - \theta m, -p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$
EH	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, \mu^{\frac{k}{2}} c_i - p_j$
OB	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$
OH	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$	$0, 0, \mu^{\frac{k}{2}} c_j - p_j$

Figure 6.4: Expected Payoffs of a Procurement with a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder (the Honest Bidder Chooses to Enter)

Notes. Each cell shows one pair of payoffs. For each pair of payoffs, the payoff of the potentially dishonest B_i is on the left side, the payoff of the procuring agent is on the right side and the payoff of honest B_j is on the right.

		Procuring Agent			
		aa	ah	ha	hh
EB	$k c_i - p_i - b - \theta t, b - \theta m, 0$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, 0$	$k c_i - p_i - b - \theta t, b - \theta m, 0$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, 0$	
EH	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, 0$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, 0$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, 0$	$(1 - \mu)^{\frac{k}{2}} c_i - p_i, 0, 0$	
OB	$0, 0, 0$	$0, 0, 0$	$0, 0, 0$	$0, 0, 0$	
OH	$0, 0, 0$	$0, 0, 0$	$0, 0, 0$	$0, 0, 0$	

Figure 6.5: Expected Payoffs of a Procurement with a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and an Honest Bidder (the Honest Bidder Chooses to Stay Out)

Notes. Each cell shows one pair of payoffs. For each pair of payoffs, the payoff of the potentially dishonest B_i is on the left side, the payoff of the procuring agent is on the right side and the payoff of honest B_j is on the right.

Proposition 2. The expected payoff for B_j to participate decreases as n increases.

The expected payoff for B_j when he chooses not to compete for the contract is the probability weighted average of payoffs from terminal nodes (4), (5), (6) and (8). Thus, $E(\pi_{B_j} | O) = 0$. The expected payoff for B_j when he chooses to compete for the contract is the probability weighted average of payoffs from terminal nodes (1), (2), (3) and (7), which is

$$\begin{aligned} E(\pi_{B_j} | E) &= \alpha\gamma\lambda(-p_j) + \alpha\gamma(1 - \lambda) \left(\mu\frac{k}{2}c_j - p_j \right) + \alpha(1 - \gamma) \left(\mu\frac{k}{2}c_j - p_j \right) + \\ &\quad (1 - \alpha) \left(\mu\frac{k}{2}c_j - p_j \right) \\ &= \mu(1 - \alpha\gamma\lambda) \frac{k}{2}c_j - p_j. \end{aligned} \tag{6.5}$$

Because α and γ are positive, $E(\pi_{B_j} | E)$ is negatively related to λ . By Lemma 2, $E(\pi_{B_j} | E)$ is negatively related to n . Accordingly, as n increases, $E(\pi_{B_j} | E)$ becomes more likely to be smaller than $E(\pi_{B_j} | O)$, and for B_j the strategy of not bidding becomes more likely to dominate the strategy of bidding. The economic implication for the procurement is that an honest bidder is less likely to participate in procurement when the procuring agent has high manipulation power of selecting the final participants and a potentially dishonest bidder exists, especially when the entry cost is high.

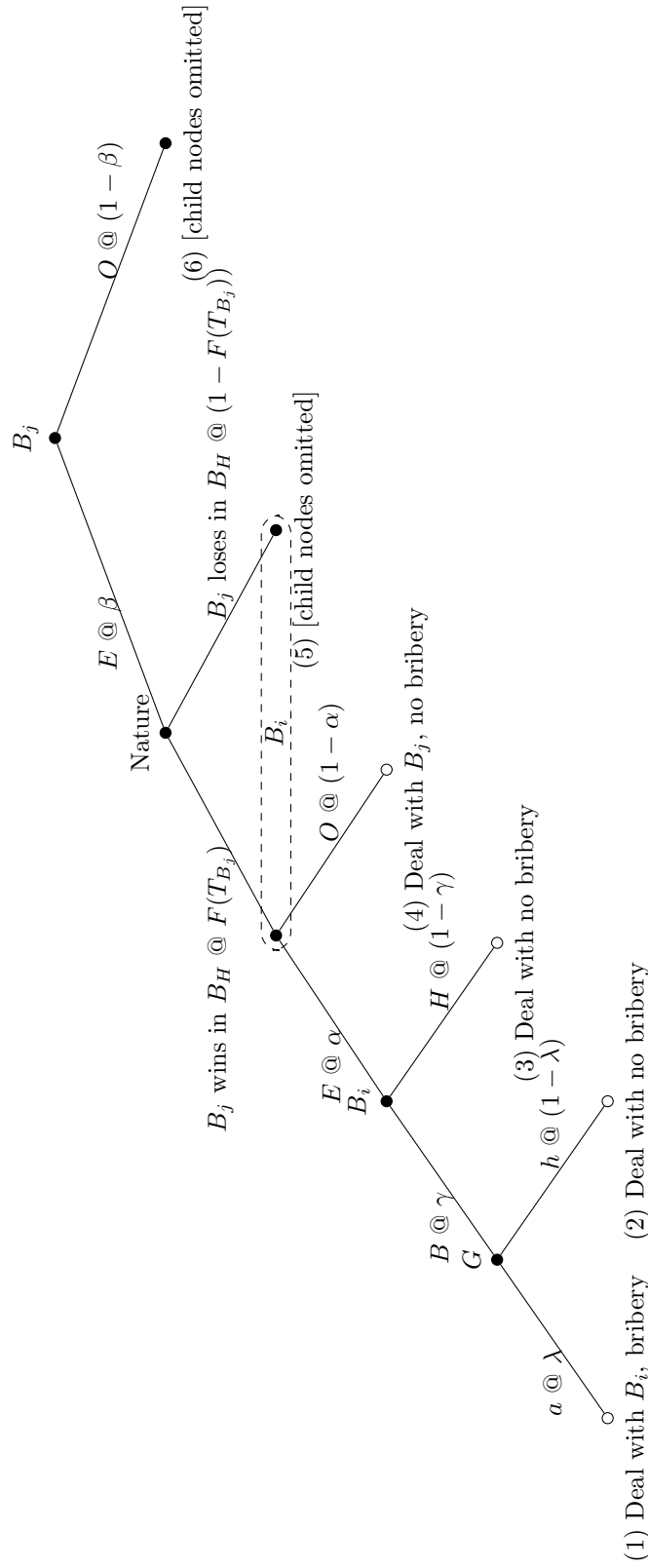
6.3.3 Case 3: A Game of a Potentially Dishonest Bidder, a Potentially Dishonest Procuring Agent and Multiple Honest Bidders

We extend Case 2 into a world with one potentially dishonest bidder B_i , one potentially dishonest procuring agent G , and a group of honest bidders $B_H = \{B_1, B_2, \dots, B_l\}$ ($l \geq 2$). Let T_{B_j} be the type of B_j ($B_j \in B_H$) and $F(\cdot)$ be the cumulative distribution function of the type of honest bidders. $F(T_{B_j})$ is equal to the probability that B_j has the lowest delivery cost among the honest bidders. When B_j chooses not to participate, his expected payoff is zero.

The event that B_j wins is equivalent to two events that hold simultaneously: (1) B_j enters the competition and becomes the winner among B_H ; and (2) B_j defeats B_i . Figure 6.6 is a simplified game tree that elaborates the case when B_j is the winner among all honest bidders and omits the details of the cases when B_j is not the winner among the honest bidders and when B_j chooses not to participate in the procurement. The expected payoff for B_j when he decides to bid for the contract is the probability weighted average of payoffs from terminal nodes (1), (2), (3) and (4) plus payoffs from child nodes of node (5):

$$\begin{aligned}
E(\pi_{B_j} | E) &= F(T_{B_j})\alpha\gamma\lambda(-p_j) + F(T_{B_j})\alpha\gamma(1 - \lambda) \left(\mu \frac{k}{N}c_j - p_j \right) + \\
&F(T_{B_j})\alpha(1 - \gamma) \left(\mu \frac{k}{N}c_j - p_j \right) + F(T_{B_j})(1 - \alpha) \left(\frac{k}{N}c_j - p_j \right) + \\
&[1 - F(T_{B_j})](-p_j) \\
&= F(T_{B_j})\mu(1 - \alpha\gamma\lambda) \frac{k}{N}c_j - p_j.
\end{aligned} \tag{6.6}$$

$E(\pi_{B_j} | E)$ decreases as λ increases, all else equal. Proposition 2 is still valid in this case.



(1) Deal with B_i , bribery (2) Deal with no bribery

Figure 6.6: A Procurement with a Potentially Dishonest Bidder, Potentially Dishonest Procuring Agent and More than One Honest bidders

6.4 Hypotheses and Data

In the empirical part of this chapter, we test four hypotheses regarding the implications of discretion and corruption to the number of bidders and to contract price, with data from the 28 EU member countries, Iceland and Norway.¹³

Hypothesis 1. The number of bidders decreases as corruption increases.

Hypothesis 2. A higher corruption is associated with lower contract rebates.

Hypothesis 3. The number of bidders decreases as the procuring agent's discretion increases.

Hypothesis 4. Higher discretion is associated with lower contract rebates.

We use the Corruption Perceptions Index (CPI) released by Transparency International to measure corruption.¹⁴ This measure is widely adopted in the literature (e.g. Lessmann and Markwardt, 2010, Diaby and Sylwester, 2015, Swaleheen, 2011). The CPI has a scale of 0 (highly corrupt) to 100 (very clean). We limit our use of the CPI to the time horizon 2012–2015 because CPI scores before 2012 are not comparable over time.

The CPI enables us to separately analyse corruption and discretion because it is constructed based on many indicators of corruption. However, as an index for country level corruption, the CPI may be too broad relative to our measures of competition, which are contract specific variables.

Our data constrain us from constructing a contract level corruption index (Coviello et al., 2018) or adopting various measures that are correlated with corruption (Knack et al., 2017). Since the theoretical literature has suggested a strong connection between

¹³The European Economic Area includes the EU member countries, Iceland, Norway and Liechtenstein. Liechtenstein is excluded from the analysis because the sample size of its contract level data is very small and information in many observations is incomplete or inaccurate.

¹⁴For information on Transparency International and the CPI, see the webpage of Transparency International: <https://www.transparency.org/>.

corruption and competition, we still hope to uncover some significant correlation between the CPI, competition and rebates in public procurement.

The contract level data are from the Tenders Electronic Daily (TED). TED is the digital version of the Official Journal of the European Union, where public procurement contracts above the EU thresholds must be advertised. The EU also encourages under-threshold contracts to be published in the TED. As a result, this database contains both above- and under-threshold contracts. The *contract rebate* is measured by the ratio between the contract value and estimated value. The *discretion* is measured by the choice of award mechanism and a dummy variable of quality concerns.

Table 6.1 provides detail on the main variables. The contract specific variables are the number of offers received, contract value, estimated value, award mechanism, quality criterion dummy, and contract type. The ratio between contract value and estimated value is used as a measure of contract rebates. Following [Bajari et al. \(2008\)](#), [Chong et al. \(2012, 2014\)](#) and [Gori et al. \(2017\)](#), we use contract value and estimated value as proxies for contract complexity. Among the four benchmark award mechanisms, the negotiated procedure and the competitive dialogue allow for higher discretion of the procuring agent than the restricted procedure and the open procedure do. The procuring agent has a higher discretion in the restricted procedure than in the open procedure. The quality criterion dummy indicates whether quality is an important factor in bid evaluation. Assessing the quality of bids also calls for more discretion than only comparing bid prices ([Compte et al., 2005](#)). We control for contract type to capture unobservable contract type specific factors.

In addition to CPI, other country level variables are controlled for. We use population for measuring country size; GDP per capita for demand; imports as a percentage of GDP for market openness. GDP per capita and imports as a percentage of GDP are highly correlated with corruption ([Ades and Di Tella, 1999](#), [Laffont and N'Guessan, 1999](#), [Montinola and Jackman, 2002](#)). We obtain data of these three country level variables from the World Bank Open Data. Legal origin, which is related to decentralisation and

corruption, is also introduced in the regressions. We classify the legal origins based on [Djankov et al. \(2004\)](#) and [La Porta et al. \(2008\)](#).

