Optimising the National Threshold Value in Public Procurement

An Analysis of the Effects of the Influential Factors on Costs and Gains for Buyers and Suppliers who Participate in the Public and Invited Tender Procedures

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Preface

This thesis is submitted as a final product for the completion of the master education in Business Administration with a specialisation of Purchasing and Supply Management at University of Twente.

The basis for this research was initiated by prof. dr. Jan Telgen from his idea to improve the decision-making process in regard to setting the threshold value for contracts below the European Union threshold. This idea was supported with a great enthusiasm by me as I was triggered to contribute with an empirical research to one of the most important decisions made by public authorities. Even though I was completely new to the complex and unique world of public procurement, it fully enthralled me. As a result, the complete process of the thesis was a pleasure and went in one breath.

In fact, a successfully completion of this thesis could not be achieved without a strong support group. I would like to thank prof. dr. Jan Telgen for his guidance throughout the whole process and priceless feedback. Also, I would like to express my gratitude to dr. ir. Fredo Schotanus for providing me valuable comments and suggestions. Lastly, special thank you to my family and loved ones for their enduring belief in me, unconditional love, support and words of wisdom.

— Anastasija Sergejcuka

Summary

One of the possible ways for public authorities to achieve an efficient and effective spending of public money is by making the right choice about which tendering procedure to apply for a certain contract. For contracts below the European Union (EU) threshold, such decision is extremely relevant as they are responsible for a large amount of public spending and outweigh the contracts above the EU threshold by both number and overall value. Unfortunately, such decision is not straightforward as it is affected by multiple aspects such as a trade-offs of various gains and costs, numerous factors that have an influence on these costs and gains, and multiple stakeholders. What makes the tender threshold problem even more complicated is the fact that there is little empirical research, as well as empirical practical approaches.

In this study we aim to remedy the above-described problem by developing a framework, which provides a data-driven methodology to determine the most beneficial contract value for setting the threshold value that will separate the public from the invited procedure. In this research, the public procedure is referred to a procedure which allows participation of all interested suppliers in a tender that is publicly available. On the other hand, the invited procedure consists of 2–5 suppliers that are invited to submit their quotes.

With this research, we contribute to existing literature by studying costs and gains associated with public procurement. We found that there is no unanimous decision on a fixed amount of costs and gains incurred during the public procurement, nor on a method for their calculation. Moreover, we acknowledged that the public procedure is 2–3 times more expensive than the invited procedure for buyers and around 3.5 times more expensive for suppliers. Interestingly, the most cost-consuming stage within the procurement delivery chain for buyers is "pre-award", which implies such activities as identification of needs, formulation of purchasing strategy choice of the procedure, etc. Buyers within the public procedure devote around 50 % of all costs to this stage, while in the invited procedure this percentage is slightly lower, namely 40 %. Contrary to buyers, the most expensive stage for suppliers is the proposal, during which they formalise a method for the proposal, calculate costs, produce administrative documentation, etc. Suppliers, participating in the public procedure, spend around 60 % of costs on this stage, while suppliers within the invited procedure — 50 %.

Another important theoretical contribution is an exhaustive list of direct and indirect influential factors on costs and gains, which is based on expert opinions and a systematic

literature review. The factor, which outweighed other factors by frequency of mentions and that has an influence not only on costs and gains for buyers, but also on costs for suppliers, is the number of bidders. Other important influential factors which we selected based on the extent to which they vary per national procedure and can be quantified are: in the category of costs for buyers — time needed to prepare a tender, administration and regulation, project size and such indirect psychological factors as fear of legal issues and avoidance of mistakes; in the category of gains for buyers — innovation, integrity and multi-nationality of suppliers, type of procedure, aggregation of purchases and new suppliers; and in the category of costs for suppliers — procedure length/complexity.

In order to contribute to the practice of efficient spending of public resources, we developed a mathematical framework, which allows to determine the most beneficial contract value for setting the national threshold value with data of any complexity. Additionally, we collected quantitative results from the existing literature of the most important factors and used them in our developed framework to get an insight in the effects of the selected factors on the different procedures and the threshold value. Based on the deployment of the decision framework, we conclude that both the differential costs and gains, calculated as difference between costs/gains of the public procedure and of the invited procedure, show an increase over contract values; however, gains increase more rapidly than costs. As a result, based on the differential method, the public procedure will be the preferred procedure starting from relatively low contact values. Moreover, the extension of the decision framework with the effects on costs for suppliers, which together with buyers is regarded as the "society", did not show any significant changes in the function of differential costs. Therefore, when buyers make a decision in regard to the contract value for the most beneficial threshold, they simultaneously optimise the threshold value for the entire society. Naturally, these examples further help in following a similar approach by any organisation with their most relevant data so that a tailor-made optimum can be found with our mathematical framework.

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List of Abbreviations

Notation	Description	Page List
ACP	additional costs of purchasing	13
ETQ	economic tender quantity	23
EU	European Union	1–4, 6–8, 11, 16, 24–26, 30, 31, 42, 54, 68, 78, 83
FTE	full time equivalent	12, 63
GDP	gross domestic product	1, 17, 21
MEAT	most economically advantageous tender	79, 91
OJEU	Official Journal of the European Union	4
PPP	public-private partnerships	30
RFP	request for proposal	28, 66
SCM	standard cost model	12
SME	small- and medium-sized enterprise	2, 8, 17
TCA	total cost of acquisition	14
TCE	transaction cost economics	11, 13, 14, 67
TCO	total cost of ownership	11, 14
TED	Tenders Electronic Daily	4

List of Nomenclature

Notation	Description	Page List
B_v^i	Overall benefit (gains minus costs) of the invited procedure (i) dependent of contract value v	26, 27
B_v^p	Overall benefit (gains minus costs) of the public procedure (p) dependent of contract value v	26, 27
$C_{s,f,v}^i$	Costs of stakeholder s for factor f at contract value v that apply to the invited procedure (i)	25
$C_{s,f,v}^p$	Costs of stakeholder s for factor f at contract value v that apply to the public procedure (p)	25
E	Threshold value of the European Union (EU) that separates the national procedure from the EU procedure	24, 26
$G_{s,f,v}^p$	Gains of stakeholder s for factor f at contract value v that apply to the invited procedure (i)	24
$G_{s,f,v}^p$	Gains of stakeholder s for factor f at contract value v that apply to the public procedure (p)	24
T	National threshold value that separates the public and invited procedures	24, 25
T^*	Optimal national threshold value (that yields the greatest overall benefit) that separates the public and invited procedures	25, 27
ΔC_v	Difference between the costs of the public procedure (p) and the invited procedure (i) dependent of contract value v	27
ΔG_v	Difference between the gains of the public procedure (p) and the invited procedure (i) dependent of contract value v	27
$\mathcal{F}$	Set of factors f that affect costs and/or gains	24
$\mathcal{S}$	Set of stakeholders s	24
$\mathcal{V}$	Set of contract values v	24

Notation	Description	Page List
$f(v)$	Probability density function of contract values $v \in \mathcal{V}$	24–27

Chapter 1

Introduction

1.1 Introduction to public procurement in Europe

Public procurement is seen as an important strategic tool for governments. Most evidently, in the modern world economy, the state is the largest customer and consumer of the products produced in different sectors (Smotritskaya, Anchishkina & Chernykh, 2017). For instance, in the European Union (EU) over 250 000 governmental organisations spend around 14 % of the gross domestic product (GDP) on public procurement of services, works and supplies per year (European Commission, 2017). While in developing countries this number is estimated to reach 15–20 % of GDP and up to 50 % or more of the total government expenditure (World Bank Group, 2015). However, governmental organisations frequently experience pressure from the higher-level authorities to cut public spending at both national and local levels (de Boer & Telgen, 1998). Therefore, procurement's role in public organisations is crucial for achieving main policy objectives such as efficient spending and budget accountability (Gurría, 2017), and for ensuring quality in governmental services (PIANOo, 2017).

Amongst different strategic purchasing decisions that public authorities need to make, an important decision is regarding purchasing processes. Purchasing processes cover different levels and areas of purchasing decision making. For instance, such decisions not only concern *within* purchasing process decisions like choices about initial purchases and operational purchasing, but also decisions *about* purchasing processes (de Boer et al., 2000). One of such decisions involves determining the tender procedure, which is of vital importance not only for buyers, but also for potential suppliers. The reason is that such decision always incorporates a trade-off of various gains and costs associated with different national procedures. Therefore, choosing a certain contract value that acts as a threshold to separate these national procedures possesses a high impact.

The main difficulty associated with the determination of the most beneficial threshold lies within the fact that there exist numerous factors which affect costs and gains of various tender procedures. Heretofore, only a modest attention was provided to studies regarding the

establishment of the optimal threshold (Chever, Saussier & Yvrande-Billon, 2017). Not to mention that none of the studies were devoted to provide an all-encompassing list of factors that influence costs and gains within the procurement processes.

In this study we attempt to approach this multidimensional problem and to contribute to the development of a decision framework which will help to determine the most beneficial contract value for setting the national threshold. In particular, we look closer at the influential quantifiable factors for buyers and suppliers associated with the national procedures to determine the optimal trade-off between costs and gains.

1.2 The regulation of public procurement contracts

To briefly introduce the regulation of public procurement contracts, three levels of legislative regulation, namely worldwide, EU and national level, are described. On the most global level, the requirements refer to the World Trade Organisation agreement (Loskutnikova & Kuperus, 2017). Regulations for public businesses in Europe are set by the EU, which specifies how purchasing processes should be organised. These regulations are then translated into national laws and concern tenders with the monetary value exceeding a particular amount, i.e. a threshold. The threshold is determined depending on the domain to which it belongs.

A further distinction for below-EU threshold contracts is prevalent across the EU Member States. Such contracts are characterised as tenders for which simplified and less rigorous procedures apply and which are regulated on the national level. Additionally, they are not covered by the procedural requirements of the EU Public Procurement Directive (OECD, 2011). Nevertheless, general principles of EU law of non-discrimination, transparency and proportionality and Treaty rules and principles still need to be respected for such public contracts (Broerse, Peelen, Vis & Norton Rose Fulbright LLP, 2013).

1.2.1 Importance of contracts below the EU threshold

According to a recent report by the Organisation for Economic Co-operation and Development (OECD, 2010), the contracts below the EU threshold represent a significant share of total procurement and even outweigh the contracts above the EU threshold by both number and overall value (Strand, Ramada & Canton, 2011). Therefore, the majority of public contracts are awarded by following national rules, policies and procedures (OECD, 2011). Moreover, contracts falling below the EU threshold are of great importance for businesses in the Internal Market, especially for small- and medium-sized enterprises (SMEs) (OECD, 2010).

Since the importance of contracts falling below the EU threshold is apparent, below-threshold procurement processes should be effective and execute the most efficient usage of public money (OECD, 2011). Interestingly, due to the country-wide diversity and different

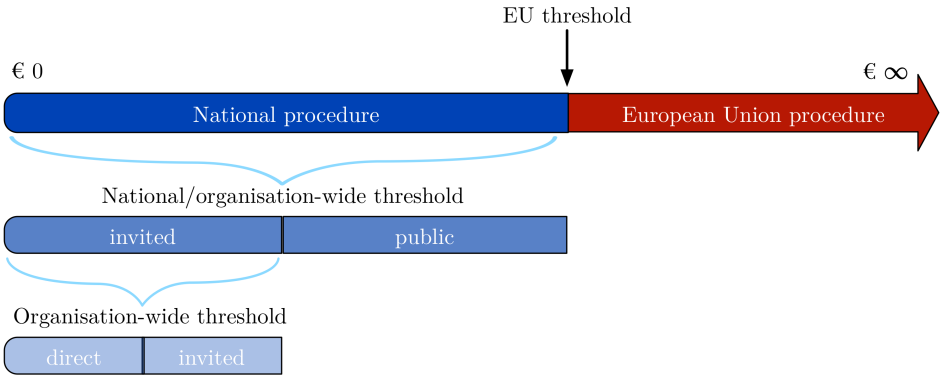

Figure 1.1: Division of tendering procedures based on the threshold value.

internal situations in terms of economy, society and administration, the EU Member States use varying means when deciding the best way for regulating the award of contracts outside the scope of the EU Directive. For instance, most of the EU Member States use the law or regulation to cover contracts below the EU threshold and require the awarding of contracts to be open, fair and competitive. However, there are a few countries that regulate below-threshold contracts using voluntary codes (OECD, 2011).

1.2.2 National threshold

Similar to the regulation of contracts above the EU threshold, depending on the national rules, public authorities can set their own national threshold. This threshold determines the award procedures which will be used for tenders below the EU-set threshold (OECD, 2010). For the national threshold the distinction is usually made between "public procedure" and "invited procedure".

However, due to a less regulated framework for tenders falling outside the EU Public Procurement Directive, there exist a variety of applications for thresholds across the EU Member States. The most often practice across the EU is having two threshold values below the level of the EU threshold (OECD, 2010). In such case, as mentioned above, one threshold separates invited and public procedures, and another threshold level makes a distinction between direct and invited procedures, with the former procedure including only 1 invited supplier, and the latter — around 2–5 suppliers. Such situation is depicted in Figure 1.1.

Other practices in regard to the regulation of the threshold value found by OECD (2010) include, for instance, the EU Member States, which have three or more bands below the EU threshold, such as Bulgaria, Cyprus, Romania, etc. Other countries such as the Netherlands, due to the absence of the national threshold, allow organisations to specify their own thresholds for the public and invited procedure, as well as thresholds for further distinction (see Figure 1.1). These are only some of the examples about the applicable national thresholds found by OECD (2010).

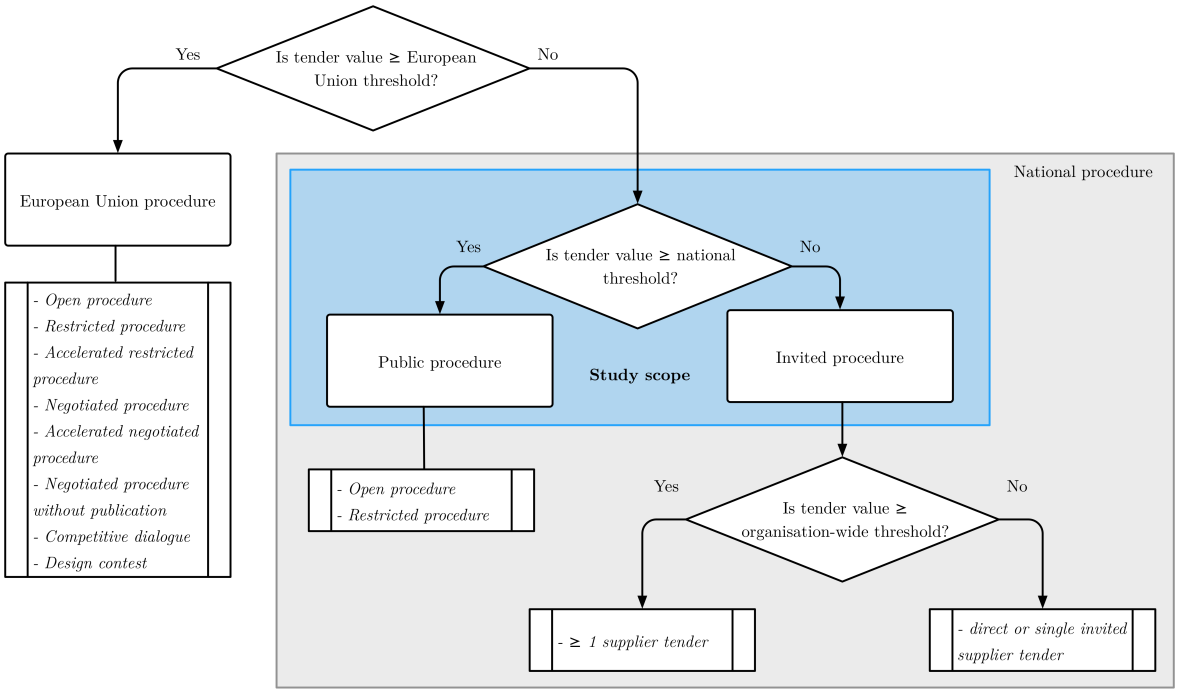

Figure 1.2: Process of tendering in the public procurement. The blue area in the figure demonstrates the study scope for this research.

1.3 Study scope

Despite the fact that depending on circumstances all mentioned procedures can be of a sound usage, our study is focused on the national threshold, which separates all contracts below the EU threshold into public and invited procedures. Figure 1.2 outlines the process of tendering in the public procurement and visualises our decision regarding the study scope.

The public procedure requires a more formal process than the invited procedure. The public procedure allows all interested suppliers to participate and it consists of an advertisement of the tender on e-tenders[1] or other appropriate media (for example, suppliers can voluntarily advertise in the Official Journal of the European Union (OJEU) or in Tenders Electronic Daily (TED)) (NPPPU, 2004). The invited procedure consists of an invitation of selected suppliers to submit their verbal or written quotes (Office of Government Procurement, 2017). Subsequently, we refer to the invited procedure with 2–5 bidders.

Both of the introduced procedures have benefits and drawbacks for the key tender stakeholders mainly, buyers and suppliers. Therefore, whichever procedure is chosen, it will always result in conflicting aims not only within an organisation, but also between the two parties. The following subsections introduces some of the most often mentioned advantages and disadvantages of the public and invited procedures.

[1]Raventós and Zolezzi (2015) define e-tendering as "the process of inviting offers from suppliers and receiving their responses electronically" (p. 2570).

1.3.1 Public procedure

Public decision certainly has some gains for both buyers and suppliers. Firstly, it obviates accusations of favouritism and fraud as any form of competitive tendering (Erridge, Fee & McIlroy, 1999). Also, it enhances competition as more suppliers are encouraged to participate (Heijboer & Telgen, 2002) and it enables the comparability of proposals (Soliño & Gago de Santos, 2016). Moreover, it is suggested that competition leads to a reduction in expenditure (Boyne, 1998). The research of Ochrana, Abonyiová, Plaček and Pček (2015) confirmed that each additionally submitted tender bid decreases the final price, which consequently leads to a decline in the level of the lowest bid price (de Boer et al., 2000).

Despite numerous advantages of the public procedure, it has also been criticised for being too complex and having encumbering procurement policies (Molander, 2014). The process of public tendering becomes even more resource-consuming when both price and quality must be assessed. Moreover, the number of submitted offers also increases the costs of procurement (Chever et al., 2017), which is known as the competition effect in the literature (Onur, Özcan & Tas, 2012). In addition, due to many potential bidders and consequently a lower chance for suppliers to win a tender, suppliers may reconsider their decision to participate, which will result in uncompetitive bids for buyers (Heijboer & Telgen, 2002). Furthermore, since it is hard for buyers to ensure that competition is not only focused on the price level, the quality could be comprised, i.e. in pursuit of winning the tender, bidders can submit a (low) bid with a low quality standard in mind (Heijboer & Telgen, 2002). Lastly, in case of any required adjustments in the tender, buyers need to undergo a formal process of control. That implies, for instance, decisions whether a new tender should be issued to ensure that all potentially qualifying parties are able to participate. Such a lengthy and encumbering process costs buyers additional money and time.

What is seen as an obvious advantage of the public procedure for buyers, namely competition, is far from being beneficial for the other main stakeholder — the supplier. A free entry for bidders leads to two unpleasant outcomes for suppliers. Firstly, they need to adjust their bids according to the level of competition in order to increase the chances of winning the tender (Hanák & Muchová, 2015). In cases when suppliers submit a low bid price, costs of participation may be too high in comparison to potential profit (Grega & Nemec, 2015). Secondly, the chances of winning the contract for suppliers decrease with each new participant. Therefore, in situations of e-auctions[2] when candidates learn that they compete with many other suppliers, the number of submissions of bids decreases (Grega & Nemec, 2015).