Figure 6.7 shows the distribution of CPI from 2012 to 2015. The level of corruption perception varies across countries and is generally stable within each country during this window of time. The lowest CPI score is 40 (France in 2012 and 2013) and the highest CPI score is 92 (Cyprus in 2014). Bulgaria (average CPI = 62.5), Portugal (average CPI = 62.75) and Czech Republic (average CPI = 68.75) have CPI scores that are closest to the cross-country mean CPI (65.58). Figure 6.8 presents the level of GDP per capita and imports as a percentage of GDP in each country.

Table 6.1: Variable Definition

Variable	Definition
No. of offers received	Number of offers received by each contract that is awarded.
Contract rebate (Contract value/Estimated value)	Final contract value (in EUR, without VAT) in each award divided by estimated value (in EUR, without VAT) in each award.
CPI	The corruption perception index in each country per year. With a scale of 0 (highly corrupt) to 100 (very clean).
Award mechanism	Contains five values: the open procedure, the restricted procedure, the negotiated procedure, the competitive dialogue, and other procedures. Other procedures do not publish any notice as a call for competition.
Quality criterion dummy	There are two award criteria: lowest price (L) and most economically advantageous tender (M). Quality criterion dummy equals to 1 for M, and 0 for L.
Log contract value	The natural logarithm of the final contract value (in EUR, without VAT). A proxy for complexity.
Log estimated value	The natural logarithm of the estimated value (in EUR, without VAT) in each award. A proxy for complexity. Estimated values are released to the public when procurement opportunities are announced. They are usually taken as a reference to budgets.
Population	Total population (in million) of each country in each year. A measure of country size.
Log GDP per capita	The natural logarithm of GDP per capita (in EUR) for each country in each year. A measure of demand.
Imports (% of GDP)	The value of all goods and other market services that an economy received from the rest of the world divided by the economy's GDP.
Legal origin	With four categories. English common law: Ireland, United Kingdom. French civil law: Belgium, Cyprus, France, Greece, Italy, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Romania, Spain. German civil law: Austria, Bulgaria, Croatia, Czech Republic, Estonia, Germany, Hungary, Latvia, Poland, Slovakia, Slovenia. Nordic law: Denmark, Finland, Iceland, Norway, Sweden.
Contract type	Contains three values: works contract (W), supply contract (U), services contract (S).

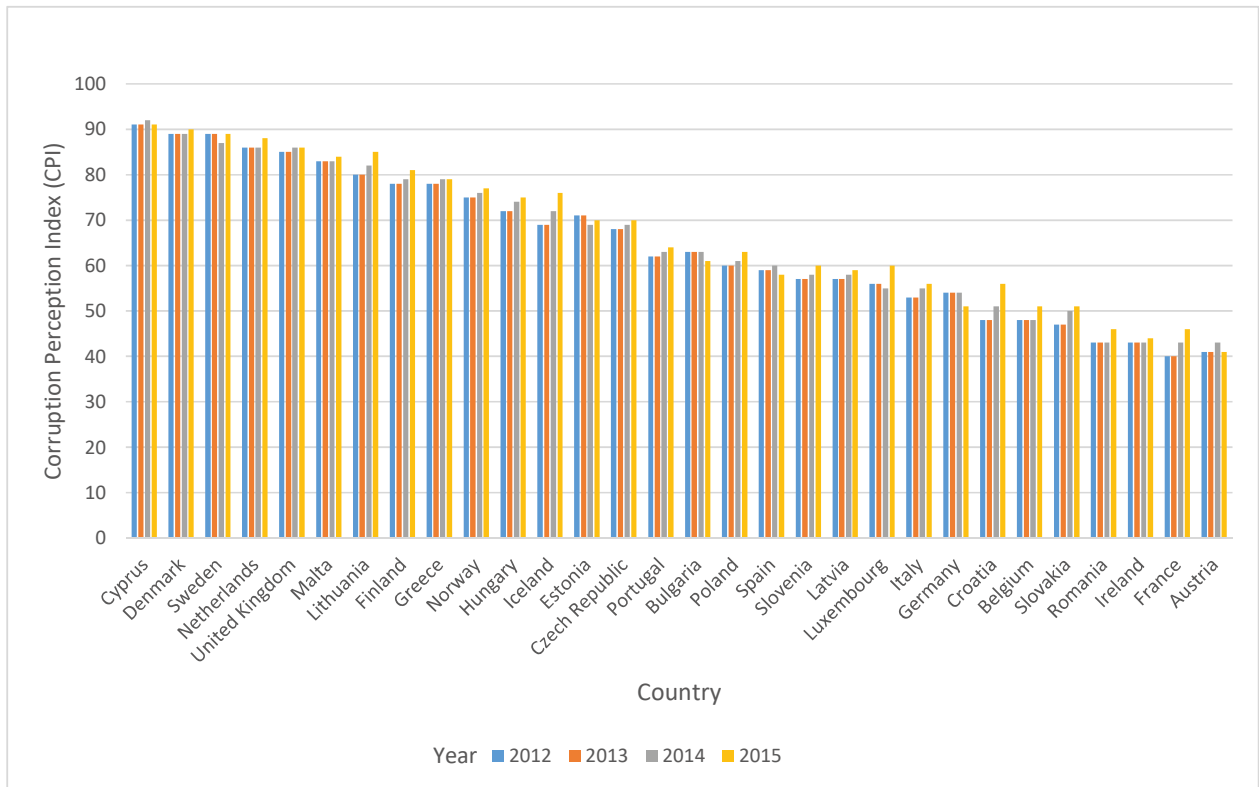


Figure 6.7: Corruption Perception Index (CPI)

Table 6.2 provides descriptive statistics of variables. Panel A describes the contract level variables. While the number of offers received, contract value and estimated value are positively skewed, the ratio between contract value and estimated value is roughly symmetrically distributed around the mean. The 95% confidence intervals for mean estimates are narrow, due to the large data size. For categorical variables, the number of observations in each category and the proportion of contracts that each category takes up are presented. Panel B is a summary of the country level variables for the 30 countries in the years 2012–2015.

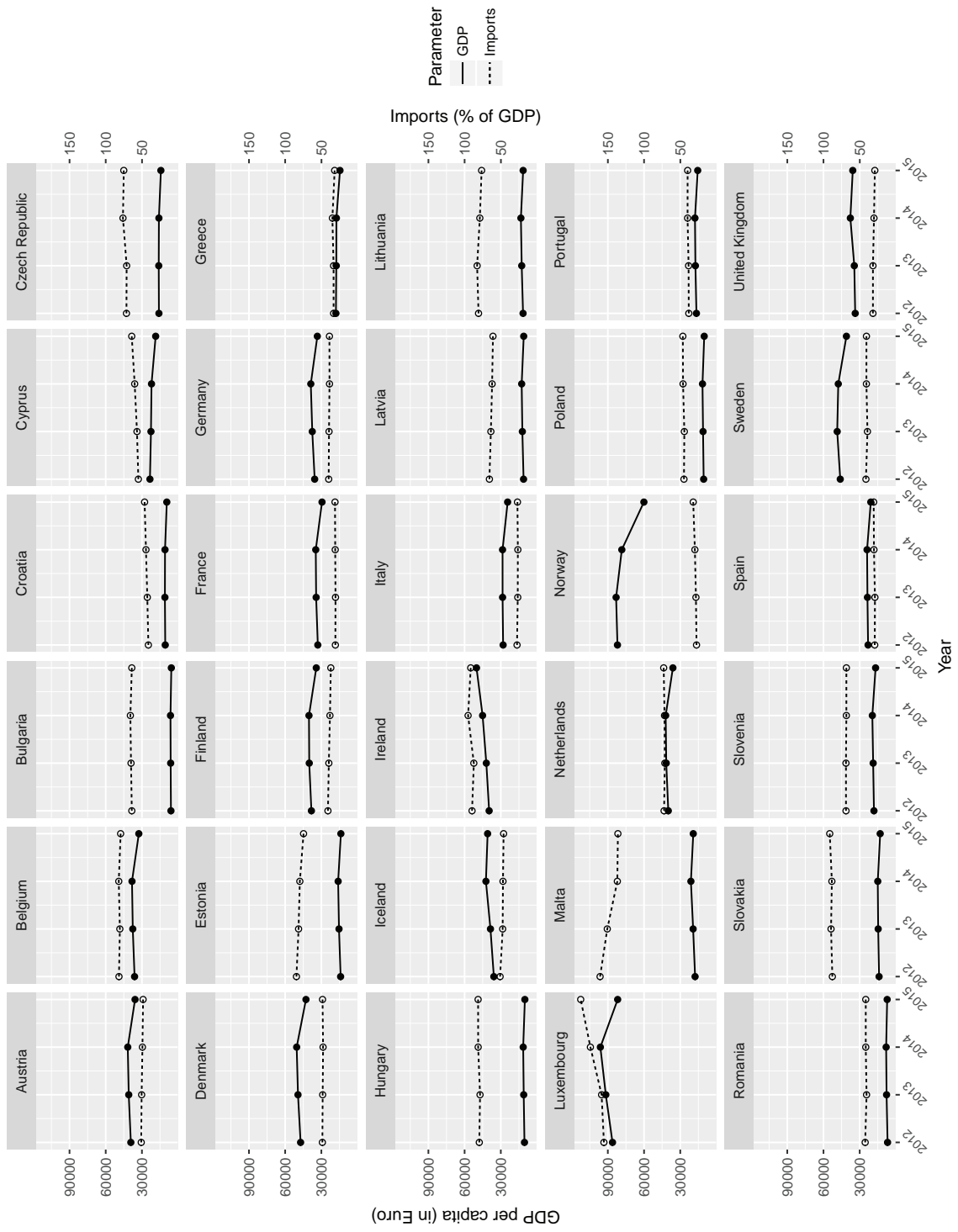


Figure 6.8: GDP and Imports (% of GDP)

Table 6.2: Descriptive Statistics

<i>Panel A: Contract Level Variables</i>					
<i>Continuous Variables</i>	No. of Obs.	Mean	CI (lower)	CI (upper)	S.D.
No. of offers received	343688	3.719	3.703	3.735	4.792
Contract value/Estimated value	323066	0.919	0.919	0.920	0.194
Contract value	343688	219940	218545	221335	417323
Estimated value	343688	263104.6	261473	264736	487926
	Min.	25th	50th	75th	Max.
No. of offers received	0	1	2	4	50
Contract value/Estimated value	0.374	0.833	0.980	1	2.191
Contract value	1749	10800	48445	222273	2906287
Estimated value	2062	12997	59418	270156	3634711
<i>Categorical Variables</i>	No. of Obs.	Proportion			
<i>Contract type</i>					
Works contract	16996	4.95%			
Services contract	112634	32.77%			
Supply contract	214058	62.28%			
All	343688	100.00%			
<i>Award mechanism</i>					
Open procedure	308891	89.88%			
Restricted procedure	10550	3.07%			
Competitive dialogue	240	0.07%			
Negotiated procedure	7032	2.05%			
Other procedures	16975	4.94%			
All	343688	100.00%			
<i>Criteria</i>					
Lowest price	217112	63.17%			
Most economically advantageous tender	126576	36.83%			
All	343688	100.00%			
<i>Panel B: Country Level Variables</i>					
	No. of Countries	Mean	CI (lower)	CI (upper)	S.D.
CPI	30	65.58	62.76	68.39	15.59
Population (million)	30	17.08	13.00	21.16	22.58
GDP per capita (€)	30	28585.47	25077.80	32093.15	19405.39
Imports (% of GDP)	30	61.08	55.17	66.98	32.66
	Min.	25th	50th	75th	Max.
CPI	40	53.75	63	79	92
Population (million)	0.32	2.95	7.87	16.82	80.98
GDP per capita (€)	5642.34	13913.23	22780.73	38866.66	96191.04
Imports (% of GDP)	26.45	39.19	48.97	77.06	187.47

Notes. “CI (lower)” and “CI (upper)” refer to the lower and upper bounds of the 95% confidence interval.