[2]Raventós and Zolezzi (2015) define e-auction as the process of using Internet technologies by suppliers "to bid down the price of the procured item until none of them is willing to go further" (p. 2570).

1.3.2 Invited procedure

In comparison to the public procedure, the invited procedure is beneficial for buyers in certain purchasing situations due to three main reasons. Firstly, it is less time-consuming as the buyers initially limit the bidder list to a few potential suppliers (Strand et al., 2011). Secondly, variable costs associated with the invited procedure could be substantially lower than for the public procedure due to a known number of bidders (Heijboer & Telgen, 2002) and due to a smaller number of offers which needs to be compared (Chever et al., 2017). Thirdly, since the nature of the invited procedure is less formal, buyers are released from some burdens in their decisions. For instance, they are free to inform their invited suppliers directly when they amend the procurement project instead of making a public announcement.

A potential problem associated with the invited procedure is the fact that a discretionary power is allocated to the buyer for the selection of suppliers, implying an opinion based selection. In most cases this power will be used to improve economic efficiency by optimising buyer-supplier relationships. Nonetheless, it can also have an opposite effect if it is used to manipulate the market (Chever et al., 2017). Additionally, it becomes harder for buyers to achieve the best value for money in the invited procedure because the number of bidders is limited and the competitive pressure amongst suppliers is weaker.

From the supplier's point of view, the invited procedure is seen as a more beneficial procedure than the public. With only a few competitors, the supplier has greater chances of winning a tender and consequently resources, which are spent on the preparation of the bid, will be more worthwhile. Moreover, when the supplier is aware that competition is weak, he is more motivated to invest time and money in preparing bids (Grega & Nemec, 2015).

1.4 Research problem and contributions

1.4.1 Problem statement

Choosing a regulatory framework has a high impact

Reflecting on the aforementioned situation that the volume of spending of public organisations on tenders *below the EU threshold* is immense and the award of contracts outside the scope of the EU Directive is of great importance for all EU Member States, it should be adequately and efficiently managed. One of the ways to achieve a sound public purchasing system below the EU threshold, is by effectively designing national procurement rules and regulations for the award of below-threshold contracts (OECD, 2010). Unfortunately, currently inefficient procurement procedures and practices are common across the EU countries. The study of OECD (2010) showed that many countries lack knowledge about the design of the regulatory framework for the award of contracts falling below the EU threshold. Additionally, the regulatory framework related to public procurement is under continuous discussion. On the

one hand, public buyers criticise it for being excessively complex and costly. On the other hand, suppliers find fault with the application of the regulatory framework and arbitrariness of buyers when choosing a supplier (Molander, 2014).

In order to ensure efficiency of the regulatory framework, a number of factors play an important role. For instance, transparency (OECD, 2009), professionalism of procurement employees and organisational framework (Schotanus, Telgen & de Boer, 2010), and more. Moreover, since the efficient use of public resources in regard to investments is a challenge for public authorities (Hanák & Muchová, 2015), choosing the most beneficial tender procedure per contract and applying a fitting threshold value can help to overcome the challenge.

Determining an appropriate threshold value is not straightforward

Whatever design of the regulatory framework is chosen, it will unavoidably incorporate a trade-off between conflicting goals, i.e. costs and gains (Molander, 2014). One of such examples is a choice of a public procurement procedure. The public procedure allows more potential suppliers to participate in the tender, which leads to a tougher competition amongst bidders and a consequent reduction in bid prices. However, administrative costs associated with such a procedure might outweigh the aforementioned gains. Therefore, the public procedure might not be chosen despite the fact that situational conditions would support its choice (Molander, 2014). Accordingly, the "best" threshold value depends on many underlying factors, and using them in a fair manner for determining the threshold value is complicated.

Little empirical research

An important requirement for analysing different factors and subsequently determining a threshold value is that such approach should have an empirical basis. Unfortunately, a relatively sparse amount of empirical research has been devoted to procurement practises of public buyers (Chever et al., 2017). Zooming in to procurement subjects about situations below the EU threshold and about the national threshold, this area enjoys an even smaller amount of research. Moreover, the EU Directive and national legislation is based only to a limited extent on analysis of transaction costs and gains, which, as mentioned earlier, play a vital role in the determination of the threshold value (Molander, 2014).

Little empirical practical approaches

In practical terms, the value of the national threshold is still under the political debate, which is unsurprising since it is not created with a data-driven approach. One of such examples was the change in the threshold for direct and invited procedures for the Dutch government in 2013. Before 2013, the threshold was set at €25 000. However, the Ministry of Housing and Government Service made a decision for an increase of the national threshold to

€50 000, meaning that purchases under this threshold could be executed using a single invited supplier tendering. The increase raised many discussions whether this decision is in line with the intended purpose of the Public Procurement Act 2012 to make the public procurement market more accessible to SME entrepreneurs. Moreover, the effectiveness and efficiency of purchases by the central government was also questioned (Algemene Rekenkamer, 2013).

Moreover, due to different national procedures across EU and a lack of a sound research basis, there exists a substantial variation in the values of the national thresholds across similar countries (OECD, 2010). Currently, not only national thresholds vary significantly per country, but also each organisation adopts a different threshold in comparison to other organisations for the same contract value. This fact raises a question — which factors drive the decision of public authorities on setting the threshold value? Some research has been devoted to this topic. For instance, a student research of Loskutnikova and Kuperus (2017) was conducted to identify how Hofstede's cultural dimensions might influence the value of national tender thresholds. The main finding of this research was that none of the six cultural dimensions has a significant effect on the national threshold value (Loskutnikova & Kuperus, 2017). Unfortunately, only a few studies have acknowledged this phenomenon from a quantitative point of view (an example of such study is research of Molander (2014)).

1.4.2 Research contributions

This study was conducted to remedy the above-described problem and to provide both theoretical and practical contributions. Firstly, we aim to fill the gap within the current literature and to contribute to the theory of quantifiable factors that influence costs and gains for buyers and suppliers associated with two national procedures. As a result of a multi-method data collection approach, we provide a comprehensive list of all quantifiable influential factors, as well as provide a selection of factors based on their relative importance. The final list of influential factors helps to determine which factors need to be taken into account when deciding the national threshold value.

Secondly, to contribute to the practice of efficient and effective management of public resources for contracts below the EU threshold, we provide a decision framework to determine the most beneficial contract value for setting the threshold. We first mathematically formalise the problem of optimising the threshold value so that decision-making becomes unambiguous and empirical. We then collect information on the relevant factors including their relationship with the costs and gains for both stakeholders to give insights in the effect on the different procedures and the threshold value. Ultimately, where necessary, we quantify and transform the factors and show how the optimal threshold can be found as if all factors are comparable.

In order to fulfil the specified contributions for the national threshold problem, we set the following research objective: **"to develop a decision framework, which provides a data-driven methodology to determine the most beneficial contract value for**

setting the threshold value that will separate the public from the invited procedure". Furthermore, to show how such methodology could be applied in practice and give a good starting point with the currently available information, we provide a comprehensive list of quantifiable influential factors and their effects on tendering costs and the acquired gains.

1.4.3 Research questions

In order to reach the objective of the research, we formulated a central question and substantiated it by sub-questions. The central research question is presented below:

How can public authorities find the most beneficial contract value for setting the threshold that will separate the public from the invited procedure?

To aid the research question, five sub-questions are stated as follows:

- What are the factors that influence **costs** and **gains** associated with public and invited procedures in public procurement tendering process for **buyers**?
- What are the factors that influence **costs** and **gains** associated with public and invited procedures in public procurement tendering process for **suppliers**?
- How can the effects of factors that influence **costs** and **gains**, stratified by contract value, associated with public and invited procedures for **buyers** be quantified?
- How can the effects of factors that influence **costs** and **gains**, stratified by contract value, associated with public and invited procedures for **suppliers** be quantified?
- How can the optimal threshold be determined with the defined costs and gains for buyers and suppliers associated with public and invited procedures?

1.5 Reading guide

The thesis project consists of 7 chapters. Firstly, in Chapter 1 we introduce the current problem of national thresholds, define our study scope and state the research motivation, as well as central and sub-questions.

The introduction is followed by Chapter 2, which presents an overview of existing literature regarding two main research concepts, namely costs and gains. In the first part of the literature review, we focus on costs associated with public procurement processes. While in the second part, we provide an overview of existing academic views on gains reaped by buyers and suppliers.

Furthermore, Chapter 3 presents research-related information. There we describe our research strategy, formally define the problem of the national threshold value mathematically and explain our approach for the data collection.

In Chapter 4, we summarise results from two data collection methods. We begin by describing findings about the influential factors from expert opinions and continue by adding the results collected from the systematic literature review.

Chapter 5 is devoted to the deployment of the developed decision framework. There we use existing data on quantitative estimations of the differential effects of factors to present an example on how the most beneficial contract value for setting the threshold can be determined.

In Chapter 6, we discuss the implications of our results for current literature. Moreover, we also discuss how the findings can be applied in practice and provide our recommendations for public authorities.

Finally, in Chapter 7, we summarise the whole process of the research and make final conclusions. In addition, we acknowledge the limitations of the study and propose directions for future research.

Chapter 2

Literature review

In this chapter we describe from a scientific perspective the core concepts of this study, namely the costs and gains of public procurement. In Section 2.1, we begin with reviewing costs associated with tender procedures. The existing scientific views on costs for both buyers and suppliers are outlined, as well as attempts to calculate these. In Subsection 2.1.3, we introduce a ground theory for the assessment of costs, which is the theory of transaction cost economics (TCE), and a total cost of ownership (TCO) approach. Subsequently, in Subsection 2.1.4, we discuss various existing approaches to group purchasing activities in order to reveal costs within the entire supply chain. In Section 2.2, we present an existing research about gains associated with tender procedures for both stakeholders.

2.1 Costs in public procurement

2.1.1 Transaction costs associated with tender procedures for the main stakeholders

Costs of tender procedures for buyers

Costs associated with tender procedures, defined as a combination of start-up costs and a cost term that increases with procurement value (Molander, 2014), are never certain. They are usually estimated based on several aspects. For instance, Molander (2014) specified costs based on costs of travelling, costs of consultant work per week, etc. The research of Strand et al. (2011), which focused on costs and gains occurring in different tender procedures across the EU Member States, used another approach for determining the procurement costs. The authors included all costs irrespective of whether they are direct results of the EU Directive's obligations or not. As a result, the determination of procurement costs is an ambiguous and complex process.

The complexity is underlined by the fact that authors in existing literature still do not reach a unanimous conclusion on how to calculate costs involved in the procurement procedures. Currently, there exist at least four definite methods of how to quantify costs of public

procedures. Firstly, costs can be converted into monetary terms by using person-days (in full time equivalent (FTE)) and their average wage (Reimarová, 2011). According to Strand et al. (2011), this method of monetising costs is robust to different interpretations. Secondly, another method implies an analysis based on monetary costs calculations. This method is criticised for including such variables as wage or currency, which can differ per country and may lead to different interpretations (Strand et al., 2011). Thirdly, the report of ECORYS (2015) develops a model denoted as standard cost model (SCM) for cost calculation, which consists of a product of costs per activity and the number of activities. Costs per activity are calculated as the multiplication of time and the pay rate plus out-of-pocket costs and external costs. The number of activities is simply calculated by multiplying total number of companies and frequency per year. Lastly, de Boer et al. (2000) propose a function for the calculation of the total (expected) costs based on a subset of suppliers. Some other examples of possible ways to calculate costs of tender processes are: by assessing production costs, which consist of the initial investment and the discounted value of the operating costs from the project's lifecycle (Soliño & Gago de Santos, 2016), and by marginal costs, which can decrease or be constant with each new bid (Chever et al., 2017). Table 2.1 below summarises the described types of costs for buyers and their calculation methods found in the literature.

Despite different opinions about how to determine costs associated with the procurement process, there is one idea that is shared by authors. This idea implies that assessment of

Table 2.1: Overview of procurement costs and their calculation methods mentioned in the literature.

Costs and calculation methods	**Authors**
Cost per kilometre of road, per consultant-week	Molander, 2014
All costs with direct and indirect results of obligations from the directives	Strand et al., 2011
Costs of person days (FTE) and the average wage	Reimarová, 2011, Strand et al., 2011
Costs of person days (FTE)	Strand et al., 2011
Administrative costs, which consist of a multiplication of costs per activity and a number of activities	ECORYS, 2015
Costs per activity, which consist of a multiplication of time and the pay rate plus out-of-pocket costs and external costs	ECORYS, 2015
Total (expected) costs associated with the selection of a subset	De Boer et al., 2000
Production cost, consisting of the initial investment plus the discounted value of the operating costs	Soliño and Gago de Santos, 2016
Marginal costs of bid evaluation	Chever et al., 2017

costs cannot be made only based on the difference between estimated and contractual prices (Sumpikova, Busina, Grega, Nemec & Orviska, 2016). Therefore, Pavel (2007) proposed to use the TCE theory, which includes all "costs connected with the realization of a given contract" (as cited in Sumpikova et al. (2016, p.2)). Hanák and Muchová (2015) support this idea and state that for the full efficiency of the investment, all costs considered from the perspective of the investment's life-cycle should be included. In order to understand the essence of the unifying theory of various opinions, we introduce it in Section 2.1.3, after we review the literature about costs for suppliers.

2.1.2 Costs of tender procedures for suppliers

When considering an optimal threshold value, not only costs for contractors need to be taken into account, but also the costs for bidders. The research of Costantino et al. (2012), which focused on the reduction of the total cost of purchasing in public procurement, revealed that side costs or additional costs of purchasing (ACP) associated with tender procedures are not only incurred by the contracting authority, but also by bidders. Moreover, the authors also found an interesting phenomenon, which is controversial with the previously described findings. They demonstrated that the reduction of bidders can have a positive financial effect for both parties; more precisely, by eliminating the number of bidders participating in the call, it is possible to increase savings. One of the ways to reduce the number of bidders is by including a pre-qualification phase as done in the invited procedure. Another research suggested for suppliers to anticipate tender competition and adapt bid prices accordingly. By making larger concessions in bids, suppliers will increase their chances of winning the contract and subsequently it will also reduce costs (Hanák & Muchová, 2015; Wu & Kersten, 2017).

The actual amount of costs for suppliers was estimated only in a single study. Molander (2014) found that the costs for suppliers range from €2700 for simple tenders to €9300 for more complex ones. Interestingly, the percentage of costs relative to the contract value was estimated to be only 1 %. However, this number can be higher depending on the relevance of the tender for the supplier and his estimation of chances to win the contract. Overall, according to the author, suppliers regard any costs incurred by tenders as a regular part of their business.

2.1.3 Transaction cost theory and the total cost of ownership approach

As mentioned before, one of the ground theories which is usually applied to the assessment of purchasing costs is the TCE theory. The TCE theory was originated in the early 30s, when Commons (1931) first proposed the idea that "individual actions are really transactions instead of either individual behavior or the "exchange" of commodities" (p.649). Later, Coase (1937) added that companies exist due to the fact that the cost of using the market or the

so called "price mechanism" is higher than the cost of the procured product. As a matter of fact, there is a mark-up for the market cost, which consists of such costs as negotiation costs, enforcement costs and many others (Costantino et al., 2012). Therefore, the TCE theory not only focuses on the market prices, but also takes into account the sum of transaction costs and direct production costs.

Subsequently, market transaction costs from the TCE theory were included as a part of the TCO approach (Costantino et al., 2012). According to Ellram (1993), the TCO is defined as costs from procured goods and services occurring during the entire supply chain. This method can be successfully used to ensure that all costs occurring over a definite time are taken into account when a buyer acquires an asset (Choi, 2010). Cousins, Lamming, Lawson and Squire (2008) argue that since the concept of TCO considers costs beyond simply price, it varies significantly against the total cost of acquisition (TCA). To conclude, both the theory of TCE and the TCO approach emphasise the importance of assessment of the whole supply chain in order to have a complete and reliable overview of incurred costs.

2.1.4 Disclosure of the hidden costs of ownership

In order to uncover all possible costs of ownership, a detailed analysis is necessary of all activities within the purchasing value chain performed by organisation and costs associated with those activities. Several authors proposed different ways to group purchasing activities and consequently to understand the TCO. Ellram and Siferd (1993) developed a framework that consists of six activity categories, namely: quality, management, delivery, service, communications and price. Another method to identify the costs of ownership is to assess the cost elements concerning the transaction sequence. Ellram (1993) distinguished three types of costs based on their order of occurrence. Those types are pre-transaction, transaction and post-transaction costs. The former type implies costs associated with the supplier selection and evaluation. The middle type includes costs which appear during the order emission and until the product delivery. The latter type of costs occurs during the use, maintenance and disposal stages. A similar approach chosen by many authors is dividing costs into ex-ante transaction costs, ex-post transaction costs and costs occurred in the process between submitting a tender and the final contract signature (Sumpikova et al., 2016; Reeves, Palcic & Flannery, 2015; Chever et al., 2017; Carbonara et al., 2015).

Interestingly, for the assessment of costs of the European procurement process, a similar method was used, namely all costs incurred across the whole procurement delivery chain are taken into account (Strand et al., 2011). The authors proposed a 4-step delivery chain based on which costs, occurring in these phases and in certain activities, are calculated. The steps are: pre-award (pre-proposal for suppliers), award (proposal for suppliers), post-award, litigation and complaint (if applicable). Figure 2.1 presents an illustration of the 4 steps and corresponding actions with a distinction for buyers and suppliers.

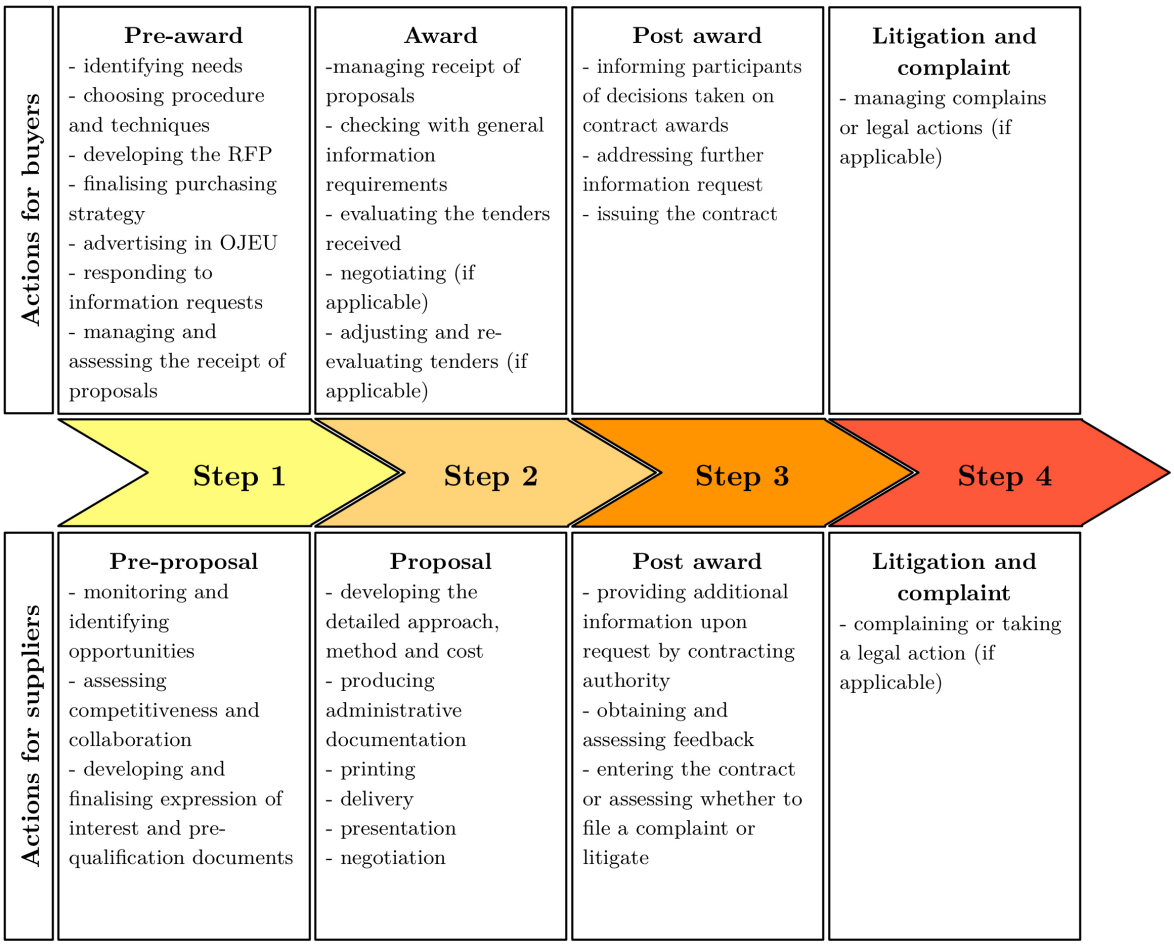

Figure 2.1: A 4-step delivery chain with a distinction of actions for buyers and suppliers.

2.2 Gains in public procurement

2.2.1 Gains associated with tender procedures for the main stakeholders

Gains of tender procedures for buyers

Apart from costs associated with public procurement rules, it is equally important to consider the gains. Unfortunately, only a few studies attempted to determine gains for buyers in comparison to the number of studies examining costs. This can be attributed to the difficulty of stating a concrete counterfactual situation in cases when a procurement framework does not exist (Keisler & Buehring, 2005). One of the widespread solutions is a repeated examination of the situation, i.e. before and after a change. The further outlined methods of calculations of gains are summarised in Table 2.2.

The general estimation of gains derived from public procedures was given by Molander (2014), who defined them "to be roughly proportional to the value of a given procurement" (p.17). Other studies proposed more concrete and quantified estimations. For instance, the research of Australian Industry Commission (1996) revealed that savings can reach up to

Table 2.2: Overview of procurement gains and their calculation methods mentioned in the literature.

Gains and calculation methods	**Authors**
Gains are approximately proportional to the value of a given procurement	Molander, 2014
Savings, which consist of a multiplication of the total value of further contractable services and an estimated amount of savings per dollar of expenditure	Australian Industry Commision, 1996
Savings of the purchasing order (i.e. "negative costs")	Duncombe and Searcy, 2007
Increase in value for money	Europe Economics, 2006
Revenue that buyers receive from public tenders	Soliño and Gago de Santos, 2016
Quality	Milne, Roy and Angeles, 2012
Effectiveness in responsiveness to consumer demands	Kavanagh, 2016

50 %, as well as they can be expressed in negative values. In their research, the savings were expressed as the multiplication of the total value of further contractable services by an estimated amount of savings per dollar of expenditure and caused by competitive tendering and contracting. Around 100 of the examined studies showed that gains vary within the range of 10–30 %, while the average was set to 20 %. Unfortunately, these results cannot be fully considered for this research as not all gains from the used studies were attributed to public procurement. The research of Duncombe and Searcy (2007) reported gains as savings of the purchasing order (essentially, these are "negative costs") and estimated them at 4 % under the condition of using a certain recommended procurement practice. Another way of calculating gains was performed by Europe Economics (2006). The report of this London consultancy company estimated gains in terms of the increase in value for money to be in the range of 2.5–10 % due to the introduction of the EU Directive in 15 different Member States during the timeframe of 11 years.

Gains can be expressed not only as percentage, but also in other terms. For instance, Soliño and Gago de Santos (2016) studied revenue that buyers receive from public tenders. It is assumed that the higher is the number of bidders, the higher is the expected revenue due to the better value for money. Another studied gain is quality, which, according to Milne, Roy and Angeles (2012), is lower when there are more bidders. Effectiveness in responsiveness to consumer demands is another example of possible gains (Kavanagh, 2016).

Gains of tender procedures for suppliers

Gains for suppliers from participation in public tendering is a more complex topic than gains for buyers due to a few reasons. Firstly, research devoted to gains from public tendering

procedures for buyers and suppliers is unequally distributed. In comparison to gains for buyers, gains for suppliers is a relatively unexplored research area. Secondly, a few studies that do address this topic, do not reach a unanimous agreement about the relevant set of gains and their estimation. For instance, one of the possible gains for suppliers can be expressed in the probability of getting a contract in a tender. In the invited procedure the chance to win a tender will be higher since the number of competitors is lower than in the public procedure. However, this benefit holds true only in cases when the supplier is actually invited to participate in the tender process. For SMEs this gain can be extremely important due to the fact that usually small business actors face more obstacles in successful participation in tenders than their bigger competitors (Thomassen et al., 2014). Another gain for suppliers acknowledged in the research of Wu and Kersten (2017) is caused by a lower level of competition, for instance, in negotiations. According to the author, a smaller number of competitors leads to smaller concessions from suppliers and increases their gains. However, this assumption is not always true. Since potential profit is estimated based on the contract value agreed between buyer and supplier, and the fact that the value and the cost function vary across suppliers, larger concessions will not always lead to lower gains for a supplier. The last reason for the complexity of gains for suppliers is the fact that these gains are not always expressed in a quantitative way. That makes it difficult to estimate them without any subjectivity.

Additionally, not only suppliers can benefit from public procurement actions, but also society itself. Choi (2010) studied the role of public procurement in relation to society. The author proposed a model with five roles of public procurement, which can also be seen as gains for society. These gains are solely of a qualitative nature. For instance, public procurement can influence national economy by serving as a source of sales and increasing GDP. Moreover, public procurement can be an excellent tool for social responsibility. Since governments have a dual role in the market — as regulators and participants — they can stimulate suppliers to comply with environmental and safety standards by procuring only from environmentally sustainable companies. Another similar category incorporated in the model of Choi (2010) is eco-friendly activities. By showing a need for an eco-friendly supply chain, public authorities as customers can stimulate suppliers towards a greener procurement, from which consequently society will benefit. Other two categories from the model are leadership in government officials and industry innovation, both of which can positively influence society.

Chapter 3

Methodology

In this chapter we present our plan of approach of contributing to the solution of the research problem fruitfully and to reach the research objective. Figure 3.1 summarises the methodological framework and serves for the reader as a guidance of the subsequent processes.

The first step in the methodology is a definition of the research problem. In Section 1.4, the problem of the tender threshold value was outlined. The problem implies the difficulty of determining the optimal threshold value that separates the invited from the public procedure due to (1) various trade-offs that need to be accounted for, (2) a variety of influential factors on costs and gains and (3) multiple participating stakeholders. In addition to its tortuousness, it is also a highly under-investigated problem.

Based on this problem, in Section 3.1 we present the research strategy, which introduces the choices in regard to the mathematical formalisation of the problem. Subsequently, the developed mathematical decision framework is presented in Section 3.2. Here we introduce and explain a function for a single purchase, the objective function of the research problem and its simplification that should be feasible in most practical cases.

In order to contribute to the completeness of the framework and to determine relevant factors, which have an impact on costs and gains of the invited and public procedure for both actors, we describe the utilised data collection methods in Section 3.3. This is executed by two research approaches, namely expert opinions and a systematic literature review.

In Chapter 4 we outline results from the data collection process and present a summary of all acknowledged factors which have a direct and indirect effect on costs and gains. Moreover, to estimate the effects of the factors in a quantitative manner, we also consult the literature for already existing numerical results.

After a full list of the relevant factors is determined and available quantifications of the effects are found, we narrow down the full list to the most important factors with differential effects for the further deployment of the decision framework. The decision-making process is described in detail in Section 5.1.

When the selection of the core factors, which influence costs and gains differently per

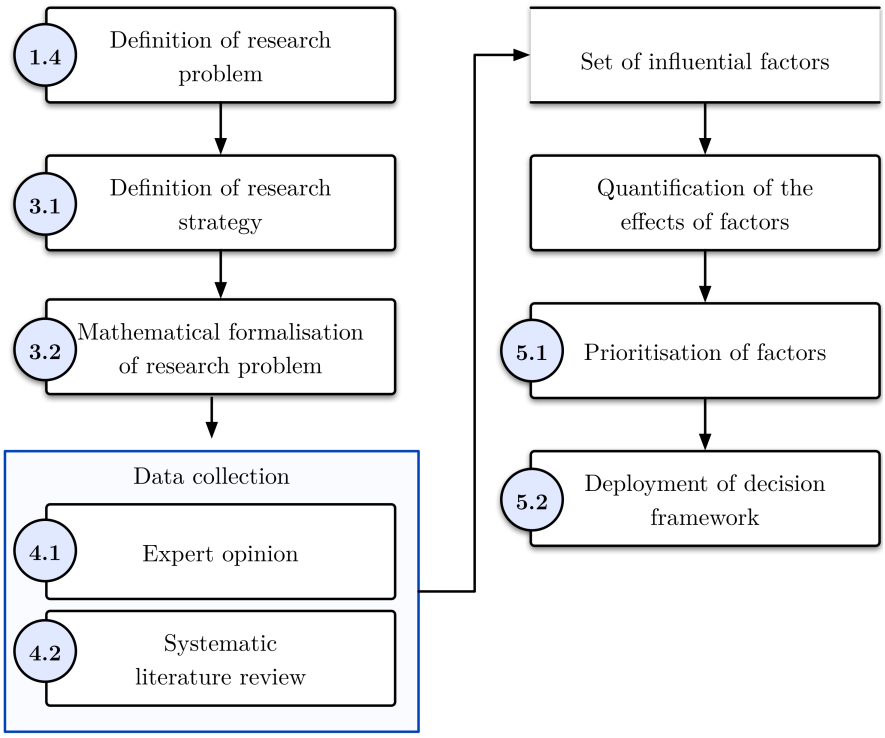

Figure 3.1: Flowchart of the methodology. The number on the left (in blue circle) signifies the section in which the relative process is considered.

procedure, is made and all available results on quantification of the effects are noted, we feed the data into our framework to get a sense of possible outcomes. In Section 5.2 we present an example with the currently available information on how the most beneficial contract value for setting the threshold can be determined.

3.1 Research strategy

As earlier investigated during the literature review, to determine the most applicable threshold value for a certain contract value, both costs and gains have to be taken into account. However, we believe that these two aspects can be simplified for the decision framework. One of the ways to do that is by creating a new variable "overall benefit", which we set equal to total gains minus total costs per particular stakeholder. Another way to simplify the two aspects is by using a differential approach and calculating the difference of gains between the public and invited procedure, and similarly, the difference of costs. Both methods are used later in the decision framework.

Moreover, due to the fact that the threshold value has an impact on both main actors in the purchasing delivery chain — namely, on buyers and suppliers — our model should be able to account for both actors or for a single actor. For example, a scenario that is focused only on buyers should propose the optimal threshold value from their point of view.

We believe that such a model can be applied on organisational levels, for instance, in local governments. Another scenario should address the overall benefit for society (i.e. the public buyer and supplier). Such scenario is a more comprehensive and realistic representation since both main stakeholders are accounted for; and it can, therefore, be useful in determining threshold values on a national level.

Unfortunately, implementing the second scenario that accounts for buyers and suppliers is subject to limitation at the moment of writing. As mentioned in Section 2.2, based on a preliminary literature review, the majority of studies acknowledge a prevailing qualitative nature among gains for suppliers. For instance, for such gains as the level of competition among bidders (Wu & Kersten, 2017), contribution to sales and GDP or improvement of social responsibility for the society (Choi, 2010) it is difficult to estimate a quantitative effect. Due to the fact that our research aims to determine the effects of various factors on costs and gains in a quantifiable manner, the presence of qualitative effects would complicate the estimation. Therefore, we decide to excluded the variable of gains for suppliers from the subsequent data collection process. Nevertheless, we believe that it is possible that in future studies researchers will be able to determine gains for suppliers that are of a quantitative nature. As a result, we kept this variable in the mathematical model.

In Figure 3.2 we present an illustration of an example of finding the optimal threshold value. The two functions represent the overall benefits of the public and invited procedures. At a certain contract value these functions intersect, which simply is equal to the most beneficial threshold value. We provide the following arguments: as mentioned before, in regulatory terms, for contract values lower than the threshold value, the invited procedure has to be used in a tendering procedure; for contract values larger than the threshold, the public procedure is applicable. As can be seen in the figure, overall benefits of the invited procedure with contract values lower than the intersection point are greater than the overall benefits of the public procedure at all times. This is indeed the procedure that should have been used based on the national regulations. The same applies to the other side of the intersection point — for all contract values the public procedure has greater overall benefits, which is also the procedure that would be used in practice. Thus, both procedures are used at the most beneficial contract values at all times, and the total overall benefits are maximised. Therefore, the intersection point of the functions of the overall benefits is by definition equal to the optimal threshold value.

As we will see later in Section 5.2, the scenario of Figure 3.2 is very likely in practise. Nevertheless, to provide a robust decision framework that is insensitive to more complex scenarios, we will account for any possibilities of the input data. We provide an argumentation of how a more complex scenario can be solved in Appendix B. In short, with more complex functions of overall benefits of the two procedures, multiple intersections in the functions might appear. This means that with a single threshold, it is impossible to find a value that separates the range of the national tendering in two regions where the most beneficial

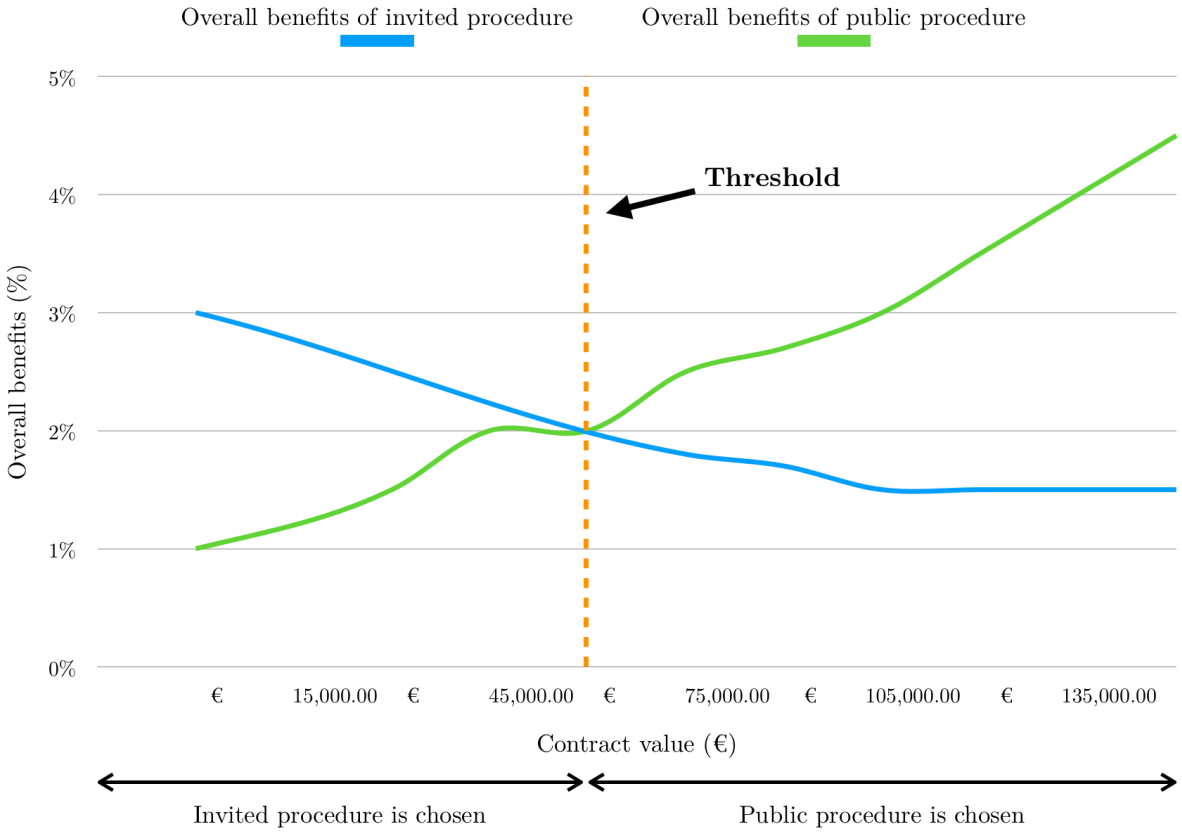

Figure 3.2: An example of the overall benefits of the invited and public procedure with a single intersection point.

procedure is applied, such as we have shown in Figure 3.2. In that figure, across the *entire* range the most beneficial procedure is applied. This is not the case when there are multiple intersection points. Therefore, the *total* overall benefits per threshold value should be found and compared. To correctly calculate the total overall benefits, the probability of occurrence of a certain contract value is important, as discussed in Appendix B.

Ultimately, in the subsequent section we will develop a single mathematical decision framework that can be applied to any situation and find the optimal threshold value for the given data. In summary, regarding the decision framework,

1. it should be able to incorporate data from multiple relevant factors;
2. it should be able to incorporate the gains and costs of multiple stakeholders;
3. it should be robust, i.e. insensitive to the complexity of input data;
4. it should provide a guaranteed optimal solution;
5. it should be tractable, i.e. not requiring extensive computational resources.

3.2 Mathematical decision framework for threshold optimisation

3.2.1 Single purchase decision-making

In the previous section we have presented the logic and argumentation of finding the optimal threshold value given the overall benefits of the invited and public procedure. We now formalise the problem mathematically so that it becomes unambiguous and straightforward to use. First of all, we present an example of a function that can be used to choose between the public and invited procedures in a scenario of a single purchase. This may be useful, as in some cases, it may be difficult to collect information on multiple purchases to estimate the optimal contract value to set the threshold, while determining the most beneficial procedure only for one project can be feasible. Therefore, we begin with presenting an example on how public authorities can make a decision for a single purchase in regard to the tender procedure.

In our example we want to make a decision in regard to the two national procedures. For that we need to estimate both costs and gains. Moreover, as it was mentioned in the previous sections, the number of bidders plays an important role in both national procedures. For instance, a higher competition amongst bidders reduces the final price for buyers (Ochrana et al., 2015). However, it also influences costs of buyers, as with more bidders, a higher number of proposals need to be assessed (Chever et al., 2017). As a result of a frequent acknowledgement of the influence of number of bidders, we include this variable in our example for the single purchase decision. Obviously, there are many more factors that are of importance in determining costs and gains associated with both procedures (as we will see later in Chapter 4.1).