6.5 Results

6.5.1 Main Results

This section presents OLS estimates to examine how discretion and corruption are related to the number of bidders and price rebates. Because of data limitations, we are unable to adopt more advanced techniques to mitigate the problem of omitted variables (e.g. information transparency) and the potential reverse causality between award mechanisms and the number of bidders. Therefore, the empirical results should be viewed as exploratory.

Table 6.3 shows the estimates using the number of offers received (specifications (1), (2), (3)) and contract rebate (i.e. the ratio between contract value and estimated value) (specifications (4), (5), (6)) as the dependent variables.¹⁵ For each dependent variable, its linear relationship with CPI is tested when not controlling for and controlling for the year and country fixed effects. Specifications (2) and (5) are better fitted than specification (1) and (4) because all year dummies and the majority of country dummies are significant (not shown in the table) and R-squared statistics are greatly improved when controlling for the year and country fixed effects. Specification (2) shows that the number of offers received is positively related to CPI. It implies that every 10-score increase in CPI (less corrupt) is associated with 0.69 more number of bidders. No significant relationship between the contract rebat and CPI is found in specification (5).

Specifications (3) and (6) explore the non-linear relationships by introducing CPI^2 as an independent variable. CPI^2 is statistically significant in both specifications. The number of offers received is minimised at a CPI of 28 ($= -\frac{-0.112}{2 \times 0.002}$), *ceteris paribus*. Since the lowest CPI score in the data is 40, the results indicate all countries in this sample would experience increases in the number of bidders when the perceived corruption improves.

¹⁵It should be noted that the number of offers received is count data, which is concentrated from 1 to 10. Therefore, the residuals in OLS regressions may not be normally distributed and the estimates may be biased. Further work should formally test residual normality and/or apply the Poisson regression model when taking the number of offers received as the dependent variable.

Holding other variables fixed, an increase from the lowest CPI (40) to the mean CPI (66) predicts 1.76 more bidders; an increase from the lowest CPI (40) to the highest CPI (92) predicts a rise of 7.9 in the number of bidders; an increase from the mean CPI (66) to the highest CPI (92) predicts 6.1 more bidders. Both the linear and non-linear estimates lend credence to *Hypothesis 1*.

Specification (6) shows that contract rebate is the smallest at a CPI level of 50 ($= -\frac{-0.004}{2 \times 0.00004}$). Below this level, contract rebate decreases as CPI scores increases. Above this level, the positive relationship between contract rebate and CPI is contrary to *Hypothesis 2*. This implies that the increase in the final contract value from the estimated value is more substantial in countries that are deemed to be less corrupt.

Table 6.4 is to find out whether the contract value or the estimated value drives this discrepancy. Specifications (1) and (2) take the natural logarithm of the contract value as the dependent variable and take the natural logarithm of estimated value as the proxy for complexity. No significant relationship between CPI and contract value is found. Specifications (3) and (4) take the natural logarithm of estimated value as the dependent variable and control the natural logarithm of contract value for complexity. A significant non-linear relationship exhibits between CPI and estimated value. The model predicts that the estimated value increases as the CPI score approaches to 50 ($= -\frac{0.005}{2 \times (-0.00005)}$) from zero and decreases as the CPI score increases from 50. This result suggests that changes in the estimated value are likely to drive the rebate changes predicted by CPI.

Table 6.5 illustrates how the estimated value changes with the change in CPI for a contract with an average level of complexity (i.e. estimated value = €263,105), using a CPI of 50, the lowest CPI (40), the average CPI (66) and the highest CPI (92). For example, an increase in CPI from 40 to 50 corresponds to an increase of €1318.819 in the estimated value; an increase in CPI from 50 to 92 corresponds to a decrease of €22211.92 in the estimated value.

Table 6.3: OLS Regressions for the Number of Offers Received and Contract Rebate

	<i>Dependent variable:</i>					
	Number of offers received			Contract rebate (Contract value/Estimated value)		
	(1)	(2)	(3)	(4)	(5)	(6)
CPI ²			0.002*** (0.0004)			0.00004** (0.00002)
CPI	-0.019*** (0.001)	0.069*** (0.011)	-0.112*** (0.038)	-0.002*** (0.00005)	-0.00005 (0.0005)	-0.004** (0.002)
Award mechanism						
Negotiated procedure (B)						
Open procedure	0.353*** (0.057)	0.711*** (0.055)	0.710*** (0.055)	-0.029*** (0.002)	-0.028*** (0.002)	-0.028*** (0.002)
Restricted procedure	-0.201*** (0.073)	0.294*** (0.071)	0.294*** (0.071)	-0.021*** (0.003)	-0.016*** (0.003)	-0.016*** (0.003)
Competitive dialogue	-1.328*** (0.305)	-0.984*** (0.295)	-0.986*** (0.295)	-0.016 (0.013)	-0.017 (0.013)	-0.017 (0.013)
Other procedures	0.294*** (0.066)	-0.178*** (0.065)	-0.182*** (0.065)	0.034*** (0.003)	0.029*** (0.003)	0.029*** (0.003)
Quality criterion dummy	0.106*** (0.019)	-0.045** (0.020)	-0.057*** (0.020)	0.017*** (0.001)	0.008*** (0.001)	0.008*** (0.001)
Log contract value	-0.008 (0.005)	-0.041*** (0.005)	-0.040*** (0.005)	0.010*** (0.0002)	0.012*** (0.0002)	0.012*** (0.0002)
Population (million)	-0.038*** (0.001)	0.034 (0.044)	0.074* (0.045)	-0.001*** (0.00004)	0.001 (0.002)	0.002 (0.002)
Log GDP per capita	0.936*** (0.027)	0.795** (0.370)	0.787** (0.370)	0.032*** (0.001)	-0.005 (0.016)	-0.006 (0.016)
Imports (% of GDP)	-0.011*** (0.001)	0.124*** (0.009)	0.117*** (0.010)	-0.0001* (0.00005)	0.001 (0.0004)	0.0004 (0.0004)
Legal origin						
English common law (B)						
French civil law	-2.773*** (0.063)	2.509 (2.189)	6.603*** (2.338)	-0.132*** (0.003)	-0.102 (0.094)	-0.017 (0.101)
German civil law	-3.928*** (0.061)	0.569 (2.379)	5.131** (2.549)	-0.074*** (0.003)	-0.008 (0.102)	0.087 (0.110)
Nordic law	-4.289*** (0.091)	-0.582 (2.336)	1.213 (2.363)	-0.042*** (0.004)	0.061 (0.100)	0.100 (0.102)
Contract type						
Works contract (B)						
Services contract	-1.566*** (0.040)	-0.975*** (0.040)	-0.972*** (0.040)	0.007*** (0.002)	0.029*** (0.002)	0.029*** (0.002)
Supply contract	-2.294*** (0.040)	-1.668*** (0.040)	-1.668*** (0.040)	0.056*** (0.002)	0.081*** (0.002)	0.081*** (0.002)
Constant	2.890*** (0.268)	-12.001** (5.713)	-12.067** (5.713)	0.698*** (0.011)	0.836*** (0.245)	0.834*** (0.245)
Year	No	Yes	Yes	No	Yes	Yes
Country	No	Yes	Yes	No	Yes	Yes
Observations	343,688	343,688	343,688	323,066	323,066	323,066
Adjusted R ²	0.063	0.125	0.125	0.038	0.068	0.068
F Statistic	1,549.287***	1,113.505***	1,089.386***	855.042***	540.317***	528.440***

Note: (B) indicates the baseline category of each variable.

* p<0.1; ** p<0.05; *** p<0.01

Table 6.4: Predicting Contract Value and Estimated Value

	<i>Dependent variable:</i>			
	Log contract value		Log estimated value	
	(1)	(2)	(3)	(4)
CPI ²		0.00002 (0.00002)		-0.00005** (0.00002)
CPI	-0.0004 (0.001)	-0.003 (0.002)	0.0004 (0.001)	0.005** (0.002)
Award mechanism				
Negotiated procedure (B)				
Open procedure	-0.053*** (0.003)	-0.053*** (0.003)	0.035*** (0.003)	0.035*** (0.003)
Restricted procedure	-0.034*** (0.004)	-0.034*** (0.004)	0.027*** (0.004)	0.027*** (0.004)
Competitive dialogue	-0.020 (0.015)	-0.020 (0.015)	0.024 (0.015)	0.024 (0.015)
Other procedures	0.020*** (0.003)	0.020*** (0.003)	-0.036*** (0.003)	-0.036*** (0.003)
Quality criterion dummy	0.017*** (0.001)	0.017*** (0.001)	-0.012*** (0.001)	-0.012*** (0.001)
Log estimated value	0.996*** (0.0002)	0.996*** (0.0002)		
Log contract value			0.984*** (0.0002)	0.984*** (0.0002)
Population (million)	0.001 (0.002)	0.001 (0.002)	-0.002 (0.002)	-0.003 (0.002)
Log GDP per capita	-0.001 (0.019)	-0.002 (0.019)	0.015 (0.019)	0.015 (0.019)
Imports (% of GDP)	-0.0001 (0.0005)	-0.0002 (0.0005)	-0.001 (0.0005)	-0.0005 (0.0005)
Legal origin				
English common law (B)				
French civil law	-0.123 (0.112)	-0.071 (0.120)	0.111 (0.111)	0.006 (0.119)
German civil law	0.001 (0.122)	0.060 (0.131)	-0.015 (0.121)	-0.132 (0.130)
Nordic law	0.077 (0.119)	0.101 (0.121)	-0.102 (0.119)	-0.150 (0.120)
Contract type				
Works contract (B)				
Services contract	0.028*** (0.002)	0.028*** (0.002)	-0.037*** (0.002)	-0.038*** (0.002)
Supply contract	0.081*** (0.002)	0.081*** (0.002)	-0.106*** (0.002)	-0.106*** (0.002)
Constant	0.008 (0.292)	0.007 (0.292)	0.176 (0.290)	0.178 (0.290)
Year	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes
Observations	323,066	323,066	323,066	323,066
Adjusted R ²	0.986	0.986	0.986	0.986
F Statistic	501,068.300*** (df = 44; 323021)	489,934.200*** (df = 45; 323020)	504,578.700*** (df = 44; 323021)	493,373.600*** (df = 45; 323020)

Note: (B) indicates the baseline category of each variable.

*p<0.1; **p<0.05; ***p<0.01

Table 6.5: Changes in Estimated Value Predicted by Changes in CPI for a Contract with an Average Level of Complexity (Estimated Value = €263,105)

Change in CPI	Change in Log estimated value	Change in estimated value (€)
From 40 to 50	+0.005	+1318.819
From 50 to 66	-0.0128	-3346.282
From 50 to 92	-0.0882	-22211.92
From 66 to 92	-0.0754	-19108.67

We offer a potential explanation of these differences in elasticity. Usually, government agents would conceal their corrupt behaviours by inflating estimated values and budgets. A high contract price due to corruption is less noticeable and sounds more reasonable when it is compared with a high estimated value. However, very corrupt government agents tend not to bother to disguise their corruption because their corruption is well-known to the public.

According to the estimates for award mechanisms in Table 6.3, compared with the negotiated procedure, the open and restricted procedures imply more number of bidders and more price rebates. Moreover, the estimates for the open procedure are more significant than that for the restricted procedure. The quality criterion dummy, which indicates a higher discretion, is negatively related to the number of bidders and price rebates. These results are consistent with *Hypothesis 3* and *Hypothesis 4*. The competitive dialogue implies less number of bidders and perhaps more price rebates than the negotiated procedure.

6.5.2 Robustness Check

This subsection provides robustness tests, repeating the estimations disaggregated by contract type (Table 6.6). The three contract types are works, services and supply contracts.

Table 6.6: Robustness Check

	<i>Dependent variable:</i>					
	Works (1)	Number of offers received Services (2)	Supply (3)	Works (4)	Log estimated value Services (5)	Supply (6)
CPI2						
CPI	0.076** (0.032)	0.063*** (0.020)	0.132*** (0.015)	0.011 (0.009)	-0.004 (0.003)	0.016*** (0.003)
Award mechanism						
Negotiated procedure (B)						
Open procedure	1.013*** (0.216)	0.966*** (0.088)	0.089 (0.088)	0.069*** (0.011)	0.037*** (0.004)	0.015*** (0.005)
Restricted procedure	-3.401*** (0.270)	0.760*** (0.106)	-0.222** (0.109)	0.034*** (0.014)	0.035*** (0.005)	0.012** (0.006)
Competitive dialogue	-4.531*** (1.677)	-0.560 (0.404)	-1.101* (0.473)	0.005 (0.086)	0.017 (0.019)	0.048* (0.026)
Other procedures	-1.349*** (0.237)	0.037 (0.095)	-2.070*** (0.105)	-0.005 (0.012)	-0.048*** (0.005)	-0.030*** (0.006)
Quality criterion dummy	0.061 (0.103)	-0.246*** (0.037)	0.013 (0.023)	-0.001 (0.005)	-0.026*** (0.002)	-0.006*** (0.001)
Log contract value	0.319*** (0.026)	0.017* (0.010)	-0.005 (0.005)	0.987*** (0.001)	0.981*** (0.0005)	0.985*** (0.0003)
Population	-0.440** (0.201)	0.055 (0.074)	-0.185*** (0.061)	0.026** (0.013)	-0.002 (0.004)	-0.016*** (0.003)
Log GDP per capita	-9.823*** (2.131)	-0.150 (0.623)	0.592 (0.479)	0.013 (0.112)	0.053* (0.030)	-0.062** (0.026)
Imports (% of GDP)	-0.097** (0.043)	0.145*** (0.015)	-0.007 (0.013)	-0.005** (0.002)	0.002*** (0.001)	-0.002*** (0.001)
Legal origin						
English common law (B)						
French civil law	-36.858*** (10.532)	-1.079 (3.508)	-2.976 (3.047)	1.010 (0.698)	0.149 (0.178)	-0.729*** (0.178)
German civil law	-24.497*** (11.144)	2.033 (3.997)	-6.585*** (3.258)	1.190 (0.803)	-0.015 (0.203)	-0.850*** (0.190)
Nordic law	-29.249*** (10.622)	1.343 (3.953)	-11.660*** (3.259)	1.475** (0.660)	-0.169 (0.190)	-0.807*** (0.181)
Constant	135.232*** (30.223)	-5.612 (8.964)	0.765 (7.848)	-1.296 (1.560)	-0.231 (0.428)	1.525*** (0.433)
Year	Yes	Yes	Yes	Yes	Yes	Yes
Country	Yes	Yes	Yes	Yes	Yes	Yes
Observations	16,513	104,232	202,321	16,513	104,232	202,321
Adjusted R ²	0.208	0.174	0.118	0.974	0.982	0.985
F Statistic	104.018*** (df = 42; 16470)	522.206*** (df = 42; 104189)	647.356*** (df = 42; 202278)	14,425.950*** (df = 43; 16469)	132,169.700*** (df = 43; 104188)	318,414.000*** (df = 43; 202277)

Note: (B) indicates the baseline category of each variable.

*p<0.1; **p<0.05; ***p<0.01

Since the main tests show that the linear and non-linear models for the number of bidders generate consistent and similar results, we adopt the linear model in the robustness tests in order to facilitate comparison. The estimates for CPI are positive, which are consistent with the main estimates. The estimates for award mechanisms are consistent with the those in the main estimates, except for the estimate of the restricted procedure for services contracts. The reason for the difference may be that services contracts are more miscellaneous and the terms of services contracts are more difficult to be standardised than the other two contracts.

The non-linear model is used for testing the estimated value. Although the estimates of CPI for works contract have the same sign as the main estimates, they are not significant. This may be because a greater proportion of works contracts are of high value and more complicated ones, which are subjected to tight regulation and supervision. Thus, the room for discretionary decision is smaller. The CPI estimates for the services contracts are with the opposite sign and are not significant. This may also be explained by the great variation within the services contract. The estimates of CPI for the supply contracts, which are generally more standardised, are significant and consistent with the main tests. The estimates for award mechanisms are consistent with those in the main estimates.

6.6 Conclusions

This chapter explores the relationship between discretion, corruption and competition in public procurement. The chapter makes two contributions. The first is providing a simple theoretical framework for understanding the interaction between corruption, competition and the choice of award mechanism. Building on the *revenue equivalence theorem*, we propose a model that taking the willingness to accept bribes as endogenously determined. The model shows increasing bribes is a mechanism that transits discretion to corruption and that honest bidders are discouraged from participation due to lower expected profit. The conclusion from the model is in accordance with the literature on corruption and competition, i.e. discretion fosters corruption, which in turn depresses the

number of bidders and softens price competition.

The second contribution of this chapter is an exploratory analysis of the relationship between discretion, corruption and competition. Evidence of a negative correlation between the perceived corruption and the number of bidders is found. In an aggregate level, an increase of 10 in the Transparency International Corruption Perceptions Index (CPI) (an improvement of integrity) predicts one more bidder in the competition.

We also find evidence that the estimated value has a non-monotonic association with the CPI.¹⁶ This result suggests that procuring agents, who conduct procurement on behalf of procuring authorities, are likely to hide the impact of their corrupt behaviour on contract price by artificially increasing the estimated value. This relationship between CPI and the estimated value is most evident in supply contracts, which are more easily standardised and are less complicated than works and services contracts. At lower CPI levels, the estimated value increases while the CPI increases; at higher CPI levels, the estimated value decreases while the CPI increases. A responsible procuring agent is more likely to act for the social welfare and to work under a tighter budget. By contrast, very corrupt procuring agents do not bother to disguise their corruption and do not care much about the estimated value and the aftermaths of cost-overruns.

While this explanation indeed deserves to be tested more rigorously, it highlights the need to monitor the estimated value of contracts more carefully.

In addition, this study tests how discretion, measured by award mechanism and quality criterion dummy, is related to competition. The results generally support that discretion is negatively related to entry and rebates. Compared with the negotiated procedure, the open procedure is associated with a greater number of bidders and more contract rebates. The competitive dialogue is associated with fewer bidders but more contract rebates than the negotiated procedure. Award criteria that consider both quality and price is related to less number of offers and fewer rebates. Our finding is consistent with [Baldi et al. \(2016\)](#), partially different from [Hyytinen et al. \(2018\)](#), and in contrast to [Coviello et al.](#)

¹⁶[Méndez and Sepúlveda \(2006\)](#) identify a non-monotonic relationship between corruption and growth.

(2018).

This study has a number of limitations. First, in the theoretical analysis, all cases of our theoretical model consider only one potentially dishonest bidder. In reality, bribe competition among bidders can exist. In addition, the models do not allow for the possibility of a corrupt relationship, where bribes are paid on successive occasions, so more dynamic studies are called for. Second, the empirical analysis has several limitations due to data unavailability: it fails to include information barriers as an explanatory variable; a contract specific measure of corruption is better than the CPI; the price rebate is measured by contractual value, but the final payment may differ (significantly) from the contractual value. Third, we show empirical evidence that discretion and corruption are related to competition and price rebates. However, the empirical result is preliminary. More comprehensive works should be done to uncover the source and direction of causality regarding the relationship between discretion, corruption and competition.

Appendix: Extensive-Form Games

This Appendix reviews the representation of an extensive-form game, and the definitions of imperfect information game and incomplete information game. Our model proposed in Section 6.3 relies on these game theory fundamentals.

Unlike normal form games, extensive-form games contain a sequence of possible moves by players.¹⁷ Extensive-form games are usually represented by game trees. Their representation consist of five components:

1. A set of players;
2. Every opportunity for each player to move (i.e. node or decision point);
3. Types of the players and possible strategies or actions for each player at each node, driven by decision or nature;
4. The knowledge of each player at each node;
5. A set of payoff functions for each player given possible combinations of all players moves.

In a game of imperfect information, some players do not know the action chosen by other players, but they know the type of other players, other players' possible strategies or actions, and possible payoffs of other players. In a game of incomplete information, some players may not know the other players' type, possible strategies or payoffs. Therefore, a game of imperfect information imposes more stringent assumptions than a game of incomplete information.

The model proposed in Case 1 in Section 6.3.1 is a game of imperfect information. It describes a procurement in a world with a bidder and a procuring agent. Both the bidder and the procuring agent may behave dishonestly if offering or accepting bribes can

¹⁷References used for this subsection are [Jackson \(2013\)](#), [Osborne \(2004\)](#) and [Tadelis \(2013\)](#).

maximise their expected monetary payoffs. When deciding whether to offer a bribe, the bidder does not know whether the procuring agent would accept the bribe.

Case 2 in Section 6.3.2 is also a game of imperfect information. It describes a world with a potentially dishonest bidder, a potentially dishonest procuring agent and an honest bidder. The honest bidder has a very high cost of corruption which cannot be compensated by any payoffs generated by the misbehaviour. As a result, the honest bidder would never offer a bribe. Any information about which bidders have chosen to enter into the competition is kept confidential to the public before the outcome of the procurement is released. The potentially dishonest bidder and honest bidder essentially simultaneously make the decision of entering. Neither of the bidders knows whether the other has opted to participate in the tender. Also, neither of the two bidders knows whether the procuring agent would accept a bribe. However, the procuring agent knows which bidder(s) choose(s) to enter the competition and whether the potentially dishonest bidder offers a bribe.

Case 3 in Section 6.3.3 is a game of incomplete information. It is a world with a potentially dishonest bidder, a potentially dishonest procuring agent and more than one honest bidders. No honest bidder can recognise the potentially dishonest bidder. Neither do they know whether the potentially dishonest bidder chooses to enter the competition or whether the potentially dishonest bidder chooses to offer a bribe. No honest bidder knows which other honest bidder would enter the competition. The potentially dishonest bidder does not know which honest bidder would choose to enter the competition. None of the bidders know the procuring agent's choice of accepting a bribe. The procuring agent knows which bidder(s) choose(s) to enter the competition and whether a bribe is offered by the potentially dishonest bidder. The distribution of the type of honest bidders is common knowledge.

Chapter 7

Conclusions

Public procurement has attracted increasing interest of both researchers and practitioners, because of its economic significance and because of concerns about saving public money and improving social welfare. Public buyers implement award mechanisms to select contractors, so the features of award mechanisms play an important role in procurement performance.

This thesis exploits the Tenders Electronic Daily (TED), a publically available EU-wide database on public procurement that has not been used in many previous research papers. The EU complies with the award mechanism classification and publication requirements of the World Trade Organisation Agreement on Government Procurement (WTO GPA), applied by 88 WTO member countries to promote international competition in public procurement. The EU applies four benchmark award mechanisms, i.e. the open procedure, the restricted procedure, the negotiated procedure and the competitive dialogue.

The thesis analyses the application of the four EU benchmark award mechanisms and their associated procurement outcomes. The thesis contains three separate but interrelated studies with each focusing on one stage of the procurement process.

The first study in this thesis (Chapter 4) focuses on the initiation stage, when a public buyer has to decide the process for purchase (i.e. the award mechanism), before it publicises the procurement. Based on UK data, this study analyses the factors that are related to public buyer's tendency in choosing a particular award mechanism. Our results generally agree with the award mechanism design theory that higher entry costs and ex

post renegotiation costs call for more discretion (e.g. prequalification and negotiation) in awarding complex contracts with a low level of completeness and that auctions are more suitable for simple contracts that are easy to be specified ([Albano et al., 2017](#), [Ehrman and Peters, 1994](#), [McAfee and McMillan, 1988](#), [Tadelis and Bajari, 2006](#)).