Several studies on purchasing costs and gains presented formulas for their calculation. Additionally, in a few researches, costs and gains were also estimated in regard to the change in number of bidders. For our example to estimate costs based on the number of bidders, we use the formula proposed in the study of Heijboer and Telgen (2002). The authors proposed two formulas to calculate total costs for buyers for different procedures. In the original study, the researchers take into account the open and restricted procedure. Since these procedures are similar in their nature to the pubic and invited procedures, we use these formulas in our example of the public and invited procedures. In the formulas below, K stands for the (proportional) costs per tender for the public procedure. For the calculation of costs in the invited procedure, due to the presence of two evaluation/selection processes, K is supplemented by two coefficients, namely, α and β. The expected tenders are denoted as T_o and ETQ stands for the economic tender quantity. Participation requests are denoted as P_r. A minimum bid in a probability distribution of bids is denoted as a, while a maximum

bid — as b. These two formulas are presented below.

$$\mathrm{C}_i = KT_0 + a + \frac{b-a}{T_0+1} \tag{3.1}$$

$$\mathrm{C}_p = \alpha K\left(P_r\right) + \beta K\left(\mathrm{ETQ}_r\right) + a + \frac{b-a}{\mathrm{ETQ}_r+1} \tag{3.2}$$

To calculate gains for buyers, we used a widespread finding that each additional bidder decreases final price by a certain percentage. The total number of bidders is denoted as N. Moreover, we also make a distinction in the number of bidders per procedure based on the findings presented in Section 1.3. In the invited procedure the number of bidders is set to 2–5 as the buyers initially limit the bidder list to only a few potential suppliers (Strand et al., 2011). While in the public procedure the number of bidders is not restricted. Therefore, we allow any number of bidders starting from 2.

Moreover, the research of Skuhrovec and Soudek (2013) found that the use of an open tender (i.e. in our case the public procedure) decreases additionally the final price by 7%. On the other hand, Grega and Nemec (2015) stated that the use of restricted procedure (i.e. in our case the invited procedure) increases final price by 11.56%. The formulas for the calculation of gains based on the number of bidders for both procedures are presented below.

$$\mathrm{G}_i = \phi N - 11.56\,\% \quad \text{with } N \in \{2..5\} \tag{3.3}$$

$$\mathrm{G}_p = \phi N + 7\,\% \quad \text{with } N \in \{2..\infty\} \tag{3.4}$$

The formulas above are examples of the calculation of costs and gains for different procedures. In order to determine which procedure is more beneficial, gains of the invited procedure can be deducted from gains of the public procedure. The same should be done for costs. After, the decision in favour of the invited procedure can be made if difference in gains is lower than difference in costs.

3.2.2 General objective function of research problem

Even though the decision-making in regard to a single purchase is useful and straightforward, in our thesis we aim to determine a contract value for setting the threshold for projects of different values. To reach our goal, we develop an objective function that seeks to maximise the overall benefit of the entire range of contracts below the EU threshold. Moreover, the objective function also incorporates the 5 aspects that are mentioned at the end of Section 3.1, as we will discuss shortly.

Let $\mathcal{S}$ denote the set of stakeholders s, let $\mathcal{F}$ denote the set of factors f that affect the costs and/or gains, and let $\mathcal{V}$ denote the set of contract values v. Furthermore, let $T \in \mathcal{V}$ denote the national threshold value, which is the decision variable, and E denote the threshold value of the EU. We define $f(v)$ as the probability density function of contract value v. Let i denote the invited procedure and p the public procedure. Finally, $G^p_{s,f,v}$ and $G^p_{s,f,v}$ designate the

gains of the invited and public procedure respectively, applicable for stakeholder s of factor f at contract value v. Similarly, and $C^{i}_{s,f,v}$ and $C^{p}_{s,f,v}$ denote the *costs* of both procedures. The objective function can than be formulated as in Equation (3.5) below:

$$\text{maximise} \quad \sum_{s\in\mathcal{S}}\sum_{f\in\mathcal{F}}\left(\sum_{v=0}^{v=T} f(v)\left(G^{i}_{s,f,v}-C^{i}_{s,f,v}\right)+\sum_{v=T}^{v=E} f(v)\left(G^{p}_{s,f,v}-C^{p}_{s,f,v}\right)\right) \tag{3.5}$$

In very general terms, the objective function sums the gains and costs (i.e. the overall benefits) of the invited procedure up to the national threshold value, and the gains and costs of the public procedure from the national threshold value to the EU threshold. This is done per contract value v, and these values are multiplied with the probability of occurrence of that contract value by the function $f(v)$. For example concerning the probability density function $f(v)$, if contract values of €100 000 are far less often occurring than projects with values of €20 000, then the gains and costs of the former contract value have a lower weight than the gains and costs that are applicable at €20 000.

Ultimately, the objective is to maximise the total overall benefits by finding the threshold value $T^{*}\in\mathcal{V}$ (with T^{*} being the optimal T) that is responsible for that greatest total overall benefit.

Going back to the function, the two outer sums simply consider all the previously mentioned gains and costs at a certain value v for all factors $f\in\mathcal{F}$ that are applicable for the considered gains and costs, and all stakeholders $s\in\mathcal{S}$. Note that in this research we consider only two stakeholders, namely buyers and suppliers.

Lastly, with T being the sole decision variable in the objective function, the variable determines up to which contract value the gains and costs of the invited procedure should be considered (left hand side of function) and starting from which contract value up to the contract value equal to the EU threshold the gains and costs of the public procedure should be considered (right hand side of the function).

In the summation, $v=T$ is included in both the invited and public procedure. Or in other words, gains and costs at a contract value equal to the threshold value are considered to belong to both procedures, implying that both the invited and public procedure can be chosen if such a scenario would occur.

Note that Function (3.5) is only an objective function, and most commonly practitioners would extend it to a full mathematical model to be able calculate a result (i.e. optimal threshold value). However, since only a single (and one-dimensional) decision variable is utilised (namely, T), the objective function can be used directly to simply check the solutions of all possible contract values $v\in\mathcal{V}$ for T (a so-called "brute force method"). In this case, such approach is still tractable and guarantees an optimal solution.

3.2.3 Simplification of decision framework

In the previous subsection we have provided an objective function of the research problem, and argued that it can be simply solved by a "brute force method" since only the solutions of all possible threshold values need to be calculated. The optimal solution is the threshold value that yields the greatest output of the objective function, namely the greatest overall benefit.

With this approach, we have fulfilled all 5 requirements as stipulated in Section 3.1. Note that due to the incorporation of the probability distribution function of contract values $f(v)$, the objective function still holds with complex input data (see Appendix B for a more detailed explanation). Nevertheless, as discussed earlier, the input data probably would not be complex (as will be presented during the application of the decision framework in Chapter 5). Therefore, we find it worthwhile to further simplify the model since that simplification can be used most of the time in practice.

In the simple scenario, having a single intersection point as in the example in Figure 3.2, this intersection directly determines the point from which one function becomes larger than the other. Or, more concretely — one of the procedures is more beneficial on one side of the intersection point, and the other procedure on the other side, meaning that the intersection point is by definition the optimal threshold value in such scenario.

Also note that the contract value probability function $f(v)$ becomes irrelevant for finding the optimal threshold, as it would affect both procedures equally and would only transform the functions in the direction of the vertical axis. This means that the intersection point will not be altered in the direction of the horizontal axis where the contract and threshold values are. Or saying it differently — $f(v)$ might influence the total overall benefit, but it will not change the *relationship* between the invited and public procedure, and thus the intersecting contract value will also not change.

We further simplify Function (3.5) by considering new definitions for gains and costs that are already an aggregation of all factors ($f \in \mathcal{F}$) by all stakeholders ($s \in \mathcal{S}$) and dependent on contract values v up to the EU threshold E. Therefore, we define the "overall benefit" variables in Equation (3.6) below. B^i_v is the overall benefit of the invited procedure per contract value v, and similarly B^p_v is the function of the public procedure.

$$B^i_v = \sum_{s\in\mathcal{S}} \sum_{f\in\mathcal{F}} \left(G^i_{s,f,v} - C^i_{s,f,v} \right) \tag{3.6a}$$

$$B^p_v = \sum_{s\in\mathcal{S}} \sum_{f\in\mathcal{F}} \left(G^p_{s,f,v} - C^p_{s,f,v} \right) \tag{3.6b}$$

Another approach can be to focus on the difference of the gains and costs between the procedures. In such case, the information of the overall benefit is lost[1], while in the previous

[1]For example, if the gains of the public and invited procedure would be 101 and 1 respectively and in another scenario 10 101 and 10 000, the difference would be the same (namely, more gains in the public procedure = 100), so there is no insight in the absolute benefit.

approach of the overall benefit, the information of the difference between gains and costs is lost[2].

As some literature incorporate the approach of the difference between gains and costs, we provide a similar definition of the differential gains and costs as in Equation (3.7) below. Here, ΔG_v is the difference of gains between the public and invited procedure, and similarly, ΔC_v considers the differential costs.

$$\Delta G_v = \sum_{s\in\mathcal{S}} \sum_{f\in\mathcal{F}} \left(G^p_{s,f,v} - G^i_{s,f,v} \right) \tag{3.7a}$$

$$\Delta C_v = \sum_{s\in\mathcal{S}} \sum_{f\in\mathcal{F}} \left(C^p_{s,f,v} - C^i_{s,f,v} \right) \tag{3.7b}$$

Naturally, using Equations (3.6), the public procedure is preferred when the overall benefits are larger than for the invited procedure, namely for v where $B^p_v > B^i_v$. Similarly, using Equations (3.7), the public procedure is preferred when the differential gains become larger than the costs, namely for v where $\Delta G_v > \Delta C_v$.

Substituting the parameters in Equation (3.5) by the simplifications in Equations (3.6)–(3.7), omitting the contract value probability distribution function $f(v)$ and finding the intersection point between the functions of the two procedures results in the simple decision rule of Equationx (3.8):

$$T^* \leftarrow \begin{cases} B^p_v = B^i_v; & \text{or} \\ \Delta G_v = \Delta C_v. \end{cases} \tag{3.8}$$

In summary, the optimal national threshold value T^* is at contract value v that results from Equation (3.8)[3]. This is valid when the costs and gains are not multimodal functions (i.e. they have a single extremum) and thus there exists a single intersection point (see Appendix B, the objective function of (3.5) should be solved then). In practise, the simplified approach will most probably be feasible most of the time.

3.2.4 Differentiation of the effects of factors on costs and gains

After providing the mathematical definition of the tender threshold problem, the effects of individual factors on costs and gains have to be estimated. In our case with six different categories, namely costs for buyers in the invited procedure, costs for buyers in the public procedure, costs for suppliers in the invited procedure, costs for suppliers in the public procedure, gains for buyers in the invited procedure and gains for buyers in the public procedure,

[2] For example, if in the public procedure, the gains and costs would be 101 and 1 respectively and in another scenario 10 101 and 10 000 (namely, overall benefit = 100), the difference would be the same, so there is no insight in the difference between costs and gains.

[3] Note that since B^p_v, B^i_v, ΔG_v and ΔC_v are discrete variables, there might not exist a pair of strictly equal values in Equation (3.8). The intersection point should then be found by interpolation or taking contract value v that comes the closest to the true intersection point.

such an estimation is complex and includes many potential overlapping effects. Moreover, no unanimous decision was reached across literature on how to calculate and analyse costs and gains incurred in purchasing processes and every researcher proposes a unique method to solve this problem. These methods were discussed earlier in Chapter 2. As a result, in order to stay focused on the most relevant effects on costs and gains and to make the research process efficient, we decide to consider only costs and gains, which values are *not* identical in the two procedures during all contract values.

By translating this decision to the current research, it implies that in spite of which procedure is chosen, some costs and gains associated with certain activities remain unchanged. For instance, costs of such activities as identifying purchasing needs or developing the request for proposal (RFP) for buyers will not change across the two national procedures. That is mainly due to the fact that such costs do not depend on the chosen procedure and consequently on the number of bidders. A similar method for identification of relevant costs was applied in the study of de Boer et al. (2000). The authors distinguished between fixed and variable costs. The former costs do not depend on the number of bidders, whereas variable costs change with the number of bidders and are related to some or to a combination of different activities.

Since costs and gains are influenced by factors, it is important to not only focus on costs and gains which are not identical per national procedures, but also to assess factors, which result in different effects on costs and gains. Therefore, in the subsequent research, we focus only on factors with a different effect depending on the public or invited procedure.

3.3 Data collection

Costs and gains associated with different national procedures are dependent on numerous factors. Unfortunately, these factors have never been studied entirely and up to now there does not exist a list of all possible influential factors. In order to contribute to this gap in the literature, we chose a two-stage data collection approach to specify a comprehensive set of influential factors on costs and gains per stakeholder and procedure. This entails expert opinions and a systematic literature review. During the data collection, we focused on the effects of factors on costs and gains with a closer look at differences between the two national procedures. Both of the data collection methods are explicated in the following subsections.

3.3.1 Expert opinion

The first data collection approach is expert opinions. According to Mahmoud (2015), this approach is useful when there is limited information available, modelling is difficult and/or a product that is forecasted is new. The expert opinion technique fits the current research due to two reasons. Firstly, a comprehensive research about influential factors and their

differential effects on costs and gains has never been conducted. Secondly, researchers in the existing literature propose different aspects of costs and gains, and their assessment methods. Subsequently, the acquired findings from expert opinions served as an input for the further data collection process.

Mahmoud (2015) propose a three-step method for a systematic selection of experts. Firstly, according to the author, it is necessary to define what is required from experts. Most importantly, experts are required to have a high-level of expertise in the public procurement area to be able to share their knowledge about questions, which we aimed to find answers for. The main questions are "What are the potential factors that can influence costs and gains for buyers and suppliers, participating in one of the two national procurement procedures?", "How do these factors influence costs and gains?", "What is the difference in the effects of factors on costs and gains per national procedure?" and "What are the estimated costs and gains for buyers and suppliers in regard to the usage of two national procurement procedures?". A complete interview guide covering these questions is presented in Appendix A.

Secondly, it is important to determine a suitable approach for the research. Since the current research aimed to make not only theoretical, but also practical contributions, we decide to acquire opinions from multiple perspectives. The sample consists of experts who work in the academic field of public procurement, as well as practitioners. Additionally, both in-house and outside experts were interviewed to ensure a trade-off between familiarity of research context and unbiased opinions.

The last step includes decisions of the suitability of experts. The sampling is performed by the convenience method and consists of seven experts. In order to get a more comprehensive opinion about the topic and potential influential factors, the sample includes both types of experts — experts with a practical experience in conducting tenders such as senior buyers, and experts with a more theoretical view on tenders, for instance, academics, policy makers, strategic consultants. The ratio of experts per knowledge/experience type is around 1:3 respectively.

After the selection phase, we collect the expert opinions. We conduct semi-structured interviews, which vary in length from 50–70 minutes. All interviews are audio taped and afterwards summarised.

3.3.2 Systematic literature review

As the second data collection method we conduct a literature review. In comparison with the literature review presented in Chapter 2, which focused on the core concepts of this study, namely *costs and gains* in public procurement, the following systematic review focuses on *factors, which influence costs and gains* for both participating parties in different national procedures. There exist three main types of literature reviews, namely, qualitative systematic

reviews, quantitative systematic reviews (or meta-analyses) and narrative reviews (B. Green, Johnson & Adams, 2006). For the second stage of the data collection approach, we decide to apply a qualitative systematic literature review. According to the Cochrane Handbook for Systematic Reviews of Interventions, by using a systematic review, all empirical evidence, which is selected based on the pre-specified criteria, is collected in order to answer the main research question (S. Green et al., 2008). Moreover, this method provides reliable findings and minimises bias due to the fact that the review is completed by explicit, detailed and rigorous methods (S. Green et al., 2008). The selected method is in line with our research objective since we strive for the completeness of results and aim to have a comprehensive overview of all influential factors and their respective relevance.

To conduct a systematic literature review, we adapt a three-step method as proposed by Tranfield, Denyer and Smart (2003). The first stage consists of planning the review. This stage implies scoping of studies and development of a review protocol. The scoping phase is done during the initial investigation of the research problem and formulation of the theoretical framework. This phase showed that literature which addresses national procurement procedures, and costs and gains associated with those, is scarce. Therefore, we define a search strategy based on these findings and divide it into two stages. Firstly, we research all studies which address the topic of national threshold. Secondly, we proceed with reviewing studies with related topics such as EU threshold, competitive tendering, restricted procedure, single-invited supplier tenders, public-private partnerships (PPP), etc. Even though these procedures do not fall within the scope of this study, they still have certain aspects in common with public and invited procedures and, therefore, were useful in identifying influential factors.

The second aspect within the first stage is the review protocol, which contains information about the research questions, the sample, the search strategy and the criteria for inclusion and exclusion of studies in the review (Tranfield et al., 2003). The research question, which is used for the systematic review, is as follows: "What are the potential factors and how do they influence costs and gains for buyers and suppliers in a different way depending on the usage of one of the two national procurement procedures?". The literature review was performed from the 15^{th} of May until the 6^{th} of June 2018. The sample consists of academic refereed journal articles, conference proceedings, unpublished studies and consultancy reports and studies. The latter type of the data input is chosen because such reports contain a lot of valuable and relevant information on public procurement in practice. The search strategy includes the search engines, search terms and timeframe. For the review we used multiple search engines, namely Scopus, Web of Science and Google Scholar. Moreover, articles are also searched using the snowballing method. The search terms are formulated based on the findings collected from the experts. The following search terms are used while conducing the literature review:

- "public tender*"

- OR “tender*”
- OR “public procurement”
- OR “public purchas*”
- OR “procurement auction”
- OR “purchasing auction”
- OR “PPP project”
- AND “number of bidder”
- OR “number of supplier”
- OR “competition”
- OR “project complexity”
- OR “procedure complexity”
- OR “spread bid”
- OR “influen* factor”
- OR “cost”
- OR “gain”
- OR “benefit”
- OR “saving”

The search timeframe is limited to the period 2000–2018 to access the most recent academic input. Lastly, we formulate inclusion and exclusion criteria. For an academic output to be included in the sample it needed to focus on public procurement, address either procedures above or below the EU threshold, present findings on the effect of an influential factor on either costs or gains for buyers or suppliers and be written in one of the previously mentioned formats. We exclude studies if they did not meet the inclusion criteria, were published more than 18 years ago and were not written in the English language.

The second stage in the systematic review is conducting the review itself (Tranfield et al., 2003). Only studies that met all the criteria are included in the review. Firstly, each academic output is assessed based on its title. Then the abstract is reviewed. Furthermore, relevant sources are retrieved and the full text is analysed in more detail.

The last stage comprises reporting and dissemination (Tranfield et al., 2003). During this stage a report is produced, which is presented in Section 4.2. This report focuses on findings and the main answer on the set research question or the so called “thematic analysis”. This analysis is presented in a form of a summary of all relevant studies and factors found in those.

Chapter 4

Results of the empirical research

On the following pages findings of the multi-method research are presented. Firstly, results from the collected expert opinions and the identified influential factors are provided. Secondly, results from the systematic literature review are outlined. It is important to mention that during the data collection we discovered a great number of factors which can influence costs and gains in different ways. Their influence varied not only in the magnitude of the effect, but also in their nature. Referring back to the research strategy, in this summary of results, we focus on factors which have a differential effect on costs and gains per national procedure and which are of a quantitative nature.

4.1 Analysis of expert opinions

During the analysis numerous factors that can influence costs and gains for buyers and suppliers in regard to two national tender procedures were determined. The factors were divided into two groups: ones that influence costs and gains directly and ones that have an indirect effect. Both types of factors are summarised below in conceptual frameworks.

4.1.1 Factors influencing costs for buyers

As seen in Figure 4.1, most of the experts have acknowledged the *number of bidders* as an important influential factor. The more bidders there are in the tender, the more costs a buyer will experience during evaluation, negotiation and complaint handling. Obviously, the effect of the number of bidders is different per type of procedure. Typically, the minimum number of bidders in the invited procedure should be 3 and maximum 5. However, in the public procedure the number of bidders is greater and can involve even 1000 of submitted proposals. Therefore, costs associated with this factor for buyers in the invited procedure will be lower than for buyers in the public procedure.