The results also show that public buyers, when facing complex contracts, rely more on the negotiated procedure and competitive dialogue, which allow for both prequalification and negotiation, than the restricted procedure, which allows for prequalification only. The results imply that public buyers tend not to differentiate the competitive dialogue from the negotiated procedure or treat the restricted procedure differently from the open procedure, when considering only contract complexity. However, public buyers use the competitive dialogue only occasionally and have tended to use the restricted procedure less frequently over time. The reasons underlying this fact deserve further exploration.

In addition, our results reveal that accumulating experience makes public buyers use the open and negotiated procedures more frequently than the other two procedures. This is probably because public buyers become more skillful in reducing costs in running an open procedure and in bargaining to extract surplus ([Bajari et al., 2008](#)).

The second study in this thesis (Chapter 5) tests the factors related to award decision speed. It focuses on the period from announcing a purchasing intention to awarding a contract. Practitioners and policymakers tend to take the negotiation as a very time-consuming process without offering convincing evidence ([Lynch, 2015](#), [UK National Audit Office, 2007](#), [Yescombe, 2007](#)). UK public procurement data exhibit results that do not agree with this conventional wisdom. The negotiated procedure is likely to be associated with more rapid decisions than the restricted procedure regarding the duration of the overall award process, the probability of delaying award, and the duration of delay. The competitive dialogue performs the worst in terms of these three decision speed measures, while the open procedure performs the best. The results indicate that bureaucratic delays arise from internal organisational reasons rather than the process of negotiation may be

responsible for a slow award procedure.¹

The negotiated procedure endows the procuring agent with high discretion throughout the whole procedure, whereas the restricted procedure allows high discretion during the prequalification but limits discretion thereafter. Transferring from a discretion-permissible stage to a discretion-forbidden stage may incur excessive bureaucratic procedures. [Bandiera et al. \(2009\)](#) also express their concerns about such bureaucratic process in procurement.

Moreover, the results show that a slower award decision speed is associated with the need to evaluate more bids, greater complexity and higher quality concerns. This highlights the need to allow for more time in awarding contracts with such features. Also, the results suggest that the public buyers may be increasingly over-confident as they accumulate more experience. This implies that more experienced public buyers should consider adopting more conservative time schedules for awarding contracts.

Based on the revenue equivalence theorem and the extensive form game, the third study (Chapter 6) develops a model to show how corruption is positively related to discretion and how honest bidders are driven out by corruption-led discretion. Although many studies acknowledge the link between discretion and corruption, few of them has shown the link in a formal model.

This third study also assesses the procurement outcomes when an award process is completed. In particular, it examines the links between discretion, corruption and competition. The majority of studies on public procurement focus on the connections between discretion and competition because corruption, especially corruption in the contract level, is difficult to quantify (e.g. [Spagnolo, 2012](#), [Baldi et al., 2016](#)). We partially overcome this problem by analysing public contracts in 30 European countries from 2012 to 2015 and adopting corruption perception index (CPI, provided by Transparency International), a

¹Both the negotiated procedure and competitive dialogue contain a negotiation process, but the competitive dialogue has an additional competitive bidding process. Neither the open procedure nor the restricted procedure allows negotiation, but the restricted procedure contains an additional prequalification process.

measure for country level corruption. Our regressions that simultaneously include discretion and corruption show a significant negative correlation between the corruption level and the number of bidders. The results also suggest that corrupt procuring agents tend to artificially increase the estimated contract value to conceal the inflated contractual price.

The estimates for discretion are consistent with the estimates for corruption. The negotiated procedure, which allows for more discretion than the open procedure, corresponds to fewer bidders and smaller contract rebates than the open procedure. It is unclear whether the restricted procedure attracts more bidders than the negotiated procedure. The rebate from the restricted procedure is smaller than that from the open procedure. Compared with the negotiated procedure, the competitive dialogue tends to receive fewer offers. These two award mechanisms do not differ significantly in rebates.

This thesis has a number of implications for practitioners and policymakers:

First, the simpler versions of auction and negotiation, i.e. the open and negotiated procedures, seem to perform better in saving time during the award process and in obtaining higher rebates. This is in accord with the increasing use of the open procedure (see Figure 2.4). However, public authorities should probably consider using the negotiated procedure more often. Also, it may be necessary to diagnose any redundant administrative process in implementing the restricted procedure and the competitive dialogue.

Second, this thesis provides theoretical and empirical evidence that corruption is a nonnegligible concern in public procurement. Reducing trade barriers and allowing firms free access to bid in public procurement contracts in foreign countries is likely not only to improve the integration of the single market but also to increase competition and mitigate corruption.

Third, it highlights that delay is an important issue in awarding public procurement contract. The literature has expressed concerns about the lengthy award process in public-private partnership (PPP) contract, the complicated and expensive public contracts. This thesis puts forward that delay in the awarding process can be a serious issue for all public

contracts (even for contracts with small values). Nearly half of the contracts in our UK sample experienced delays in awarding. Public buyers should adopt more reasonable time schedules for awarding contracts and take measures to meet the schedule.

Future research may extend from this thesis from the following dimensions:

First, the results from this thesis indicate that the more complicated auction and negotiation versions, i.e. the restricted procedure and the competitive dialogue, perform worse than their simpler counterparts, i.e. the open procedure and the negotiated procedure, regarding the process outcome (i.e. award decision speed) and ex ante economic outcome (i.e. contractual price). Future research may investigate whether the ex post economic outcomes (i.e. final payment, quality and delivery time) justify the use of the restricted procedure and the competitive dialogue.

Second, empirical research on corruption in public procurement is still scarce and measuring corruption and discretion separately will generate more accurate results. Future studies may construct contract specific corruption index, for example, using the difference between the market value of the purchase and the price paid (e.g. [Coviello et al., 2018](#)), or conduct questionnaire to survey firms that have participated in the bidding.

Third, while this thesis underlines the problem of delaying contract award, it has not provided a very clear solution to this problem. Future research may investigate the role of over-confidence in the award process and the factors that can predict a reliable time schedule for awarding contracts or speed up the award process.

Lastly, it calls for further exploiting details in public procurement data. For example, most studies in the literature focus on works contracts as a whole but sector-specific attributes may exist. The common procurement vocabulary (CPV) may be a proper sector indicator, but to group the CPVs into sectors requires careful subjective judgements.

Bibliography

- Ades, A. and Di Tella, R. (1999), ‘Rents, competition, and corruption’, *The American Economic Review* **89**(4), 982–993.
- Ahsan, K. and Gunawan, I. (2010), ‘Analysis of cost and schedule performance of international development projects’, *International Journal of Project Management* **28**(1), 68–78.
- Akerlof, G. A. (1970), ‘The market for lemons: quality uncertainty and the market mechanism’, *The Quarterly Journal of Economics* **84**(3), 488–500.
- Aktas, N., De Bodt, E. and Roll, R. (2008), ‘Negotiation under the threat of an auction: friendly deals, ex-ante competition and bid premiums’, *SSRN eLibrary*.
- Albano, G. L., Buccirosi, P., Spagnolo, G. and Zanza, M. (2006), Preventing collusion in procurement, in N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of procurement’, Cambridge University Press, chapter 14, pp. 347–380.
- Albano, G. L., Cesi, B. and Iozzi, A. (2017), ‘Public procurement with unverifiable quality: The case for discriminatory competitive procedures’, *Journal of Public Economics* **145**, 14–26.
- Albano, G. L., Dimitri, N., Pacini, R. and Spagnolo, G. (2006), Information and competitive tendering, in N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of procurement’, Cambridge University Press, chapter 6, pp. 143–167.
- Allison, P. D. (1982), ‘Discrete-time methods for the analysis of event histories’, *Sociological Methodology* **13**, 61–98.
- Amaral, M., Saussier, S. and Yvrande-Billon, A. (2009), ‘Auction procedures and competition in public services: The case of urban public transport in France and London’, *Utilities Policy* **17**(2), 166–175.
- Anderson, P. A. (1983), ‘Decision making by objection and the Cuban missile crisis’, *Administrative Science Quarterly* pp. 201–222.
- Asker, J. and Cantillon, E. (2008), ‘Properties of scoring auctions’, *The RAND Journal of Economics* **39**(1), 69–85.
- Asker, J. and Cantillon, E. (2010), ‘Procurement when price and quality matter’, *The Rand Journal of Economics* **41**(1), 1–34.
- Assaf, S. A. and Al-Hejji, S. (2006), ‘Causes of delay in large construction projects’, *International Journal of Project Management* **24**(4), 349–357.
- Bailey, M. J. and Rubin, P. H. (1994), ‘A positive theory of legal change’, *International Review of Law and Economics* **14**(4), 467–477.
- Bajari, P., Houghton, S. and Tadelis, S. (2014), ‘Bidding for incomplete contracts: An empirical analysis of adaptation costs’, *American Economic Review* **104**(4), 1288–1319.

- Bajari, P., McMillan, R. and Tadelis, S. (2008), ‘Auctions versus negotiations in procurement: an empirical analysis’, *Journal of Law, Economics, and Organization* **25**(2), 372–399.
- Bajari, P. and Tadelis, S. (2001), ‘Incentives versus transaction costs: a theory of procurement contracts’, *RAND Journal of Economics* pp. 387–407.
- Baldi, S., Bottasso, A., Conti, M. and Piccardo, C. (2016), ‘To bid or not to bid: that is the question: public procurement, project complexity and corruption’, *European Journal of Political Economy* **43**, 89–106.
- Baldwin, R. E. (1970), *Nontariff distortions of international trade*, Brookings Institution.
- Baldwin, R. E. (1984), ‘Trade policies in developed countries’, *Handbook of International Economics* **1**, 571–619.
- Bandiera, O., Prat, A. and Valletti, T. (2009), ‘Active and passive waste in government spending: evidence from a policy experiment’, *American Economic Review* **99**(4), 1278–1308.
- Baum, J. and Wally, S. (2003), ‘Strategic decision speed and firm performance’, *Strategic Management Journal* **24**(11), 1107–1129.
- Bayens, B. and Martell, M. (2007), ‘Budget and organization reform: impact on public procurement in Belgium’, *Public Procurement: International Case and Commentary*, Routledge, London .
- Beck, T. and Levine, R. (2002), ‘Industry growth and capital allocation:: does having a market-or bank-based system matter?’, *Journal of Financial Economics* **64**(2), 147–180.
- Becker, G. S. (1994), Human capital revisited, in ‘Human Capital: A Theoretical and Empirical Analysis with Special Reference to Education (3rd Edition)’, The University of Chicago Press, pp. 15–28.
- Becker, G. S. and Stigler, G. J. (1974), ‘Law enforcement, malfeasance, and compensation of enforcers’, *The Journal of Legal Studies* **3**(1), 1–18.
- Bennett, J. and Iossa, E. (2006), ‘Building and managing facilities for public services’, *Journal of Public Economics* **90**(10-11), 2143–2160.
- Bentz, A., Grout, P. and Halonen, M. (2005), What should governments buy from the private sector – assets or services?, Technical report, mimeo, University of Bristol.
- Berle, A. A. and Means, G. G. C. (1991), *The Modern Corporation and Private Property*, Transaction Publishers.
- Besley, T. and Ghatak, M. (2001), ‘Government versus private ownership of public goods’, *The Quarterly Journal of Economics* **116**(4), 1343–1372.
- Bliss, C. and Di Tella, R. (1997), ‘Does competition kill corruption?’, *Journal of Political Economy* **105**(5), 1001–1023.
- Blume, L. E. and Rubinfeld, D. L. (1982), ‘The dynamics of the legal process’, *The Journal of Legal Studies* **11**(2), 405–419.

- Board, S. (2011), ‘Relational contracts and the value of loyalty’, *American Economic Review* **101**(7), 3349–67.
- Bourgeois, L. J. and Eisenhardt, K. M. (1988), ‘Strategic decision processes in high velocity environments: Four cases in the microcomputer industry’, *Management Science* **34**(7), 816–835.
- Branco, F. (1997), ‘The design of multidimensional auctions’, *The RAND Journal of Economics* pp. 63–81.
- Brennan, G. and Buchanan, J. M. (1980), ‘The power to tax’, *Cambridge Books* .
- Brown, T. L., Potoski, M. and Slyke, D. V. (2016), ‘Managing complex contracts: A theoretical approach’, *Journal of Public Administration Research and Theory* **26**(2), 294–308.
- Bulow, J. and Klemperer, P. (1996), ‘Auctions versus negotiations’, *The American Economic Review* **86**(1), 180–194.
- Bulow, J. and Klemperer, P. (2009), ‘Why do sellers (usually) prefer auctions?’, *The American Economic Review* **99**(4), 1544–1575.
- Burguet, R. and Che, Y.-K. (2004), ‘Competitive procurement with corruption’, *RAND Journal of Economics* pp. 50–68.
- Caldwell, N., Walker, H., Harland, C., Knight, L., Zheng, J. and Wakeley, T. (2005), ‘Promoting competitive markets: the role of public procurement’, *Journal of Purchasing and Supply Management* **11**(5), 242–251.
- Calzolari, G. and Spagnolo, G. (2009), ‘Relational contracts and competitive screening’.
- Cameron, L. J. (2000), ‘Limiting buyer discretion: effects on performance and price in long-term contracts’, *American Economic Review* **90**(1), 265–281.
- Capen, E. C., Clapp, R. V., Campbell, W. M. et al. (1971), ‘Competitive bidding in high-risk situations’, *Journal of petroleum technology* **23**(06), 641–653.
- Celentani, M. and Ganuza, J.-J. (2002), ‘Corruption and competition in procurement’, *European Economic Review* **46**(7), 1273–1303.
- Che, Y.-K. (1993), ‘Design competition through multidimensional auctions’, *The RAND Journal of Economics* pp. 668–680.
- Chipman, J. S. (1960), ‘The foundations of utility’, *Econometrica: Journal of the Econometric Society* pp. 193–224.
- Chong, E., Staropoli, C. and Yvrande-Billon, A. (2012), Auctions versus negotiations in public procurement: the implication of political scrutiny, in ‘CInSt Workshop Public Procurement: Current Research Trends, HSE’.
- Chong, E., Staropoli, C. and Yvrande-Billon, A. (2014), ‘Auction versus negotiation in public procurement: Looking for empirical evidence’, *The Manufacturing Markets, Legal, Political and Economic Dynamics* pp. 120–142.

- Claessens, S. and Laeven, L. (2003), ‘Financial development, property rights, and growth’, *The Journal of Finance* **58**(6), 2401–2436.
- Compte, O., Lambert Mogiliansky, A. and Verdier, T. (2005), ‘Corruption and competition in procurement auctions’, *Rand Journal of Economics* pp. 1–15.
- Coviello, D., Guglielmo, A. and Spagnolo, G. (2018), ‘The effect of discretion on procurement performance’, *Management Science* .
- Coviello, D. and Mariniello, M. (2014), ‘Publicity requirements in public procurement: Evidence from a regression discontinuity design’, *Journal of Public Economics* **109**, 76–100.
- Cox, D. R. (1992), Regression models and life-tables, *in* ‘Breakthroughs in Statistics’, Springer, pp. 527–541.
- Cox, J. C., Isacc, R. M., Cech, P.-A. and Conn, D. (1996), ‘Moral hazard and adverse selection in procurement contracting’, *Games and Economic Behavior* **17**(2), 147–176.
- Cripps, M. and Ireland, N. (1994), ‘The design of auctions and tenders with quality thresholds: the symmetric case’, *The Economic Journal* pp. 316–326.
- Crook, R. C. and Sverrisson, A. S. (1999), ‘To what extent can decentralized forms of government enhance the development of pro-poor policies and improve poverty-alleviation outcomes?’. Background paper for the 2000 World Development Report. Washington, DC: World Bank.
- Cushing, C. and Cushing, B. (2007), Conditional logit, iia, and alternatives for estimating models of interstate migration, *in* ‘Annual Meeting of the Southern Regional Science Association. Charleston, SC’.
- D’Aveni, R. A., Dagnino, G. B. and Smith, K. G. (2010), ‘The age of temporary advantage’, *Strategic Management Journal* **31**(13), 1371–1385.
- David, R. and Brierley, J. E. (1978), *Major legal systems in the world today: an introduction to the comparative study of law*, Simon and Schuster.
- Davoodi, H. and Tanzi, V. (2002), Corruption, growth, and public finances, *in* ‘The Political Economy of Corruption’, Routledge, pp. 101–122.
- Debreu, G. (1960), ‘Review of R.D. Luce individual choice behavior’, *American Economic Review* **50**, 193–224.
- Decarolis, F. (2014), ‘Awarding price, contract performance, and bids screening: evidence from procurement auctions’, *American Economic Journal: Applied Economics* **6**(1), 108–32.
- Della Porta, D. and Vannucci, A. (1999), *Corrupt exchanges: actors, resources, and mechanisms of political corruption*, Transaction Publishers.
- Dellarocas, C., Dini, F. and Spagnolo, G. (2006), Designing reputation mechanisms, *in* N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of Procurement’, Cambridge University Press, chapter 18, pp. 446–482.

- Deloitte (2016), ‘Procurement: Cfos right hand in managing costs, risks and more’, *The Wall Street Journal*. December 14, 2016.
- Demirgüç-Kunt, A. and Maksimovic, V. (1998), ‘Law, finance, and firm growth’, *The Journal of Finance* **53**(6), 2107–2137.
- Demirgüç-Kunt, A. and Maksimovic, V. (1999), ‘Institutions, financial markets, and firm debt maturity’, *Journal of Financial Economics* **54**(3), 295–336.
- Dewatripont, M. and Legros, P. (2005), ‘Public-private partnerships: contract design and risk transfer’, *EIB Papers* **10**(1), 120–145.
- Diaby, A. and Sylwester, K. (2015), ‘Corruption and market competition: evidence from post-communist countries’, *World Development* **66**, 487–499.
- Dimitri, N., Dini, F. and Piga, G. (2006), When should procurement be centralized?, in N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of procurement’, Cambridge University Press, chapter 3, pp. 47–81.
- Dini, F., Pacini, R. and Valletti, T. (2006), Scoring rules, in N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of Procurement’, Cambridge University Press, chapter 12, pp. 293–321.
- Djankov, S., La Porta, R., Lopez-de Silanes, F. and Shleifer, A. (2002), ‘The regulation of entry’, *The Quarterly Journal of Economics* **117**(1), 1–37.
- Djankov, S., McLiesh, C., Klein, M. U. et al. (2004), *Doing business in 2004: understanding regulation*, Vol. 1, World Bank Publications.
- Dougherty, C. (2007), *Introduction to Econometrics*, Oxford University Press.
- Duhaime, I. M. and Schwenk, C. R. (1985), ‘Conjectures on cognitive simplification in acquisition and divestment decision making’, *Academy of Management Review* **10**(2), 287–295.
- Easley, D. and Kleinberg, J. (2010), *Networks, crowds, and markets: reasoning about a highly connected world*, Cambridge University Press.
- Eastin, R. V. and Arbogast, G. L. (2014), Demand and supply analysis: introduction, in CFA Institute, ed., ‘2015 CFA Level I Volume 2 Economics’, Wiley Global Finance.
- Ehrman, C. and Peters, M. (1994), ‘Sequential selling mechanisms’, *Economic Theory* **4**(2), 237–253.
- Eisenhardt, K. M. (1989), ‘Making fast strategic decisions in high-velocity environments’, *Academy of Management Journal* **32**(3), 543–576.
- Eklöf, M. (2005), ‘Assessing social costs of inefficient procurement design’, *Journal of the European Economic Association* **3**(4), 826–850.
- Elbanna, S. and Child, J. (2007), ‘Influences on strategic decision effectiveness: development and test of an integrative model’, *Strategic Management Journal* **28**(4), 431–453.
- Engelbrecht-Wiggans, R. (1993), ‘Optimal auctions revisited’, *Games and Economic Behavior* **5**(2), 227–239.

- Engelbrecht-Wiggans, R., Milgrom, P. R. and Weber, R. J. (1983), ‘Competitive bidding and proprietary information’, *Journal of Mathematical Economics* **11**(2), 161–169.
- Europe Economics (2011), ‘Estimating the benefits from the procurement directives—a report for dg internal market’, http://ec.europa.eu/internal_market/publicprocurement/docs/modernising_rules/estimating-benefits-procurement-directives_en.pdf.
- European Commission (2008), ‘Guide to the common procurement vocabulary (cpv)’, https://simap.ted.europa.eu/documents/10184/36234/cpv_2008_guide_en.pdf.
- European Commission (2017a), ‘Single market scoreboard: Public procurement’, http://ec.europa.eu/internal_market/scoreboard/performance_per_policy_area/public_procurement/index_en.htm. Online; accessed 6 June 2018.
- European Commission (2017b), ‘Ted advanced notes’, <https://data.europa.eu/euodp/en/data/dataset/ted-csv>.
- European Parliament and European Council (2004), ‘Directive 2004/18/ec’, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32004L0018>.
- European Parliament and European Council (2009), ‘Directive 2009/81/ec’, <http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1524817915478&uri=CELEX:32009L0081>.
- European Parliament and European Council (2014a), ‘Directive 2014/23/eu’, <http://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1524817589147&uri=CELEX:32014L0023>.
- European Parliament and European Council (2014b), ‘Directive 2014/24/eu’, <http://eur-lex.europa.eu/legal-content/GA/TXT/?uri=celex:32014L0024>.
- European Parliament and European Council (2014c), ‘Directive 2014/25/eu’, <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32014L0025>.
- Evenett, S. J. and Hoekman, B. M. (2005), ‘Government procurement: market access, transparency, and multilateral trade rules’, *European Journal of Political Economy* **21**(1), 163–183.
- Fan, C. S., Lin, C. and Treisman, D. (2009), ‘Political decentralization and corruption: Evidence from around the world’, *Journal of Public Economics* **93**(1), 14–34.
- Federal acquisition regulation, 48 C.F.R. (US)* (2002), <https://www.gpo.gov/fdsys/search/pagedetails.action?collectionCode=CFR&searchPath=Title+48%2FChapter+1%2FSubchapter+C%2FPart+13&granuleId=&packageId=CFR-2002-title48-vol1&oldPath=Title+48%2FChapter+1%2FSubchapter+C&fromPageDetails=true&collapse=true&yrcord=2100>.
- Fisman, R. and Gatti, R. (2002), ‘Decentralization and corruption: evidence across countries’, *Journal of Public Economics* **83**(3), 325–345.
- Flyvbjerg, B., Bruzelius, N. and Rothengatter, W. (2003), *Megaprojects and risk: an anatomy of ambition*, Cambridge University Press.