Other factors mentioned more than once are *administration and regulation*, and *preparation of tender*. Firstly, the experts identified administration and regulation to have a positive

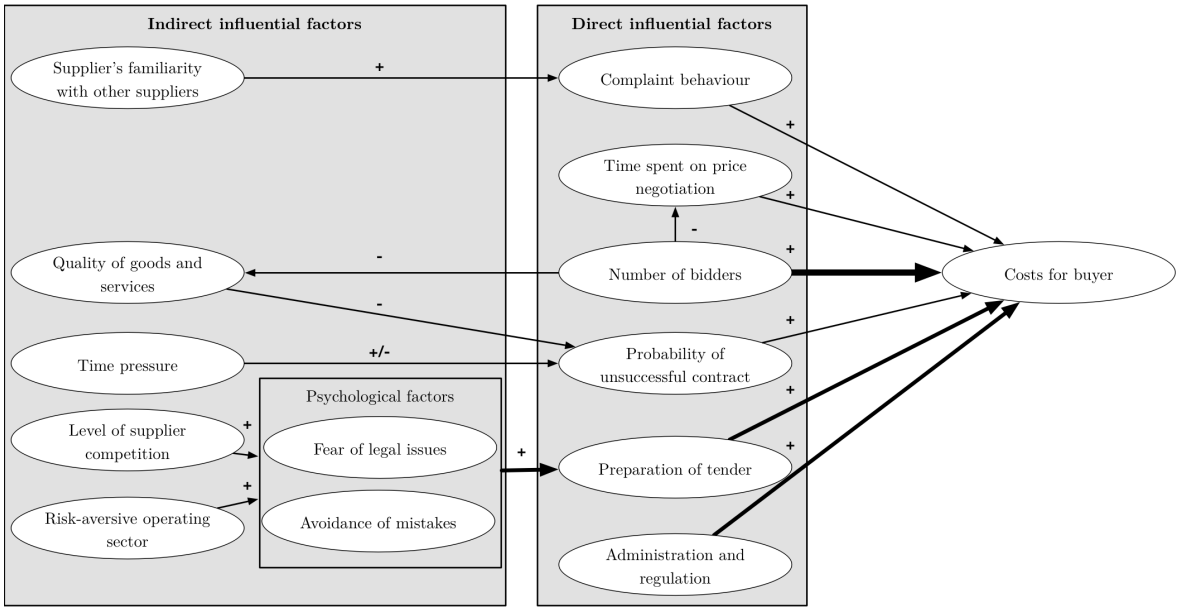

Figure 4.1: The summary from the collected expert opinions about the factors which influence costs for buyers associated with the public and invited procedures. Please note that the width of the arrows signifies the frequency a particular factors was named, e.g. wide arrows mean that a factor was acknowledged often.

effect on costs, meaning that the more regulated the process is, the more costs will be involved for buyer. Due to a more strict guideline for the public procedure, buyers will need to invest more time in the tender process than buyers following the invited procedure. Subsequently, that will lead to higher costs.

Secondly, *preparation of tender* was mentioned, which was influenced by two psychological factors, namely, *fear of legal issues* and *avoidance of mistakes*. The fear of legal issues stimulates buyers to more carefully consider preparation of tender, meaning that more time and money is devoted to, for instance, creation of specifications. This fear is more apparent in the public procedure since the tender is freely available to everyone and increases the probability of litigation. Therefore, the costs associated with this factor will be higher for the public procedure than for the invited procedure. Another similar psychological factor, which is avoidance of mistakes, is also more often noticed in the public procedure. This factor means more time-consuming tender preparation which is explained by buyers' willingness to protect their reputation and avoid unnecessary mistakes.

These psychological factors can be affected by two other indirect factors, which are *level of supplier competition* and *risk-aversive operating sectors*. The level of competition determines the probability of litigation and complaints. In the more aggressive markets, suppliers will more likely take a legal action against the buyer. The level of risk-avoidance within the operating sector also can influence the psychological nature of buyers and determine which procedure they will choose.

Additionally, there were other direct influential factors which were mentioned by single experts. For instance, *complaint behaviour of suppliers* can have a direct effect on costs or indirect via *suppliers' familiarity with other suppliers*. The expert explained that in case of the invited procedure, suppliers are more likely to know each other, which increases the risk of complaint. If a particular supplier was not awarded a contract and he knows the capabilities of the winning supplier, he is more likely to complain. As a result, costs for the buyer will increase.

Moreover, another direct influential factor is a *probability of unsuccessful contract*, which leads to a long-term risk for buyers. This factor can be affected by two aspects – *quality of goods and services* and *time pressure*. The quality of goods and services is influenced by an already previously mentioned factor, which is number of bidders. Taking into account costs, when there are more bidders competing, suppliers, in order to win the contract, are more likely to lower the offer price. This subsequently can expose quality of products or services to risk. With low quality procured goods or services, a buyer is expected to experience problems during the contract and might even need to create another tender later on. The risk of lowering the quality of products is higher in the public procedure due to the number of competing bidders.

The second indirect effect for probability of unsuccessful contract is time pressure. According to the experts, when assuming that the open procedure is a more regulated and longer tender procedure, suppliers have more time to prepare their offers and consider all relevant aspects. Therefore, the likelihood that a buyer will need to renegotiate the contract or even conduct a new tender is lower in contrast to the invited procedure. However, sometimes within the invited procedure buyer can provide more time to his invited suppliers to place a bid and prepare a proposal. As a result, there is no unanimous agreement among the experts which procedure is less costly in regard to the time pressure.

Lastly, the number of bidders can also influence the *time spent to negotiate the contract*. With less bidders, a buyer can devote more time to negotiate all the details of the contract, which will result in higher costs. Again, since the number of bidders in the invited procedure is significantly lower than in the public procedure, the costs associated with this factor will be different between the two procedures.

4.1.2 Factors influencing gains for buyers

Figure 4.2 presents a conceptual framework which summarises all differential influential factors for gains of buyers. It shows that most of the factors have a direct influence on gains. However, the most often acknowledged combination of factors consists of an indirect factor, which is *new suppliers*, and a direct factor - *innovation*. The number of previously unknown suppliers have a positive effect on innovativeness, since they can deliver new solutions which were not possible with the old suppliers. In its turn, innovative ideas might

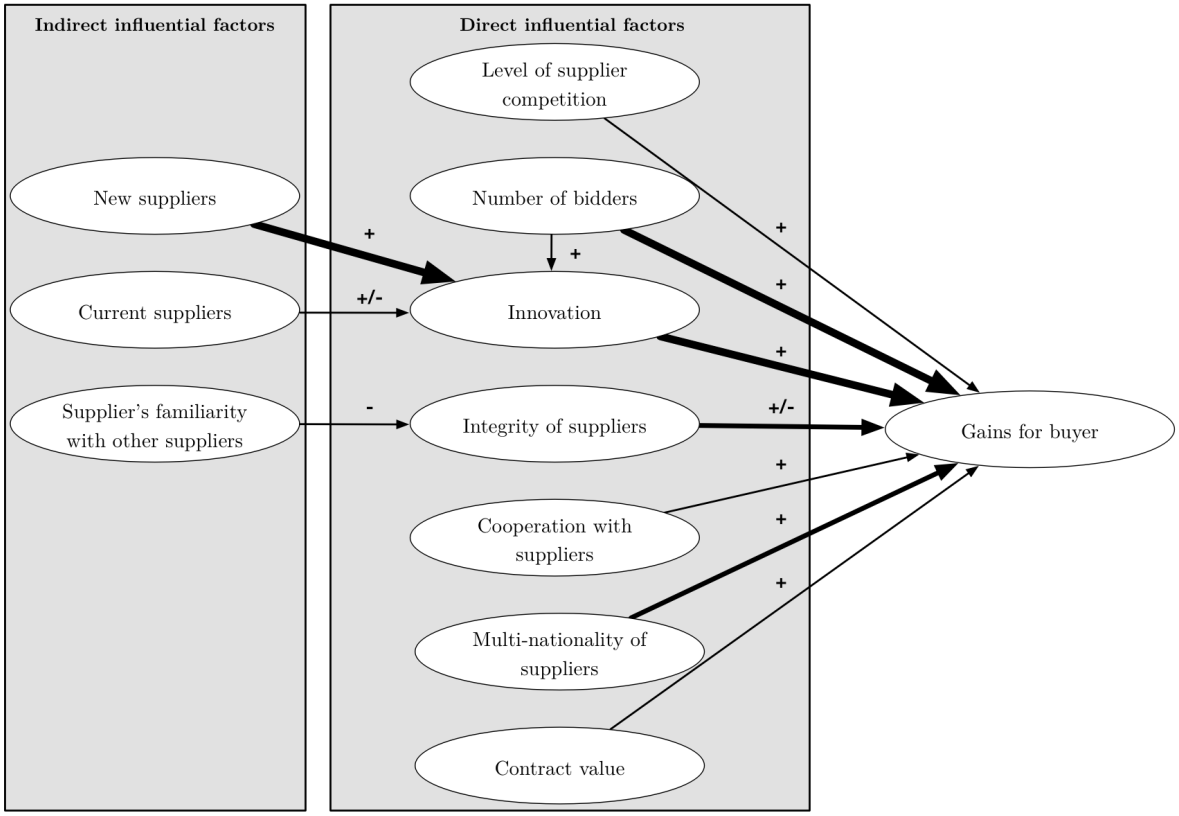

Figure 4.2: The summary from the collected expert opinions about the factors which influence gains for buyers associated with the public and invited procedures. Please note that the width of the arrows signifies the frequency a particular factors was named, e.g. wide arrows mean that a factor was acknowledged often.

help a buyer to reach savings. Since the public procedure allows anyone to participate, new suppliers will be present there. Consequently, they will lead to more innovative solutions and increase in gains. In comparison to the public procedure, in the invited procedure new suppliers is a rare phenomenon, which results in a difference between the two procedures.

In addition to an indirect effect of new suppliers, innovation can also be influenced by the presence of *current suppliers*. However, the effect of this indirect factor is ambiguous. On the one hand, current suppliers can be restricted in innovativeness due to their status. If they are always participating in tenders of a certain buyer, they might follow the same proposals and not think about any novelties. Consequently, this will provide buyers with less innovative proposals and will lower their gains. On the other hand, current suppliers already know a buyer and are aware of his preferences. This advantage can lead to more tailor-made proposals, which can contain specially designed innovative ideas. In that case, the buyer will gain more from current suppliers.

Another often mentioned direct influential factor is the *number of suppliers*. This factor has a positive effect on gains for buyers since with more suppliers, a buyer has a higher probability to get a creative and innovative solution for his request. As it was already

mentioned before, the number of bidders is higher in the public procedure. Therefore, based on this influential factor, buyers receive more gains within the public procedure than within the invited procedure. Interestingly, the number of bidders can also influence innovativeness of suppliers' ideas. When there are more bidders, suppliers are forced to think more innovatively in order to stand out with their proposals and have a higher chance to win the contract.

Two other factors, which were stated less frequently than the previous, but still more than one time, are *integrity of suppliers* and the *multi-national aspects of suppliers*. Firstly, integrity of suppliers is the extent to which a buyer can trust suppliers. On the one hand, according to some experts, it is easier for suppliers to collude with others in the invited procedure since they know who is invited. That is also supported by the indirect factor, which is *familiarity of suppliers*. In that way, the collusion can negatively affect gains for a buyer because suppliers can then manipulate prices of their offers. On the other hand, trust in suppliers is usually involved in the invited procedure because a buyer will less likely invite a dishonest supplier to bid. Following this idea, buyers can spend less time for preparation of the tender, more freely share their needs, rely more on the suppliers' opinion and subsequently get a better quality of proposals. Additionally, in the public procedure suppliers are less likely to advise a buyer if some of the details in the project are wrong or can be improved. The reason for that is the fact that suppliers can use this information about inefficiencies as their own advantage later during the contract to increase the price. As a result, supplier integrity can have a positive as well as negative effect on gains for buyers in both procedures and the distinction in the effects should be based on a certain situation.

Secondly, the number of *international suppliers* have a positive effect on gains for buyers. The willingness of international suppliers to start a business in a new country drives prices of their offers down as they usually expect to gain more from the operation in a foreign market later on. Since the public procedure allows an entry of not only new suppliers, but also of suppliers from other countries, this factors results in more gains in comparison to the invited procedure.

Lastly, the three factors mentioned by single experts are *level of supplier competition*, *cooperation with suppliers* and *contract value*. The level of competition on a supplier side is a meaningful factor in determining gains for buyers. If a market is competitive and suppliers do not know their competitors as in the case of the public procedure, they will invest more time in preparation of their bids instead of giving a random bid. Consequently, this factor will increase gains for a buyer participating in the public procedure as opposed to buyers choosing the invited procedure.

According to another expert, in the invited procedure it is easier to build a strategic relationship with a supplier. By establishing a cooperative relationship, a buyer is able to more easily receive a better quality and achieve a risk reduction. Thus, based on this factor, the gains for a buyer will be higher from the participation in the invited procedure.

Another factor, namely, contract value, can influence gains for a buyer by dint of the

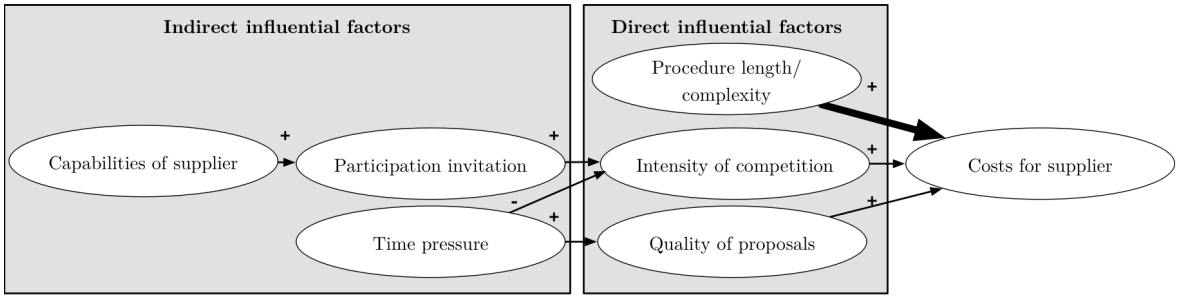

Figure 4.3: The summary from the collected expert opinions about the factors which influence costs for suppliers associated with the public and invited procedures. Please note that the width of the arrows signifies the frequency a particular factors was named, e.g. wide arrows mean that a factor was acknowledged often.

contract value – contract duration relation. For instance, contracts for such services as cleaning or catering of a higher value tend to last for a longer period of time than contracts of a lower value. Therefore, a buyer will need to issue a new tender later than he would do it for a lower-value contract, which results in higher savings. Sometimes buyers use bundling of services or goods to reach a higher contract value. In the example of the Dutch guideline of proportionality, contracts with lower values need to be procured through the invited procedure meaning that in that procedure less savings can be achieved based on the previously mentioned factor.

4.1.3 Factors influencing costs for suppliers

Figure 4.3 summarises factors that have a differential influence on costs for suppliers depending on the chosen national procedure. The factor which was acknowledged by almost all experts is *procedure length and complexity*. Usually the public procedure is more regulated, which requires more time and money from suppliers to prepare a bid. Moreover, if a supplier forgets to submit one of the required documents in the public procedure, that can cause a severe problem. Sometimes in the invited procedure suppliers can agree with a buyer to deliver a short-version of their proposals, which significantly decreases the preparation time. As a result, based on the procedure length and complexity, the difference in the effect on costs for suppliers is in favour of the invited procedure.

Another direct factor, which was mentioned once, is *intensity of competition*. First of all, the intensity of competition is influenced by *participation invitation*, which is a factor with an indirect effect on costs for suppliers. As mentioned during one of the interviews, suppliers need to weight total costs of bidding against possible gains from the contract. To calculate total costs of bidding, they need to multiply costs for bidding with the probability of winning the contract. Evidently, the chances of winning are higher in the invited procedure. Moreover, the overall costs based on this calculation method will be also higher for the

invited procedure. Important to mention is that this holds only for suppliers who are invited to participate in the tender. Therefore, invitation to participate in the tender is one of the influential factors. This factor is affected by *capabilities of suppliers*, namely, when a supplier shows a required level fo capabilities, a buyer will more likely invite him to participate in tender. Second of all, the intensity of competition can also be affected by the *time pressure*, which suppliers experience. For instance, if there is limited time to prepare proposals, there will be less suppliers willing to participate in tender.

Lastly, costs for suppliers can be directly influenced by the *quality of submitted proposals*. If a supplier is required to create a proposal within a short-period of time and experiences a *time pressure*, which is an indirect effect, then it is more likely that the proposal will not be well thought-out and its quality will be low. Consequently, that increases the probability that a risk will occur on a long term causing additional costs for suppliers to adjust or correct defects. As it was mentioned in the previous subsection, suppliers can be provided more time for preparation of proposals in both procedure, depending on circumstances. Therefore, a clear distinction of the effect of this indirect factor on costs cannot be made based on the collected information during the expert opinions.

4.1.4 Analysis of costs quantification

Estimation of fixed costs

During the interviews, we also asked the experts to estimate the overall transaction costs, incurred throughout the entire supply chain, for buyers and suppliers per public and invited procedure. In regard to the overall costs of buyers, all experts acknowledged that the public procedure is more expensive than the invited procedure. However, there was no unanimous agreement on the difference between the two procedures. Some experts stated that the proportion of these costs is equal to 1:1.25 or 1:1.70. Others claimed that public procedure is much more expensive, namely with the proportion of 1:10. The actual estimated costs also vary a lot, from €3000 to €30 000. To summarise, costs associated with the public procedure were estimated to range from €10 000 to €20 000 due to more bids which need to be assessed, more complaints to handle, etc. In the invited procedure, costs are significantly lower, namely from €3000 to €10 000.

In regard to the overall transaction costs for suppliers, experts expressed an analogous opinion as about costs for buyers. The public procedure is more expensive for suppliers than the invited procedure. Interestingly, the provided estimations of costs were significantly higher than for buyers. To be more precise, the costs varied within the range of €6000–50 000. Looking at the costs per procedure, experts stated that costs of the public procedure are from €20 000 to €50 000, while costs associated with the invited procedure range from €6000 to €20 000. Note that all the estimations of costs for suppliers were given for construction projects.

Table 4.1: Summary of distribution of costs per step in the procurement delivery chain for buyers.

	Pre-award	Award	Post-award	Complaint
Public procedure	50%	27%	12%	11%
Invited procedure	40%	33%	20%	7%

Note: The distribution of costs as percentage for buyers was estimated by the experts during the interviews.

Procurement delivery chain

In order to summarise the results from the experts regarding the distribution of costs per step in the procurement delivery chain, we decided to take an average percentage as an indication of the estimated costs. Table 4.1 provides and overview of the average percentage per step. Note that some experts instead of estimating costs as percentage, did it in days. We have also took them into account after transforming them into percentage.

The summary of the results shows that the most cost-consuming step within both procedures is pre-award. In the public procedure, this step requires a higher percentage of costs in comparison to the invited procedure. According to some experts, 15% of these costs are spent on arguing why a certain product needs to be procured, why a buyer chose a certain procedure, etc. For both procedures the award step is the second most expensive step. Interestingly, this step requires most resources from buyers in the invited procedure rather than in the public procedure. Even thought, some of the experts stated that this step is more expensive within the public procedure, the majority distributed the percentage in favour of the invited procedure. Similarly, the post-award is almost twice as expensive as the invited procedure. Lastly, the complaint phase is the least expensive stage in general. But in the public procedure the average percentage of costs is higher than in the invited procedure. As noted by an expert, that can be attributed to the fact that in the public procedure there are more unsatisfied suppliers. Therefore, it is more likely that there will be more complaints which need to be handled.

The summary of the distribution of costs for suppliers was done in the same way as for the buyers. Table 4.2 shows that in comparison to costs for buyers, where the most cost-consuming step was pre-award, in case of suppliers the most expensive step for both procedures is proposal. In the public procedure, suppliers spend around 58% of their costs on creation of proposal, while in the invited procedure this percentage is slightly lower — 49%. Some experts explain it with the fact that within the invited procedure suppliers do not need to submit information about their qualifications and the public procedure is more regulated and restricted in terms of submission of proposals. Moreover, suppliers tend to be more relaxed when creating the offer in the invited procedure. Additionally, if buyer is willing

Table 4.2: Summary of distribution of costs per step in the procurement delivery chain for suppliers

	Pre-proposal	Proposal	Post-proposal	Complaint
Public procedure	21%	58%	14%	7%
Invited procedure	27%	49%	21%	3%

Note: The distribution of costs as percentage for suppliers was estimated by the experts during the interviews.

to ask questions in regard to submitted proposals, then in the invited procedure there might be only one round of questions due to a lower risk associated with a lower contract value, while in the public procedure questions can be asked within 2–3 rounds. Despite the fact that most of experts acknowledged that in the public procedure the proposal step is more expensive, one expert stated that it is not always the case since in the invited procedure suppliers need to invest more time in discussions to understand the buyer better.

The second costly step for both procedures is pre-proposal. For the pre-proposal the experts noted that the invited procedure will require more resources from suppliers than the public procedure. That can be explained by the fact that when a supplier is already invited to submit his bid, there is more at stake for him. Therefore, he will spend more time on, for instance, the assessment of competitiveness and collaboration opportunities. Moreover, within the invited procedure suppliers need to start building relationship with a buyer. Nevertheless, the difference in the distribution of costs for this step is not large. A possible explanation can lie in the fact that within the first step, suppliers who want to participate in the public tender need to research the market and possible options, while in the invited procedure that is not required.

According to experts, the post-proposal step is more expensive for suppliers, participating in the public procedure. This step is similar for both procedures in terms of the required actions, as buyers within the post-proposal usually invite non-chosen suppliers to explain them their decision. Despite that, in the invited procedure buyers will take more time to explain their choice in order to build relationship with potential suppliers for further projects. The complaint step is the least cost-consuming and requires more resources from suppliers in the public procedure.

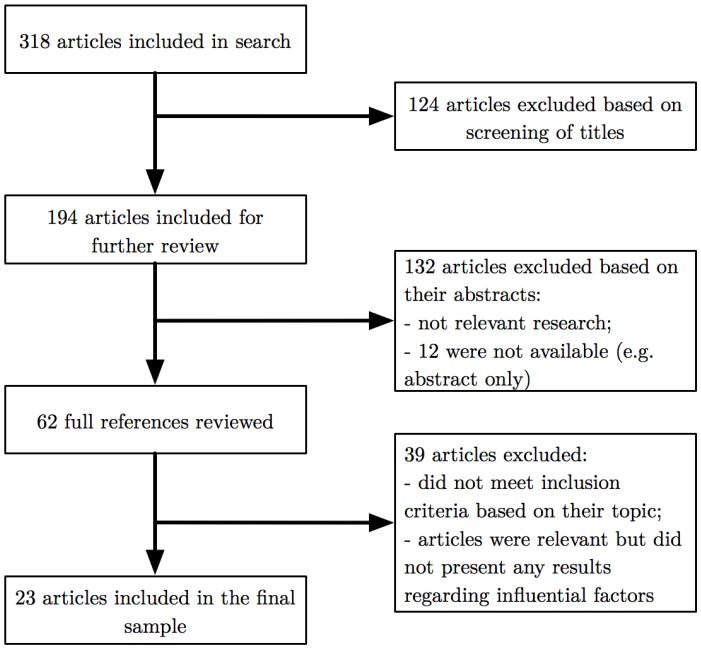

Figure 4.4: Study selection for inclusion in systematic literature review.

4.2 Analysis of literature review

4.2.1 Study selection

We reviewed 318 articles, from which we identified 23 references about costs or gains associated with tendering procedures for buyers and suppliers. From the final selection of references, 12 references addressed costs for buyers, 22 – gains for buyers, and 5 – costs for suppliers. See Figure 4.4 for the study selection process and results for inclusion in the systematic literature review. In Appendix C we present a full list and a summary of references included in the final sample.

Overall, none of the reviewed studies addressed the national threshold, while most of the studies focused on tenders above the EU threshold. The literature review revealed a variety of influential factors with the most common one – number of bidders. A number of influential factors found in the existing studies echos with factors discovered during the collection of expert opinions such as number of bidders, project complexity, etc. Even though, we managed to find numerous influential factors during the literature review, not all of their effects differ between the two tender procedures. Since this research is focused on differences in costs and gains between public and invited procedures, in the following descriptive analysis we provide information solely about factors with the differences in the effects per procedure.

4.2.2 Factors influencing costs for buyers

During the literature review many influential factors were found. While we provide a full overview of all direct and indirect factors in Appendix C, hereby only factors that differ per

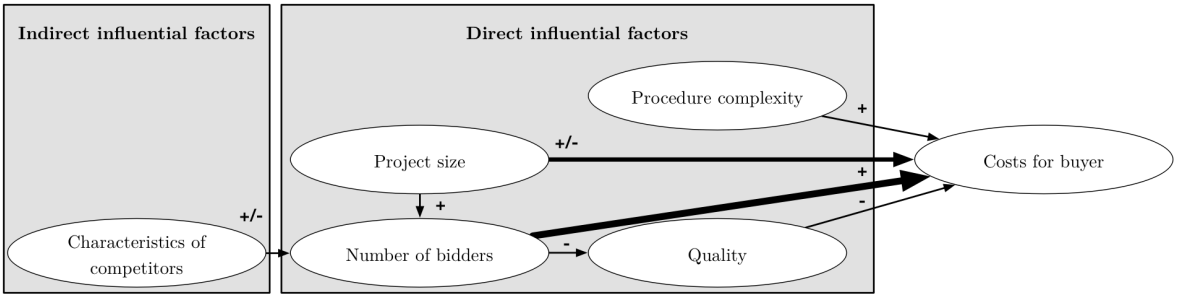

Figure 4.5: The summary of factors which influence costs for buyers associated with the public and invited procedures based on the literature review. Please note that the width of the arrows signifies the frequency a particular factors was named, e.g. wide arrows mean that a factor was acknowledged often.

national procedure are presented. Figure 4.5 shows that the most often addressed influential factor for costs for buyers in the literature, which clearly differs per national tender procedure, is *number of bidders*. Authors of two studies, namely, Costantino et al. (2012) and Onur et al. (2012), agree that there exist a positive relationship between the number of bidders and procurement costs, more precisely, the more there are potential suppliers, the higher the transaction costs for buyers are. Even though the authors of the third study support the idea that ex-ante costs are higher when the number of competitors is high, Carbonara et al. (2015) found a U-shaped relationship between the influential factor and costs, and different reasons for that. Firstly, costs can increase with the number of bidders due to the unwillingness of suppliers to invest time in preparation of the bid. Secondly, costs can increase with the low number of bidders because of the absence of competition, opportunistic behaviour, lower quality of bids and the need to renegotiate contract later during the project.

The second factor, which is also different per procedure and was mentioned twice in the literature, is *project size*. Both studies, namely the study of Carbonara et al. (2015) and Chever et al. (2017), acknowledge that ex-ante costs for small size projects are higher in regard to the percentage of the total project value in comparison to large projects. Chever et al. (2017) add that small projects are better to tender via the invited procedure due to the fact that open auctions involve a large amount of resources for a small part of the activity itself. To sum up, there are more costs involved for smaller contracts, which are procured via the invited procedure than for projects with a greater contract value, procured via the public procedure.

Other influential factor, which was mentioned once, but still can vary per procedure, is *procedure complexity*. According to Carbonara et al. (2015), ex-ante costs are higher for complex procedures due to the higher level of information which needs to be managed. However, ex-post costs are higher for simpler procedures due to the need for a greater effort in the monitoring phase and the likelihood of ex-post changes. Such findings result in a U-shaped relationship. In the study, the public procedure is referred to a more simple procedure

due to the simple methods of evaluation (i.e. absence of the initial selection of suppliers to invite to the tender), and the invited procedure is denoted as a more complex procedure. Consequently, the procedure complexity can have both a positive and a negative effect on costs for buyers in both national procedures.

According to Carbonara et al. (2015), the effect of the number of bidders on costs for buyers can also depend on the *size of project*. Usually, the bigger the project is, the more bidders are available. When translating these findings to the national procedures, we can say that bigger projects are procured with the public procedure. Therefore, based on these results, in the public procedure more bidders are expected.

Another indirect influential factor for the number of bidders is *characteristics of competitors*. Elmaghraby (2005) found an interesting phenomenon that auctions with both global and small suppliers decrease buyers' costs more than auctions solely with small bidders. Moreover, combined auctions with global and small suppliers can not only decrease, but also increase costs. When the number of global and small bidders is moderate to high, the probability that global suppliers will win and define the payment is high. Translating these findings to the situation in regard to the invited and public procedures, we can say that global suppliers are more often seen in the public procedure since their participation is not restricted. Therefore, depending on the participating suppliers, costs for suppliers increase or decrease in the public procedure.

Lastly, the indirect effect of the number of bidders on costs through *quality of offers* was presented by Milne et al. (2012). The authors argue that with a high number of bidders, the quality of offers decreases leading to higher costs for buyers. Based on the fact that in the public procedure there are usually more participating bidders than in the invited, the costs associated with the quality of offers will be higher in the public procedure.

4.2.3 Factors influencing gains for buyers

Similarly to the results about the influential factors for buyers' costs, the most often acknowledged factor that affects gains for buyers was the *number of bidders*. In total, 14 studies investigated the effect of the number of bidders on savings and several authors provided numerical outcomes for this relationship. Figure 4.6 presents an overview of factors which have a different influence on gains for buyers depending on which national procedure is chosen. For instance, Grega and Nemec (2015) found that every additional bidder decreases savings by 2.63 %. Gupta (2002) stated that the increase in bidders from 2–8 results in 12–14 % of savings, while increase in bidders from 2–6, in only 9–10 % of savings. Another study by Janke and Packova (2016) revealed that each new competitor causes an increase in savings for about 2.852%, while each bid — for 0.134 %. Gómez-Lobo and Szymanski (2001) found that when two bidders participate in a tender, savings increase by 12–13% in comparison to single bidder case. The findings of Carr (2005) are similar to the latter ones. The author

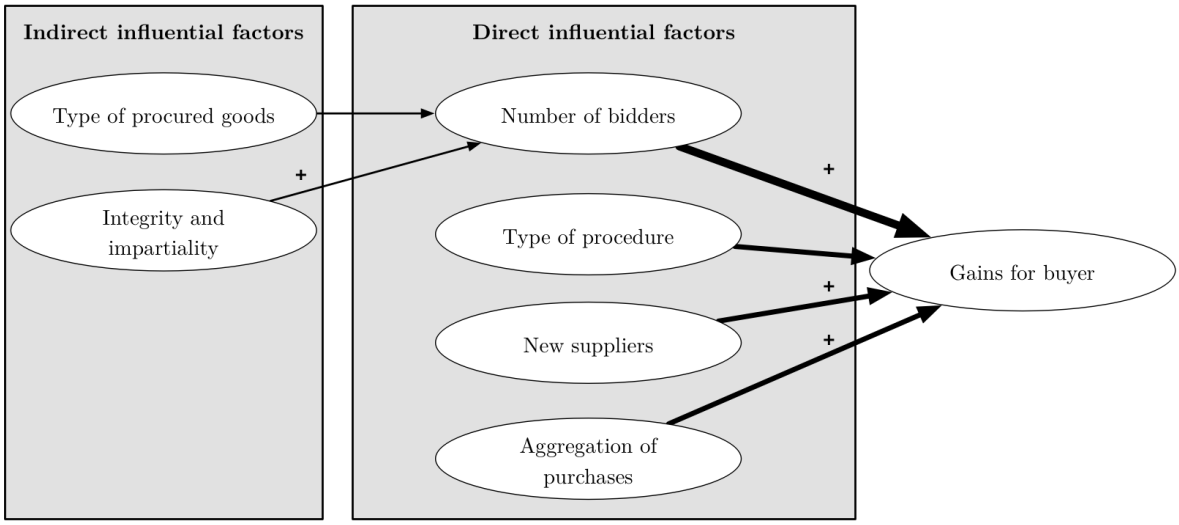

Figure 4.6: The summary of factors which influence gains for buyers associated with the public and invited procedures based on the literature review. Please note that the width of the arrows signifies the frequency a particular factors was named, e.g. wide arrows mean that a factor was acknowledged often.

states that in case when only one bidder participates, the price is approximately 15 % higher than with 2 participants. Moreover, he adds that the price reduces by 27 % when 8 bidders enter the tender and stagnates when more than 8 bidders participate.

Another frequently acknowledged influential factor for gains was the *type of procedure*. Hereby, authors of different studies share different opinions. Skuhrovec and Soudek (2013) found that the use of an open tender decreases the final price by 7 %, while Grega and Nemec (2015) revealed that the use of the restricted procedure increases final price by 11.56 %. Both studies agree that it is more beneficial for buyers to apply the public procedure. However, Costantino et al. (2012) argue that by introducing the pre-qualification phase and limiting the number of bidders, both the buyer and bidders are able to save money.

Foreign and new bidders formed another factor, namely *new suppliers*, that influences gains for buyers. According to Raventós and Zolezzi (2015), new participants in auctions bid more aggressively. Onur et al. (2012) support this idea and state that opening of auction to foreign bidders leads to cost-effective procurement auctions. Similarly to findings based on the expert opinions, new and foreign suppliers most often take part in the public procedure. Therefore, according to the above-mentioned authors, the effect of new and foreign bidders on gains will be higher for buyers in the public procedure than in the invited procedure.

Another influential factor from the literature review was the *aggregation of purchases*. Authors of the two reviewed references identified the importance of such an influential factor as aggregation of purchases. According to Karjalainen (2011) and Carbonara et al. (2015), economies of scale result in significant savings. The savings vary per procured product. For instance, for toner cartridges savings reach 8% and for flights – 37%. Since the value

of contracts is higher in the public procedure, it is expected that buyers will more likely aggregate their purchases in order to reach a greater contract value. As a result, gains associated with this influential factor are greater for buyers who choose the public procedure than for buyers who procure via the invited procedure with smaller contract values.

In the existing literature we also found two indirect influential factors for gains for buyers, which differ per national procedure, namely *integrity* on the number of bidders, and *type of procured goods* on the number of bidders. Sidwell, Budiawan and Ma (2001) claim that when integrity and impartiality are not established, potential suppliers may hesitate to make a bid. The reason for such hesitation is the fact that the formulation of bid requires a significant amount of invested time and resources. Consequently, fewer bidders will participate in tender and the best value for money may not be achieved. According to the experts, whose opinions were presented earlier, integrity is more likely to be established in the invited procedure. Therefore, there will be more costs associated with this indirect effect for buyers who choose the public procedure instead of the invited procedure. Lastly, the research of Onur et al. (2012) showed that the auction type, as well as the type of procured goods significantly affect the number of bidders.

4.2.4 Factors influencing costs for suppliers

In comparison to influential factors affecting buyers, factors that have an effect on suppliers are relatively sparsely mentioned in the literature. As shown in Figure 4.7, there were only 2 varying factors per procedure, which we identified. Firstly, *number of bidders* was acknowledged to have an influence not only on costs and gains for buyers, but also on costs for suppliers. The increase in the number of bidders results in decreased project bid prices for suppliers (Esmaeeli et al., 2007). The authors showed that there is a meaningful relation between number of bidders and (lowest bid)/(design estimate) or (mean bid)/(design estimate). By translating this to already known distribution of the number of bidders per procedure, costs for suppliers participating in the public procedure with more competitors are higher than for those who is invited to the tender.

Another influential factor with a differential effect on costs for suppliers found in the literature was *familiarity of bidders*. In case of the invited procedure, suppliers are more likely to know their competitors. This practice can provide a useful information when deciding whether to bid or not, as well as it helps to strategically set an offer price to optimise the likelihood of winning the contract (Ballesteros-Pérez, Skitmore, Pellicer & Gutiérrez-Bahamondes, 2016). Consequently, the effect of this factor on costs is positive for suppliers who participate in the public procedure where the familiarity of bidders is low.

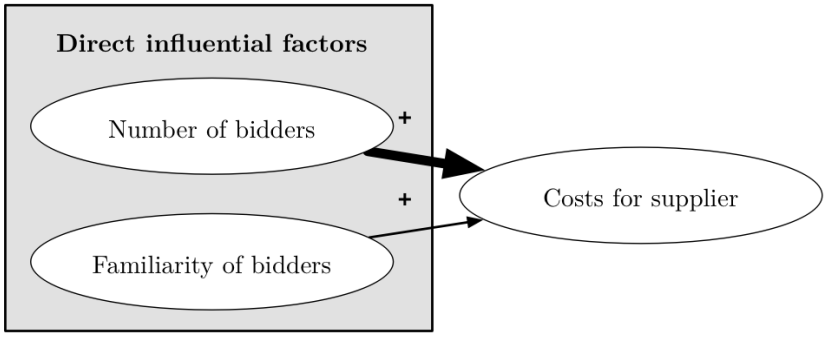

Figure 4.7: The summary of factors which influence costs for suppliers associated with the public and invited procedures based on the literature review. Please note that the width of the arrows signifies the frequency a particular factors was named, e.g. wide arrows mean that a factor was acknowledged often.

Chapter 5

Deployment of the decision framework

5.1 Selection of influential factors

After the information about the influential factors from the multi-method approach was collected and analysed, the next step is combining factors from the two data sources. Moreover, based on the list with the combined factors, we were able to make a selection of the most relevant factors for the further integration in the developed decision framework.

To begin with, we merged all the influential factors into a table to provide a clear and comprehensive overview of the findings. In Table 5.1, we present factors for which differential effects on costs and gains were found during the data collection. Similar factors were matched and are shown in the same line.

Even though all factors presented below certainly have an effect on costs and gains for the stakeholders depending in which procedure they participate, for the further integration of factors into the decision framework we make a selection. The selection is required because at the moment of performing this study, not all factors met the set criteria. The criteria consisted of 2 aspects.

First and foremost, the effects of the selected factors need to vary per national procedure because the main focus of the research is to compare costs and gains between the two national procedures. Therefore, if a factor does not result in differentiation of costs and gains between the two procedures, such a factor is not relevant for the current research. This criteria is named *variability*.

In general, the data collection was performed with the aim to focus only on factors which provide a differential effect. However, due to the varying nature of factors, effects of some factors are easier to differentiate per procedure than of the others. For instance, the differential influence of the number of bidders on costs and gains for buyers and suppliers is evident. The number of participating suppliers is usually higher in the public procedure.

Table 5.1: An overview of the combined influential factors from the expert opinions and literature review.