- Forbes, D. P. (2005), 'Managerial determinants of decision speed in new ventures', *Strategic Management Journal* **26**(4), 355–366.
- Fox, J. (2015), *Applied regression analysis and generalized linear models*, Sage Publications.
- Fredrickson, J. W. and Iaquinto, A. L. (1989), 'Inertia and creeping rationality in strategic decision processes', *Academy of Management Journal* **32**(3), 516–542.
- Fredrickson, J. W. and Mitchell, T. R. (1984), 'Strategic decision processes: comprehensiveness and performance in an industry with an unstable environment', *Academy of Management journal* **27**(2), 399–423.
- French, K. R. and McCormick, R. E. (1984), 'Sealed bids, sunk costs, and the process of competition', *Journal of Business* pp. 417–441.
- Galbraith, J. R. (1977), *Organization design*, Addison Wesley Publishing Company.
- Ganuza, J.-J. (2007), 'Competition and cost overruns in procurement', *The Journal of Industrial Economics* **55**(4), 633–660.
- Glaeser, E. L. and Shleifer, A. (2002), 'Legal origins', *The Quarterly Journal of Economics* **117**(4), 1193–1229.
- Goldberg, V. P. (1977), 'Competitive bidding and the production of precontract information', *The Bell Journal of Economics* pp. 250–261.
- Gori, G. F., Lattarulo, P. and Mariani, M. (2017), 'Understanding the procurement performance of local governments: A duration analysis of public works', *Environment and Planning C: Politics and Space* **35**(5), 809–827.
- Grimsey, D. and Lewis, M. K. (2002), 'Evaluating the risks of public private partnerships for infrastructure projects', *International Journal of Project Management* **20**(2), 107–118.
- Grossman, S. J. and Hart, O. D. (1986), 'The costs and benefits of ownership: A theory of vertical and lateral integration', *Journal of Political Economy* **94**(4), 691–719.
- Grout, P. A. (1997), 'The economics of the private finance initiative', *Oxford Review of Economic Policy* **13**(4), 53–66.
- Guccio, C., Pignataro, G. and Rizzo, I. (2012), 'Determinants of adaptation costs in procurement: an empirical estimation on italian public works contracts', *Applied Economics* **44**(15), 1891–1909.
- Gumpert, D. E. and Stevenson, H. (1985), 'The heart of entrepreneurship', *Harvard Business Review* **63**(2), 85–94.
- Harris, M. and Raviv, A. (1981), 'Allocation mechanisms and the design of auctions', *Econometrica: Journal of the Econometric Society* pp. 1477–1499.
- Hart, O. (1995), *Firms, Contracts, and Financial Structure*, Clarendon Press.
- Hart, O. (2003), 'Incomplete contracts and public ownership: remarks, and an application to public-private partnerships', *The Economic Journal* **113**(486), C69–C76.

- Hart, O. and Moore, J. (1990), ‘Property rights and the nature of the firm’, *Journal of Political Economy* **98**(6), 1119–1158.
- Hattori, T. (2010), ‘Determinants of the number of bidders in the competitive procurement of electricity supply contracts in the Japanese public sector’, *Energy Economics* **32**(6), 1299–1305.
- Hayek, F. A. (2013), *The constitution of liberty: the definitive edition*, Vol. 17, Routledge.
- Hayes, J. R. (1981), *The complete problem solver*, Routledge.
- Hitt, M. A. and Tyler, B. B. (1991), ‘Strategic decision models: Integrating different perspectives’, *Strategic Management Journal* **12**(5), 327–351.
- Holland, J. H. (2014), *Complexity: a very short introduction*, Oxford University Press.
- Holt, C. A. (1979), ‘Uncertainty and the bidding for incentive contracts’, *The American Economic Review* **69**(4), 697–705.
- Holt, C. A. (1980), ‘Competitive bidding for contracts under alternative auction procedures’, *Journal of Political Economy* **88**(3), 433–445.
- Hosmer, D. W., Lemeshow, S. and Sturdivant, R. X. (2013), *Applied logistic regression*, Vol. 398, John Wiley & Sons.
- Hyttinen, A., Lundberg, S. and Toivanen, O. (2018), ‘Design of public procurement auctions: Evidence from cleaning contracts’, *The RAND Journal of Economics* **49**(2), 398–426.
- Iossa, E. and Legros, P. (2004), ‘Auditing and property rights’, *Rand Journal of Economics* pp. 356–372.
- Iossa, E. and Martimort, D. (2012), ‘Risk allocation and the costs and benefits of public–private partnerships’, *The RAND Journal of Economics* **43**(3), 442–474.
- Jackson, M. O. (2013), ‘Matching, auctions, and market design’.
- Jin, J. and Zou, H.-f. (2002), ‘How does fiscal decentralization affect aggregate, national, and subnational government size?’, *Journal of Urban Economics* **52**(2), 270–293.
- Johnson, S., Boone, P., Breach, A. and Friedman, E. (2000), ‘Corporate governance in the Asian financial crisis’, *Journal of Financial Economics* **58**(1), 141–186.
- Judge, W. Q. and Miller, A. (1991), ‘Antecedents and outcomes of decision speed in different environmental context’, *Academy of Management Journal* **34**(2), 449–463.
- Jullien, B. (2006), Pricing and other business strategies for e-procurement platforms, in N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of procurement’, Cambridge University Press, chapter 10, pp. 249–266.
- Kagel, J. H. and Levin, D. (1986), ‘The winner’s curse and public information in common value auctions’, *The American Economic Review* pp. 894–920.
- Kalbfleisch, J. D. and Prentice, R. L. (2011), *The statistical analysis of failure time data*, Vol. 360, John Wiley & Sons.

- Kaplan, S. N. and Strömberg, P. (2003), ‘Financial contracting theory meets the real world: an empirical analysis of venture capital contracts’, *The Review of Economic Studies* **70**(2), 281–315.
- Keen, P. G. (1988), *Competing in time: using telecommunications for competitive advantage*, Harper Business.
- Kenny, C. and Crisman, B. (2016), ‘Results through transparency: Does publicity lead to better procurement?’.
- Klein, B. and Leffler, K. B. (1981), ‘The role of market forces in assuring contractual performance’, *Journal of Political Economy* **89**(4), 615–641.
- Kleinbaum, D. G. and Klein, M. (2012), *Survival analysis: a self-learning text*, Springer Science & Business Media.
- Kleinbaum, D. and Klein, M. (2010), *Logistic regression: a self learning text*, Springer Science & Business Media.
- Klemperer, P. (2002), ‘What really matters in auction design’, *The Journal of Economic Perspectives* **16**(1), 169–189.
- Knack, S., Biletska, N. and Kacker, K. (2017), ‘Deterring kickbacks and encouraging entry in public procurement markets: evidence from firm surveys in 88 developing countries’, <http://documents.worldbank.org/curated/en/817871496169519447/Deterring-kickbacks-and-encouraging-entry-in-public-procurement-markets-evidence-f> World Bank Working Paper.
- La Porta, R., Lopez-de Silanes, F. and Shleifer, A. (2002), ‘Government ownership of banks’, *The Journal of Finance* **57**(1), 265–301.
- La Porta, R., Lopez-de Silanes, F. and Shleifer, A. (2008), ‘The economic consequences of legal origins’, *Journal of Economic Literature* **46**(2), 285–332.
- La Porta, R., Lopez-de Silanes, F., Shleifer, A. and Vishny, R. (1999), ‘The quality of government’, *The Journal of Law, Economics, and Organization* **15**(1), 222–279.
- La Porta, R., Lopez-de Silanes, F., Shleifer, A. and Vishny, R. W. (1997), ‘Legal determinants of external finance’, *The Journal of Finance* **52**(3), 1131–1150.
- La Porta, R., Lopez-de Silanes, F., Shleifer, A. and Vishny, R. W. (1998), ‘Law and finance’, *Journal of Political Economy* **106**(6), 1113–1155.
- Lædre, O., Austeng, K., Haugen, T. I. and Klakegg, O. J. (2006), ‘Procurement routes in public building and construction projects’, *Journal of Construction Engineering and Management* **132**(7), 689–696.
- Laffont, J.-J. and N’Guessan, T. (1999), ‘Competition and corruption in an agency relationship’, *Journal of Development Economics* **60**(2), 271–295.
- Laffont, J.-J. and Tirole, J. (1993), *A theory of incentives in procurement and regulation*, MIT press.
- Lambert-Mogiliansky, A. and Sonin, K. (2006), ‘Collusive market sharing and corruption in procurement’, *Journal of Economics & Management Strategy* **15**(4), 883–908.

- Langley, A. (1989), 'In search of rationality: the purposes behind the use of formal analysis in organizations', *Administrative Science Quarterly* pp. 598–631.
- Lengwiler, Y. and Wolfstetter, E. (2006), Corruption in procurement auctions, *in* N. Dimitri, G. Piga and G. Spagnolo, eds, 'Handbook of Procurement', Cambridge University Press, chapter 16, pp. 412–429.
- Lessmann, C. and Markwardt, G. (2010), 'One size fits all? decentralization, corruption, and the monitoring of bureaucrats', *World Development* **38**(4), 631–646.
- Levine, R. (1998), 'The legal environment, banks, and long-run economic growth', *Journal of Money, Credit and Banking* pp. 596–613.
- Levine, R. (1999), 'Law, finance, and economic growth', *Journal of Financial Intermediation* **8**(1), 8–35.
- Lewis, G. and Bajari, P. (2011), 'Procurement contracting with time incentives: theory and evidence', *The Quarterly Journal of Economics* **126**(3), 1173–1211.
- Loader, K. (2013), 'Is public procurement a successful small business support policy? a review of the evidence', *Environment and Planning C: Government and Policy* **31**(1), 39–55.
- Lord, R. G. and Maher, K. J. (1990), 'Alternative information-processing models and their implications for theory, research, and practice', *Academy of Management Review* **15**(1), 9–28.
- Love, P. E., Sing, C., Wang, X., Edwards, D. J. and Odeyinka, H. (2013), 'Probability distribution fitting of schedule overruns in construction projects', *Journal of the Operational Research Society* **64**(8), 1231–1247.
- Luce, R. D. (2005), *Individual choice behavior: A theoretical analysis*, Courier Corporation.
- Lynch, J. (2015), '8 causes of delays in the public procurement process and how to avoid them', <https://procurementclassroom.com/causes-of-delays-in-public-procurement/>. Viewed 10 November 2017.
- Mahoney, P. G. (2001), 'The common law and economic growth: Hayek might be right', *The Journal of Legal Studies* **30**(2), 503–525.
- Makadok, R. (1998), 'Can first-mover and early-mover advantages be sustained in an industry with low barriers to entry/imitation?', *Strategic Management Journal* pp. 683–696.
- Manelli, A. M. and Vincent, D. R. (1995), 'Optimal procurement mechanisms', *Econometrica: Journal of the Econometric Society* pp. 591–620.
- March, J. G., Olsen, J. P., Christensen, S. and Cohen, M. D. (1976), *Ambiguity and choice in organizations*, Universitetsforlaget Bergen.
- Mas-Colell, A., Whinston, M. D., Green, J. R. et al. (1995), *Microeconomic theory*, Vol. 1, Oxford university press New York.

- Maskin, E. and Riley, J. (2000), 'Asymmetric auctions', *The Review of Economic Studies* **67**(3), 413–438.
- Maskin, E. S. and Riley, J. G. (1985), 'Auction theory with private values', *The American Economic Review* **75**(2), 150–155.
- Mathews, T. (2004), 'The impact of discounting on an auction with a buyout option: A theoretical analysis motivated by ebays buy-it-now feature', *Journal of Economics* **81**(1), 25–52.
- Mathews, T. and Katzman, B. (2006), 'The role of varying risk attitudes in an auction with a buyout option', *Economic Theory* **27**(3), 597–613.
- Mauro, P. (1995), 'Corruption and growth', *The Quarterly Journal of Economics* **110**(3), 681–712.
- McAfee, R. P. and McMillan, J. (1986), 'Bidding for contracts: a principal-agent analysis', *The RAND Journal of Economics* pp. 326–338.
- McAfee, R. P. and McMillan, J. (1987a), 'Auctions and bidding', *Journal of Economic Literature* **25**(2), 699–738.
- McAfee, R. P. and McMillan, J. (1987b), 'Auctions with entry', *Economics Letters* **23**(4), 343–347.
- McAfee, R. P. and McMillan, J. (1988), 'Search mechanisms', *Journal of Economic Theory* **44**(1), 99–123.
- McAfee, R. P. and McMillan, J. (1989), 'Government procurement and international trade', *Journal of International Economics* **26**(3-4), 291–308.
- Méndez, F. and Sepúlveda, F. (2006), 'Corruption, growth and political regimes: Cross country evidence', *European Journal of Political Economy* **22**(1), 82–98.
- Méon, P.-G. and Sekkat, K. (2005), 'Does corruption grease or sand the wheels of growth?', *Public Choice* **122**(1), 69–97.
- Milgrom, P. R. (1981), 'Rational expectations, information acquisition, and competitive bidding', *Econometrica: Journal of the Econometric Society* pp. 921–943.
- Milgrom, P. R. and Weber, R. J. (1982), 'A theory of auctions and competitive bidding', *Econometrica: Journal of the Econometric Society* pp. 1089–1122.
- Miller, R. (1981), 'Survival analysis. john willey & sons', *Inc. waterloo. Ontario: Canada* .
- Mintzberg, H., Raisinghani, D. and Theoret, A. (1976), 'The structure of "unstructured" decision processes', *Administrative science quarterly* pp. 246–275.
- Montinola, G. R. and Jackman, R. W. (2002), 'Sources of corruption: a cross-country study', *British Journal of Political Science* **32**(1), 147–170.
- Morck, R., Yeung, B. and Yu, W. (2000), 'The information content of stock markets: why do emerging markets have synchronous stock price movements?', *Journal of Financial Economics* **58**(1), 215–260.