Expert opinions	**Literature review**
Influential factors for costs for buyers	
Number of bidders	Number of bidders[a]
Administration and regulation	Procedure complexity
Fear of legal issues	
Avoidance of mistakes	
Complaint behaviour	
A long-term risk	
	Project complexity
	Project size[a]
	Quality
Influential factors for gains for buyers	
Number of bidders	Number of bidders[a]
Innovation	
Integrity of suppliers	
Multi-nationality of suppliers	
Level of supplier competition	
Cooperation with suppliers	
Contract value	Aggregation of purchases
	New suppliers
	Type of procedure[a]
Influential factors for costs for suppliers	
Procedure length/complexity	
Participation invitation	
A long-term risk	
	Number of bidders[a]
	Familiarity of bidders

[a] Quantitative results were found in the existing literature for these effects of factors. The results are presented in Table 5.2.

Therefore, the variability of costs and gains which are affected by each additional bidder is easy to distinguish.

On the contrary, the effects of, for instance, the complaint behaviour are more ambiguous in terms of differentiation per procedure. If a supplier complains, then costs for buyers associated with the complaint handling probably will not differ per procedure. However, it is important to mention that when the factor "complaint behaviour" is supplemented by the indirect influential factor, which is "supplier's familiarity with other suppliers", it becomes easier to distinguish its effects on costs per public or invited procedure. That is due to a small number of suppliers who are invited to participate in a tender and a higher probability that suppliers will know each. Therefore, it is more likely that suppliers will complain in case they are not awarded a contract.

Table 5.2: An overview of quantitative results about the effects of influential factors found in the literature.

Factor	Quantification
Influential factors for costs for buyers	
Number of bidders	The study provided a graph with the total cost of purchasing for a varying number of bidders. The number of bidders varies within the range of 0–66. The results show that the optimal number of invited suppliers, for which the total costs would be minimal, varies with the scenario[a] and increases with the standard deviation of costs among bidders. Moreover, the optimal number of suppliers can range from 3 to 34 (Costantino et al., 2012).
	The study showed in a graph that tendering costs, consisting of direct and indirect costs of inviting a number of suppliers, increase linearly with every additional bid (de Boer et al., 2000).
Project size	The authors found that ex-ante costs in regard to changes in project size do not vary per procedure. However, the difference in ex-post costs for small project to large projects is higher for procedure with a low level of information. More precisely, the biggest difference in ex-post costs is 9.5 for the procedure with the lowest level of information (i.e. public procedure). While the smallest difference in ex-post costs is 3.5 for the procedure with a high level of information (i.e. invited procedure) (Carbonara et al., 2015).
Influential factors for gains for buyers	
	Every additional candidate results in a 2.63 % increase in savings (Grega & Nemec, 2015).
	Each new competitor results in contract savings of approximately 2.852%; each bid increases savings by more than approximately 0.134 % (Janke & Packova, 2016).

	Each additional bid decreases the price by 3.4 % of the expected price (Pavel & Sičáková-Beblavá, 2013).
	Every additional supplier reduces the price for sugar by 5.2 % (Yakovlev, Bashina & Demidova, 2014).
	The presence of an extra bidder results in around a 3.9 % decrease in procurement price relative to the estimated cost (Onur et al., 2012).
	Increase in bidders from 2–8 result in 12–14 % of savings; from 2–6 — in 9–10 % (Gupta, 2002).
	When 1 bidder participates in an auction, the price is approximately 15 % higher (deviation from the estimate) than when 2 bidders compete. This figure is reduced by 27 % when eight bidders enter the auction and stagnates when more than eight bidders enter the auction (Carr, 2005).
	The presence of two bidders reduces expenditure by about 12–13% compared with the single bidder case. The average saving from CCT over the sample is between 20–22%. For the case of 4 bids, the cost savings are 13% of the original level (Gómez-Lobo & Szymanski, 2001).
Influential factors for costs for suppliers	
Number of bidders	The study provided a graph with the total social cost of purchasing (i.e. costs for buyers and suppliers) for a varying number of bidders. The number of bidders varies within the range of 0–66. The results show that the optimal number of invited suppliers, for which the total costs would be minimal, varies with the scenario[a] and increases with the standard deviation of costs among bidders. Moreover, the optimal number of suppliers can range from 3 to 18 (Costantino et al., 2012).
	The study provided a graph, in which the value/designer's estimate is shown per number of bidders. According to the findings, there is a significant relation between number of bidders and (lowest bid)/(design estimate) or (mean bid)/(design estimate). Moreover, an increase in number of bidders, decreases (lowest bid)/(design estimate) or (mean bid)/(design estimate) and it means a decrease in buyer's mark-up (Esmaeeli et al., 2007).

[a] Scenarios denote different standard deviations of the cumulative distribution of the production cost. Costantino et al. (2012) use five parameters for the scenarios, namely 0.01 % (S_1), 0.025 % (S_2), 0.05 % (S_3), 0.10 % (S_4), and 0.15 % (S_5).

To sum up, the extent of differentiation of the effects varies per factor. When assessing all factors based on the criteria of variability, the following factors in the category "Influential factors for costs for buyers" are selected: number of bidders, administration and regulation and procedure complexity, fear of legal issues, project complexity and project size. Regarding the category "Influential factors for gains for buyers", the factors number of bidders, multi-nationality of suppliers, contract value and aggregation of purchases, new suppliers and type

of procedure are chosen. And in the category "Influential factors for costs for suppliers" we selected such factors as procedure length/complexity, participation invitation, number of bidders.

Second of all, in order for the factors to be integrated in a model which provides guidance on the choice of the contract value in a mathematical way, the *quantifiability* of factors is an important criterion. With the quantifiability we mean to what extent an effect of a factor can be quantified based on the collected information. During the systematic literature review, we found that only a limited number of researches about the influential factors estimated their effects on costs and gains in a quantitative way. The majority of studies either only acknowledged the presence of a relationship or provided qualitative results regarding the effects. Although, such findings contributed to the composition of an overview of influential factors, they are not useful in the further process. In Table 5.1 we marked factors, for which quantifiable effects were available, while in Table 5.2 we present an overview of these quantitative findings.

To conclude, based on the two criteria presented above, the factors which will be included in the further process of deployment of the decision framework and estimation of the functions per factor in the category "Influential factors for costs for buyers" are number of bidders and project size. In the category "Influential factors for gains for buyers", as well as in the category "Influential factors for costs for suppliers" the only factor, which is number of bidders, will be used for the deployment of the decision framework. It is important to mention, that at this stage of the research, other factors are not selected due to their inability to meet our selection criteria. However, if in a future research quantification of these factors will be estimated, then the framework can be complemented with those.

5.2 Estimation of effects per influential factor

After the decision framework was formalised mathematically and all the effects of influential factors were researched and selected, as the next step we estimate the effects of individual factors in more detail in regard to the differences in costs and gains for the two national procedures, and insert them into the proposed model. The main purpose of the decision framework deployment is to validate its functionality and get a sense of how the different factors might influence the most beneficial threshold value.

Note that the results of the subsequent decision framework deployment are not fair since the studies, which we used for the quantification of the effects, applied different study scopes, regions, the time frame for data collection, etc. Moreover, most of the time the scale of resulted data is incomparable, as one study may have used, for instance, a proportional difference and another a monetary scale. Therefore, the results should not be interpreted literally. Our goal is to provide all data that, to the best of our knowledge, was available at the moment of writing, and provide some insight in the relationships.

5.2.1 Framework deployment setup

The deployment of the decision framework is divided into four steps. Firstly, we selected relevant factors based on the variability and quantifiability. The selection process was outlined in Section 5.1.

Next, we determine a few variables which are necessary for the deployment of the decision framework and which will not change depending on the different factors. We set the maximum contract value, which is used for the range of the functions and calculation of the total overall benefits, to €150 000. This value is chosen as according to OJEU (2018), the EU threshold is currently €144 000. Moreover, to make a distinction between the two procedures for one of the most important factors within each category, namely, the number of bidders, we set a number of bidders in the invited procedure to 2–5 bidders and in the public procedure to 5–35 bidders[1].

Thirdly, we transform the output of each study to a standardised format. More precisely, in some studies, the gains or costs of factors were not directly stratified by contract values. To transform the functions of the factors to our format, we used a proxy (e.g. number of bidders) to map the output of the function to the number of bidders, and subsequently map the number of bidders to a certain contract value of a procedure. An example can be found in Appendix D.

After the transformations, we quantify costs and gains of the relevant factors that are stratified by contract value. We then calculate differences of the effects on costs and gains from various factors. For this we subtract costs or gains associated with the invited procedure from the costs or gains of the public procedure. The same differential approach is used to calculate all costs and gains presented in the subsequent sections. After we sum these differential results per factor in order to reach the highest granularity of "Total differential costs" and "Total differential gains". In case of multiple functions for the same factors (as will be seen for the factor "number of bidders"), the average is used of that particular factor for the calculation of the total differential costs or gains. In the next subsection, we present our results of the framework deployment.

5.2.2 Results of the deployment of the decision framework

After following all the steps for the preparation and standardisation of data, we run the analysis on the differential costs and gains for buyers and for society (i.e. buyers and suppliers). In this section we first briefly introduce aggregated results of different studies about quantitative estimations of the differential effects on costs and separately on gains. Then we combine the summated differential costs and gains into one model. Since we decided to

[1]In the expert opinions, there was a consensus that usually 5 bidders is the boundary where the public procedure would start. Regarding the chosen maximum of 35 bidders, this is determined by the literature, where most of the studies used an upper bound of approximately 35 bidders.

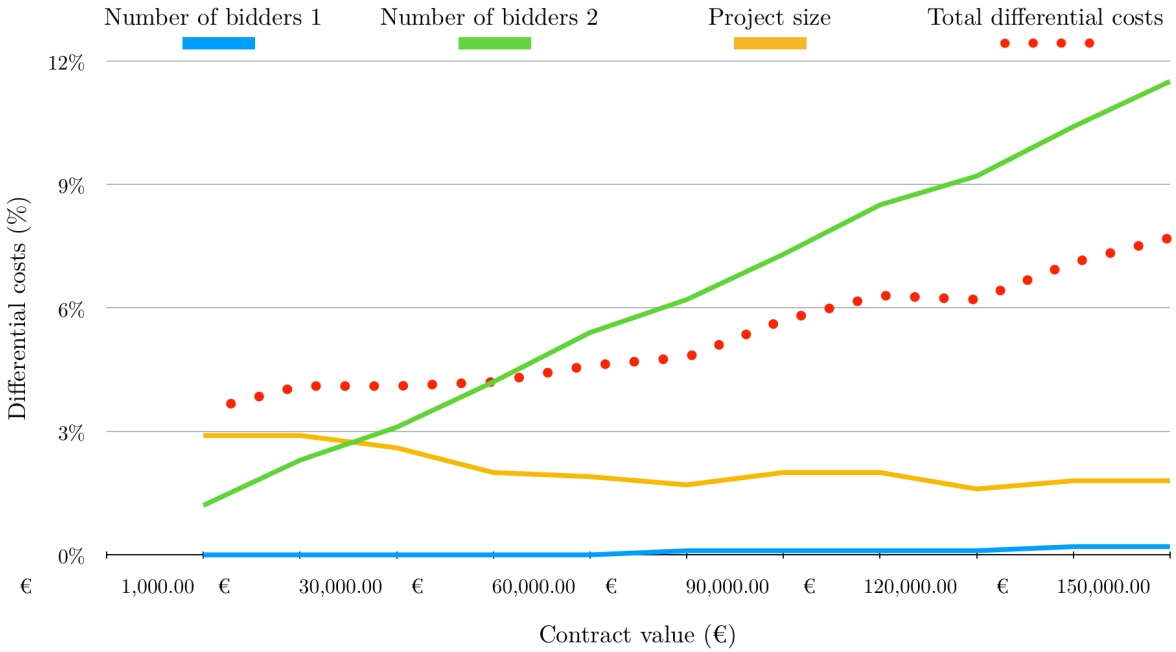

Figure 5.1: Aggregated results of differential costs for buyers. Used sources for the data are: Costantino et al. (2012) for "Number of bidders 1"; de Boer et al. (2000) for "Number of bidders 2"; Carbonara et al. (2015) for "Project size".

not only examine the scenario with buyers, but also to assess effects of factors on the whole society, the same analysis will be performed for the results which include factors for the society. A more detailed analysis on the estimations of the effects on costs and gains per factor and per separate study, prior to the calculation of differences per procedure, can be found in Appendix D.

Aggregated results of differential costs and gains for buyers

To begin with, we provide a graphical presentation of the aggregated results of the differential effects on costs and gains for the factors which we selected earlier in Section 5.1. Each function in the graphs below represents a numerical outcome of different studies based on a certain factor. The graphs also include a function of total differential costs or gains, which is the sum of all individual functions.

In Figure 5.1 the function of "Total differential costs" presents the summated results of all available studies about the differential effects of influential factors on costs for buyers. We can see that the total difference in costs between the two procedures caused by two influential factors, namely number of bidders and project size, increases with contract value given our model assumptions. More precisely, costs of the public procedure increase greater for more expensive contracts than costs of the invited procedure.

When studying the differential effects on costs per factor and per study, we can see that findings differ significantly. The function "Number of bidders 1", which was based on the

study of Costantino et al. (2012), reveals an insignificant difference in costs per procedure based on the number of bidders. A small difference in costs is noticed only for very high contract values. However, another study, namely the study of de Boer et al. (2000), which findings are presented by function "Number of bidders 2", stated that costs affected by the number of bidders increase linearly and rapidly. The main explanation can be the difference in the number of participating bidders per national procedures. As mentioned before, we assume that in the invited procedure, the number of bidders remains within the range of 3–5 over different contract values. Therefore, based on the findings of de Boer et al. (2000), the costs associated with the number of bidders in this procedure vary slightly. On contrary to the number of participating bidders in the invited procedure, in the public procedure we assume the number is significantly higher, which requires buyers to spend more time and consequently money on, for instance, processing of bids. As a result, buyers, who choose the public procedure, will have costs that increase more rapidly with contract value than buyers who use the invited procedure.

As a last influential factor for costs for buyers, which we chose to use in the framework deployment, is project size. The effect of the project size was estimated based on the study of Carbonara et al. (2015). Interestingly, as shown in the graph, the difference in costs for this factor is opposite to the previously mentioned factors, i.e. for greater contract values, the difference in costs decreases. That means that costs, associated with this factor, become lower when buyer procures a more expensive project. The authors explain it with the difference in effects on ex-ante and ex-post costs. According to the original study, the restricted procedure (in our case the invited procedure) possesses a medium level of information, while the open procedure (i.e. public procedure) — a low level of information (Carbonara et al., 2015). Such a distinction was made due to the pre-qualification phase, which is apparent in the invited procedure and which requires a higher amount of information for buyers. Going back to the costs associated with the project size, ex-ante costs do not change significantly in relation to changes in the level of information. However, ex-post costs vary per different procedure. More precisely, simpler and accordingly smaller projects will require a greater effort for the monitoring of contract and enforcement. Therefore, contracts of small values in the public procedure will be more expensive for buyers than contracts of higher values and the difference in costs decreases between the two procedures with increase in contract values.

The results of total differential gains for buyers presented in Figure 5.2 are similar to the situation of the total differential costs. More precisely, in both situations the difference in costs and gains are higher for greater contract values for buyers choosing the public procedure than for buyers using the invited procedure. However, the main difference between the total differential costs and gains is in the fact that values for gains have a reverse meaning than values for costs, i.e. the higher the differential gains, the more favourable the procedure is. However, in case of the total differential costs, the higher they are, the less beneficial the procedure is.

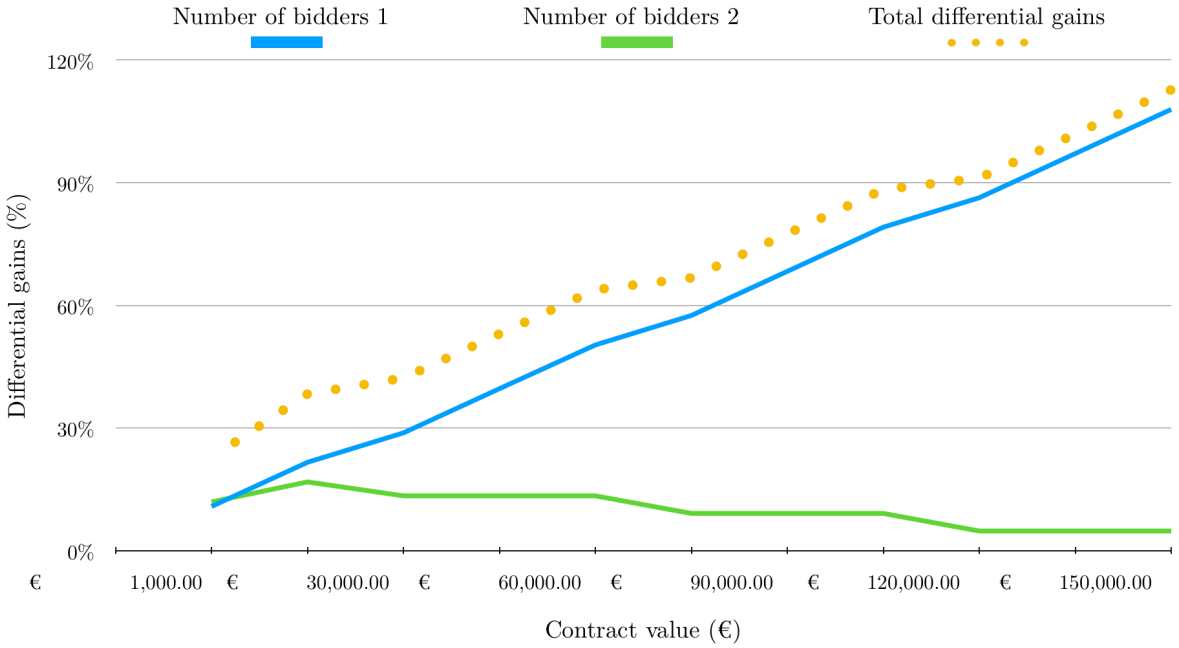

Figure 5.2: Aggregated results of differential gains for buyers. Used sources for the data are: Grega and Nemec (2015); Janke and Packova (2016); Pavel and Sičáková-Beblavá (2013); Yakovlev et al. (2014); Onur et al. (2012) for "Number of bidders 1"; Gupta (2002); Carr (2005) for "Number of bidders 2".

To estimate the total differential gains, we used one influential factor, which we chose based on the selection described in Section 5.1. This factor is number of bidders. Since multiple studies researched the effect of the number of bidders on savings for buyers, we used all the available findings and divided them in two groups. The authors of the first group of studies, whose aggregated findings are presented in function "Number of bidders 1", concluded that there is an equal increase in gains with each additional bidder. Since each study calculated a different increment within a range of 2.63–5.2%, we decided to take an average of these results as an increment for the aggregated results. That resulted in a linear increase in differential costs.

The second function, which is "Number of bidders 2", is based on two other studies, namely the studies of Gupta (2002) and Carr (2005). The function shows that the difference in gains decreases with higher contract values in contrast to the first function. The decrease is caused by the stagnation point of gains, which was found by the authors of the studies. For both procedures, we used the average number of bidders from the two studies after which gains do not increase anymore. This stagnation point is reached at 6 bidders. In the public procedure the stagnation point is reached already at the lowest contract values, since the maximum number of bidders is assumed to be 35 for the highest contract values. However, in the invited procedure the stagnation point is not reached at all, since the maximum number of bidders is assumed to be 5. As a result, for the lowest contract values the difference in

gains is high, but after €15 000, the difference decreases.

Aggregated results of costs for the society

In order to assess the differential effects of factors not only on costs for buyers, but for the whole society, we added the functions of the differential costs affected by the number of bidders for suppliers. Figure 5.3 presents these combined results.