- Myerson, R. B. (1981), 'Optimal auction design', *Mathematics of Operations Research* **6**(1), 58–73.
- Nadler, D. A. and Tushman, M. L. (1999), 'The organization of the future: Strategic imperatives and core competencies for the 21st century', *Organizational Dynamics* **28**(1), 45–60.
- Odeh, A. M. and Battaineh, H. T. (2002), 'Causes of construction delay: traditional contracts', *International Journal of Project Management* **20**(1), 67–73.
- Osborne, M. J. (2004), *An introduction to game theory*, Vol. 3, Oxford University Press.
- Papadakis, V. M., Lioukas, S. and Chambers, D. (1998), 'Strategic decision-making processes: the role of management and context', *Strategic Management Journal* **19**(2), 115–147.
- Payne, J. W., Bettman, J. R. and Johnson, E. J. (1988), 'Adaptive strategy selection in decision making.', *Journal of Experimental Psychology: Learning, Memory, and Cognition* **14**(3), 534.
- Perlow, L. A., Okhuysen, G. A. and Repenning, N. P. (2002), 'The speed trap: exploring the relationship between decision making and temporal context', *Academy of Management Journal* **45**(5), 931–955.
- Pfeffer, J. (1981), *Power in organizations*, Vol. 33, Pitman Marshfield, MA.
- Pfeffer, J. (1994), 'Competitive advantage through people', *California Management Review* **36**(2), 9–28.
- Pfeffer, J. and Sutton, R. I. (2013), *The knowing-doing gap: how smart companies turn knowledge into action*, Harvard Business Press.
- Pickard, J. (2017), 'Smes locked out of state contracts, says labour', *Financial Times* . December 28, 2017.
- Plimmer, G. (2016), 'Government wasting billions on procurement', *Financial Times* . March 7, 2016.
- Prentice, R. L. and Gloeckler, L. A. (1978), 'Regression analysis of grouped survival data with application to breast cancer data', *Biometrics* pp. 57–67.
- Priest, G. L. (1977), 'The common law process and the selection of efficient rules', *The Journal of Legal Studies* **6**(1), 65–82.
- Pugh, D. S., Hickson, D. J., Hinings, C. R. and Turner, C. (1968), 'Dimensions of organization structure', *Administrative Science Quarterly* pp. 65–105.
- Rajagopalan, N., Rasheed, A. M. and Datta, D. K. (1993), 'Strategic decision processes: critical review and future directions', *Journal of Management* **19**(2), 349–384.
- Reeves, E., Palcic, D. and Flannery, D. (2015), 'PPP procurement in ireland: An analysis of tendering periods', *Local Government Studies* **41**(3), 379–400.
- Reeves, E., Palcic, D., Flannery, D. and Geddes, R. R. (2017), 'The determinants of tendering periods for ppp procurement in the uk: an empirical analysis', *Applied Economics* **49**(11), 1071–1082.

- Reynolds, S. S. and Wooders, J. (2009), 'Auctions with a buy price', *Economic Theory* **38**(1), 9–39.
- Riley, J. G. and Samuelson, W. F. (1981), 'Optimal auctions', *The American Economic Review* **71**(3), 381–392.
- Riley, J. and Zeckhauser, R. (1983), 'Optimal selling strategies: When to haggle, when to hold firm', *The Quarterly Journal of Economics* pp. 267–289.
- Romer, P. (1994), 'New goods, old theory, and the welfare costs of trade restrictions', *Journal of Development Economics* **43**(1), 5–38.
- Rose-Ackerman, S. (1975), 'The economics of corruption', *Journal of Public Economics* **4**(2), 187–203.
- Rose-Ackerman, S. (1978), *Corruption: a study in political economy*, Academic Press.
- Rubin, P. H. (1977), 'Why is the common law efficient?', *The Journal of Legal Studies* **6**(1), 51–63.
- Rubin, P. H. (1982), 'Common law and statute law', *The Journal of Legal Studies* **11**(2), 205–223.
- Sambasivan, M. and Soon, Y. W. (2007), 'Causes and effects of delays in Malaysian construction industry', *International Journal of Project Management* **25**(5), 517–526.
- Samuelson, W. F. (1985), 'Competitive bidding with entry costs', *Economics Letters* **17**(1-2), 53–57.
- Schmidt, K. M. (1996), 'The costs and benefits of privatization: an incomplete contracts approach', *Journal of Law, Economics, and Organization* **12**(1), 1–24.
- Schmidt, P. and Witte, A. D. (1989), 'Predicting criminal recidivism using split populationsurvival time models', *Journal of Econometrics* **40**(1), 141–159.
- Schoenfeld, D. (1982), 'Partial residuals for the proportional hazards regression model', *Biometrika* **69**(1), 239–241.
- Schweiger, D. M., Sandberg, W. R. and Ragan, J. W. (1986), 'Group approaches for improving strategic decision making: A comparative analysis of dialectical inquiry, devil's advocacy, and consensus', *Academy of Management Journal* **29**(1), 51–71.
- Schwenk, C. R. (1983), 'Laboratory research on ill-structured decision aids: the case of dialectical inquiry', *Decision Sciences* **14**(1), 140–144.
- Shankar, V., Carpenter, G. S. and Krishnamurthi, L. (1998), 'Late mover advantage: how innovative late entrants outsell pioneers', *Journal of Marketing Research* pp. 54–70.
- Shepherd, N. G. and Rudd, J. M. (2014), 'The influence of context on the strategic decision-making process: a review of the literature', *International Journal of Management Reviews* **16**(3), 340–364.
- Shleifer, A. and Vishny, R. W. (1993), 'Corruption', *The Quarterly Journal of Economics* **108**(3), 599–617.

- Shrivastava, P. and Grant, J. H. (1985), ‘Empirically derived models of strategic decision-making processes’, *Strategic Management Journal* **6**(2), 97–113.
- Siemonsma, H., Van Nus, W. and Uyttendaele, P. (2012), ‘Awarding of port ppp contracts: the added value of a competitive dialogue procedure’, *Maritime Policy & Management* **39**(1), 63–78.
- Siggelkow, N. and Rivkin, J. W. (2005), ‘Speed and search: designing organizations for turbulence and complexity’, *Organization Science* **16**(2), 101–122.
- Singer, J. D. and Willett, J. B. (2003), *Applied longitudinal data analysis: modeling change and event occurrence*, Oxford University Press.
- Smith, B. C. (1985), *Decentralization: the territorial dimension of the state*, Allen & Unwin London.
- Spagnolo, G. (2012), ‘Reputation, competition, and entry in procurement’, *International Journal of Industrial Organization* **30**(3), 291–296.
- Spaniel, W. (2014), ‘Game theory 101: Bargaining’, <https://www.amazon.co.uk/Game-Theory-101-William-Spaniel-ebook/dp/BOOMTW6L5K>.
- Spence, M. (1973), ‘Job market signaling’, *The Quarterly Journal of Economics* pp. 355–374.
- Stigler, G. J. (1964), ‘A theory of oligopoly’, *Journal of political Economy* **72**(1), 44–61.
- Swaleheen, M. (2011), ‘Economic growth with endogenous corruption: an empirical study’, *Public Choice* **146**(1-2), 23–41.
- Tadelis, S. (2012), ‘Public procurement design: lessons from the private sector’, *International Journal of Industrial Organization* **30**(3), 297–302.
- Tadelis, S. (2013), *Game theory: an introduction*, Princeton University Press.
- Tadelis, S. and Bajari, P. (2006), Incentives and award procedures: competitive tendering vs. negotiations in procurement, in N. Dimitri, G. Piga and G. Spagnolo, eds, ‘Handbook of Procurement’, Cambridge University Press, chapter 5, pp. 121–139.
- Thaler, R. H. (1988), ‘Anomalies: The winner’s curse’, *The Journal of Economic Perspectives* **2**(1), 191–202.
- The government procurement law of the People’s Republic of China* (2002), http://www.npc.gov.cn/englishnpc/Law/2007-12/06/content_1382108.htm.
- Train, K. E. (2009), *Discrete choice methods with simulation*, Cambridge University Press.
- Treisman, D. (2000), ‘The causes of corruption: a cross-national study’, *Journal of Public Economics* **76**(3), 399–457.
- Trionfetti, F. (2000), ‘Discriminatory public procurement and international trade’, *The World Economy* **23**(1), 57–76.

- Tucker, C. and Gilfillan, B. (2014), 'Public procurement in south africa: overview', [https://uk.practicallaw.thomsonreuters.com/Document/I2ef128af1ed511e38578f7ccc38dcbee/View/FullText.html?transitionType=SearchItem&contextData=\(sc.Default\)](https://uk.practicallaw.thomsonreuters.com/Document/I2ef128af1ed511e38578f7ccc38dcbee/View/FullText.html?transitionType=SearchItem&contextData=(sc.Default)).
- UK National Audit Office (2007), 'Improving the pfi tendering process', <https://www.nao.org.uk/report/improving-the-pfi-tendering-process/#>.
- UK National Audit Office (2010), 'Nao report: Procurement of the m25 private finance contract', <https://www.nao.org.uk/wp-content/uploads/2010/11/1011566.pdf>.
- Uyarra, E. and Flanagan, K. (2010), 'Understanding the innovation impacts of public procurement', *European Planning Studies* **18**(1), 123–143.
- Van den Hurk, M. and Verhoest, K. (2015), 'The governance of public–private partnerships in sports infrastructure: Interfering complexities in belgium', *International Journal of Project Management* **33**(1), 201–211.
- Verbeek, M. (2008), *A guide to modern econometrics*, John Wiley & Sons.
- Vickrey, W. (1961), 'Counterspeculation, auctions, and competitive sealed tenders', *The Journal of finance* **16**(1), 8–37.
- Vickrey, W. (1962), 'Auctions and bidding games', *Recent Advances in Game Theory* **29**, 15–27.
- Wally, S. and Baum, J. R. (1994), 'Personal and structural determinants of the pace of strategic decision making', *Academy of Management journal* **37**(4), 932–956.
- Williams, R. (2000), *The politics of corruption series*, Edward Elgar Publishing.
- Williamson, O. E. (1971), 'The vertical integration of production: market failure considerations', *The American Economic Review* **61**(2), 112–123.
- Williamson, O. E. (1976), 'Franchise bidding for natural monopolies-in general and with respect to catv', *The Bell Journal of Economics* pp. 73–104.
- Wooldridge, J. (2009), *Introductory econometrics: a modern approach*, Nelson Education.
- Wooldridge, J. M. (2010), *Econometric analysis of cross section and panel data*, MIT Press.
- World Bank Group (2017), 'Doing business 2017: equal opportunity for all', <http://www.doingbusiness.org/~media/WBG/DoingBusiness/Documents/Annual-Reports/English/DB17-Report.pdf>.
- World Trade Organisation (2012), 'Agreement on government procurement', https://www.wto.org/english/docs_e/legal_e/rev-gpr-94_01_e.htm.
- Wurgler, J. (2000), 'Financial markets and the allocation of capital', *Journal of Financial Economics* **58**(1), 187–214.
- Yescombe, E. R. (2007), *Public-private partnerships: principles of policy and finance*, Butterworth-Heinemann.