The function "Total differential costs" presents the estimated differential costs for the society. We can see that the difference in costs between the two procedures increases with higher contract values, meaning that costs for the society in the public procedure are greater for higher contract values than in the invited procedure. When comparing total differential costs of buyers only with differential costs for the society, we conclude that the latter costs show a more steep increase. Moreover, the difference in costs for buyers only ranges within 3.5–7.7 %, while the difference for the society is within a greater range, namely within 7–26 %. This increase in differential costs is due to an additional factor for costs for suppliers, namely, number of bidders and its effect on costs. For the quantitative estimations of the effects from this factor, we used two studies. The findings of these studies are outlined in more detail below.

Function "Number of bidders 1 suppliers" shows an increase in differential costs for suppliers when a contract value increases. According to the study of Costantino et al. (2012), a smaller number of bidders participating in a procurement tender leads to a decrease in costs

Figure 5.3: Aggregated results of differential costs for suppliers. Used sources for the data are: Costantino et al. (2012) for "Number of bidders 1 buyers"; de Boer et al. (2000) for "Number of bidders 2 buyers"; Carbonara et al. (2015) for "Project size"; Costantino et al. (2012) for "Number of bidders 1 suppliers"; Esmaeeli et al. (2007) for "Number of bidders 2 suppliers".

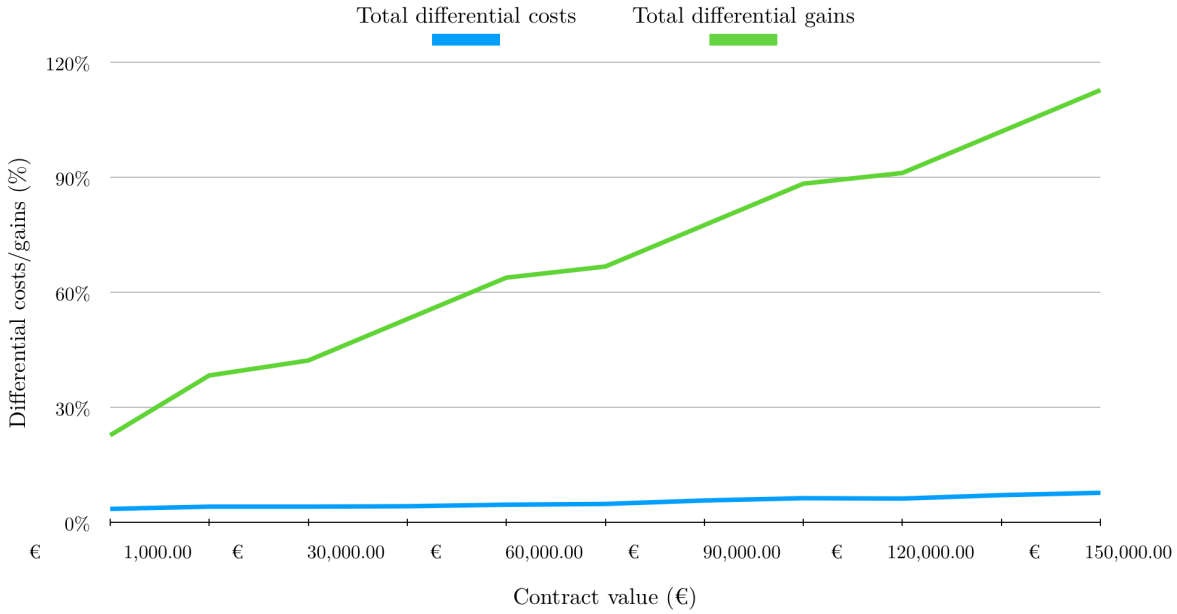

Figure 5.4: The total differential costs and gains for buyers.

for the society. Since the number of bidders participating in the public procedure is assumed to be higher for higher contract values than in the invited procedure, the difference in costs increases. However, after reaching a contract value of €120 000, the increase diminishes.

Another study, which acknowledged the effects of the number of bidders on costs for suppliers, also showed an increase in differential costs with each additional bidder (see function "Number of bidders 2 suppliers"). According to Esmaeeli et al. (2007), with a higher number of bidders, there is a decrease in supplier's mark-up. Since in our estimation of functions we assume an increase in number of bidders for higher contract values, we observe such a linear increase in differential costs between the two procedures.

Total differential costs and gains for buyers

After we aggregated the estimated effects on differential costs and gains from various studies in one model and combined them into functions of total differential costs and gains, we plotted these functions in one graph. Based on the earlier developed decision framework, in case of the non-multimodal functions, the intersection point of two functions is the optimal contract value for setting the threshold. Therefore, since the resulted functions of the total differential costs and gains do not have multiple peaks, the simplified decision framework with the above-mentioned solution for the optimal threshold value can be applied.

Figure 5.4 summarises all the previously described effects on differential costs and gains for buyers and shows that both total differential costs and gains increase with the contract values. However, the total differential gains increase at a higher rate than differential costs. A possible explanation can be in the fact that studies, which were used for the estimation of

the quantitative effects, used different scales, data and scope. Therefore, the measurements of the gains are not directly comparably with the measurements of costs.

Moreover, the graph shows no intersection point of the two functions meaning that when the differential gains are larger than the differential costs, the public procedure is preferred at all times. There are three possible explanations for this outcome. First of all, it can be true that despite the fact that usually the invited procedure is chosen for the majority of contracts, the public procedure in reality is more beneficial for any contract value. In that case, the threshold value should be placed as low as possible to ensure that majority of contracts is procured using the public procedure.

Second of all, the alternative explanation, considering the used data from the studies, is that due to different measurements scales, used unites, contexts and many other differing aspects, the quantitative results of the original studies are difficult, if not possible to compare. Therefore, it is possible that the functions of the total differential costs and gains are vastly different, and in reality do intersect. But unfortunately with the data we possess, it is not possible to determine what the actual aggregated functions are and whether and where they intersect.

Lastly, it is possible that the functions of the differential costs and gains look different depending on the operating sectors, markets, influence of other factors, which were not taken into account for this decision framework, etc. Since we took two influential factors for the deployment of the framework as a starting point, with additional data the functions most probably will follow a different pattern with a new proposed threshold value.

Total differential costs and gains for society

In order to find the optimal threshold for the society, we added the earlier presented quantified effects of factors on differential costs for the suppliers to the costs for buyers. Figure 5.5 presents the summated differential costs and gains. From the graph we see a similar situation as with the differential costs and gains for buyers, namely the two functions do not have an intersection point. That means that in order to reap maximum gains with minimum costs for the society, it is also advised to place the threshold at the lowest contract values. Such a decision will ensure that the majority of contracts is procured via the public procedure, which, given our model estimations, is more beneficial than the invited procedure. Interestingly, since the optimal threshold value for only buyers was also estimated to be at the lowest contract values, when taking into account only costs and gains for a single stakeholder, namely buyer, the public authorities already make an optimal decision for the society too.

Despite the fact that the functions for the society look almost identical as functions for buyers, the function of the total differential costs for the society slightly differs. Since we added the estimated effects from number of bidders on costs for suppliers to the total differential costs for buyers, the end function moved up in the graph. Moreover, now we can

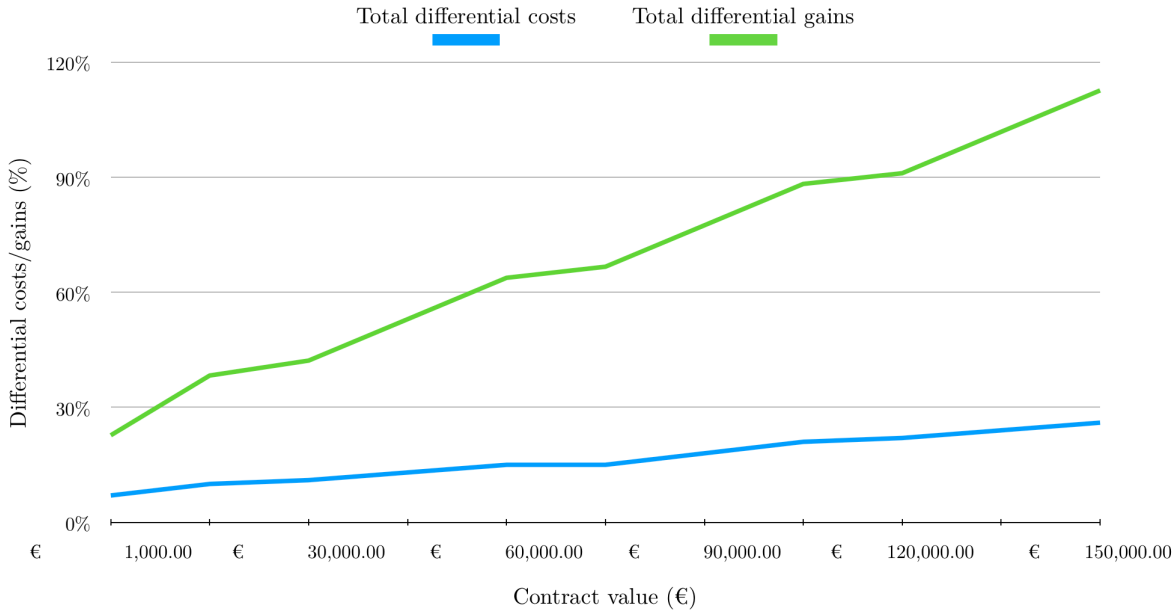

Figure 5.5: The total differential costs and gains for society.

see an increase in differential costs with higher contract values, which was almost not visible in the situation with buyers only.

Chapter 6

Discussion of results

In this chapter, we discuss the implications of the previously presented findings for current literature and provide our recommendations for practice. To achieve the goal of the study, which is to provide public authorities with a systematic way to choose the optimal threshold in order to maximise gains of all tenders, we took a comprehensive approach. That implies the development of a decision framework based on multiple dimensions of public tendering, which are discussed below.

Ambiguity of costs and gains in public procurement

First of all, we assessed the core aspects of decision-making in public procurement, namely, costs and gains. The assessment was done by means of a literature review and collection of expert opinions. Interestingly, both sources of information do not refer to one fixed amount of costs and gains. The reason for that is the dependance of costs and gains on the situational context, geographical area, operating sector and most importantly — factors that influence these two concepts. Therefore, the quantitative amount of costs and gains cannot be generalised and is strongly dependent on many aspects.

Public procedure is more cost-consuming than the invited procedure

Despite the fact that costs and gains of public procurement cannot be expressed by a single number, all the experts agreed that the public procedure is certainly more expensive than the invited procedure. The overall transaction costs incurred by buyers choosing the public procedure can vary within the range of €10 000–20 000, which is 2–3 times more expensive than the invited procedure, which was estimated to cost €3000–10 000. The most common explanation for the differences in the overall costs for buyers was the fact that in the public procedure a greater number of bidders take part, which require more person-days or FTEs for each individual bidder and associated activities such as the assessment of a proposal, negotiation, etc.

A similar conclusion in regard to the overall transaction costs was reached for suppliers.

Experts unanimously stated that the public procedure is significantly more expensive. The costs for the invited procedure for a single supplier were estimated at €6000–20 000, while costs for the public procedure were concluded to start at €20 000 and more.

Buyers spend more during the pre-award stage, while suppliers — during the proposal stage

Additionally, we found that even though the awarding phase for buyers requires a lot of time from purchasing employees to manage proposals and evaluate and if necessary negotiate them, it is not the most cost-consuming stage of the procurement delivery chain. According to the experts, the first step, namely the pre-award, is the phase when buyers spend the most money. More precisely, the pre-award phase of the invited procedure requires 40 % of the overall transaction costs, while in the invited procedure this number reaches 50 %. This finding is in line with the statement that the greatest impact on costs for buyers is made within the specification phase, namely, when deciding what exactly will be purchased (de Boer & Telgen, 2010). As a result, the stage which has the highest impact on potential costs is also the most expensive stage in regard to transaction costs.

However, for suppliers it is indeed the second step of the procurement delivery chain or the proposal stage, which requires the most resources. The experts argued that these costs can reach nearly 50 % in the invited procedure and nearly 60 % in the public procedure. One of the reasons for such difference in the distribution of costs per procedure lies within the psychological factor. According to the experts, suppliers can have an ease of mind when preparing their proposals within the invited procedure as they have already been invited to the tender. Other reasons are more regulations in the public procedure in regard to the submission of proposals and more required adjustments of proposals due to having a higher contract value than in the invited procedure.

A full list of influential factors for costs and gains as the main contribution to current literature

After costs and gains were analysed, we performed a research on another important aspect of the public tendering — influential factors. Two sources of information showed that costs and gains for buyers and suppliers change depending on a variety of factors. These factors form a complex relationship, which includes direct and indirect factors, factors, which effects can be estimated numerically and factors of a qualitative nature. The most often acknowledged factors by experts and in the literature with differential effects on buyers' costs are number of bidders, time needed to prepare a tender, administration and regulation, project size and such indirect psychological factors as fear of legal issues and avoidance of mistakes. The most frequent effects on gains for buyers were mentioned from such factors as number of bidders, innovation, integrity and multi-nationality of suppliers, type of procedure, aggregation of

purchases and new suppliers. Finally, the most frequent factors, which influence costs for suppliers, are number of bidders and procedure length/complexity.

The main insight which we added to the current literature is an exhaustive list of all influential factors with different extents of influence on costs and gains for both stakeholders. To the best of our knowledge, a similar comprehensive analysis was not performed previously and only certain factors were studied in isolation of other factors. For instance, in our study we showed that the most often studied factor, namely the number of bidders, is not the only factor which influences costs and gains. During the decision framework application we found that the function of the factor "project size", which was studied less frequently, has a reverse differential effect on costs for buyers. That suggests that in order to have a complete view on how costs and gains change depending on different contract values, all influential factors need to be considered simultaneously and our proposed list of influential factors is of a great value to accomplish that.

Differences between the total differential costs and gains

Lastly, we applied the earlier developed decision framework with the available quantified results from literature. The application revealed that both differential costs and gains increase with contract values. However, for buyers the increase in costs with contract values has a negative effect since they need to spend more on bigger projects. On the contrary, the increase in gains is beneficial for them as there are more benefits associated with greater contract values. This finding suggests that there is indeed a point in contract values where the associated gains of the invited procedure surpass the costs and it becomes more beneficial to choose the public procedure.

The framework application also revealed that even though the differential costs and gains show an increase over contract values, gains increase more rapidly than costs. The function of total differential gains show an almost linear growth of 22.7–112.7 %, while the quantified effects on the differential costs increase only within 3.5–7.7 % within the same range. As a result, we can conclude that gains play a more significant role in the determination of the threshold value than costs.

A simultaneous optimisation of the threshold value for buyers only and for the society

The extension of the decision framework with functions of the effects on costs for suppliers showed that the function of the total differential costs for society did not change significantly. That suggests that the effects of factors on costs for suppliers do not vary to a great extent. Therefore, when buyers make a decision in regard to the contract value for the most beneficial threshold, they simultaneously optimise the threshold value for the whole society.

6.1 Recommendations

Based on the conducted research, we are not only able to provide new insights to the current literature about decision-making in the public procurement, but also to contribute to practice. The results of the study helped to formulate a list of recommendations for public authorities, which are presented below. Firstly, we conclude that in order to find reliable functions of the total or differential costs and gains, all potential influential factors have to be considered simultaneously. Obviously, every public organisation or even a project is unique. Therefore, we suggest public authorities to determine a set of the most important influential factors for their specific organisations before applying the decision framework.

If an empirical research with companies' data and influential factors is not possible, then we recommend public authorities to begin with determining the optimal threshold value by using our proposed factors. More precisely, we advice to use factors, which were mentioned the most frequently, are easy to differentiate per national procedure and are easy to quantify. Such factors were selected and presented in Section 5.1 and are as follows: for the category "influential factors for costs for buyers" — *number of bidders, administration and regulation, fear of legal issues* and *project size*; for the category the category "influential factors for gains for buyers" — *number of bidders, integrity and multi-nationality of suppliers, aggregation of purchases, new suppliers* and *type of procedure*; for the category "influential factors for costs for suppliers" — *procedure length/complexity* and *number of bidders*.

Moreover, in case the quantification of certain factors is too complex or not possible due to other reasons, we advise to include those influential factors, which have the highest impact on the most cost-consuming stages of the procurement delivery chain. Such stages were acknowledged to be the pre-award stage for buyers and the proposal stage for suppliers. As an example, the factor "administration and regulation" causes the most costs for buyers during the pre-award stage since during that stage buyers choose the procedure which will be followed, develop the RFP, place the advertisement, etc. Therefore, in case an exhaustive approach is not possible, this factor should be included at first.

Secondly, based on the results of the decision framework application on tenders for supplies and services with existing quantitative data, we recommend public authorities to consider setting the threshold as low as possible. Even though the functions of the differential costs and gains did not show any intersection point (as seen in Figures 5.4–5.5), the gains increase more rapidly than costs. That means that even if the gains would be lower than the costs at the lowest contract value, the gains will quickly reach the levels of the costs and probably surpass the costs at relatively low contract values. In other words, the public procedure will be the preferred procedure starting from relatively low contact values. Additionally, this finding is in alignment with the conclusion of Molander (2014), who computed an optimal threshold value for Sweden in the range of €5000–6000, although the authors did not account for multiple influential factors and for stakeholders as opposed to our research.

Chapter 7

Conclusions

In our study, we contribute to the problem of the national threshold in several ways. First, we define this problem mathematically and provide a decision framework which can guide public authorities in setting the most beneficial threshold value. The decision framework is structured in such a way to help in the decision-making of any complexity — from single purchase decision to a situation with a multitude of multimodal factors and a complex frequency distribution of contract values.

Secondly, our decision framework is novel in terms of its comprehensive approach. In order to determine the optimal contract value, several trade-offs have to be accounted for, such as costs and gains, influential factors and multiple stakeholders. In regard to the first trade-off, namely costs and gains, we estimated the overall transaction costs and gains associated with the public and invited procedures for buyers and suppliers based on the transaction cost economics (TCE) theory. In addition to that, we provided an overview of the distribution of the overall costs per stage of the procurement delivery chain.

The influential factors were studied by means of a multi-method research. Both sources of information provided useful insights about factors with differential effects on costs and gains for buyers and suppliers. These factors were assessed based on their effect, variability per procedure, quantification and frequency of mentions. At the end, the factors were summarised in conceptual frameworks, which can serve as a comprehensive overview for current literature and as a guideline for practitioners when choosing the factors to include in the decision framework.

Furthermore, we deployed the model with the available data on certain factors and reviewed the total differential costs and gains of these factors for both stakeholders. The findings showed that the differential costs based on the two trial factors, namely the number of bidders and the size of project, for the public procedure increase more rapidly than for the invited procedure. However, gains for the public procedure are higher, too. Ultimately, the used example showed that the public procedure is more beneficial than the invited procedure for all contract values. As a result, we can recommend public authorities to prioritise the

public procedure and thus set the threshold at a relatively low contract value in order to reap the most overall benefits.

7.1 Limitations

Naturally, our study has its limitations. Firstly, despite our intention to strive for completeness of the decision framework, in our research we have not accounted for gains received by suppliers. According to the conducted literature review in Section 2.2, gains for suppliers are under-researched, diverse and difficult to estimate quantitatively. These facts cause the estimation of gains to be subjective. Therefore, we decided to exclude the gains for suppliers from the data collection and subsequently did not study factors that influence them and did not use them in the framework application. Nevertheless, we incorporated this variable in our mathematical model in order to ensure that when there will be more information available about gains reaped by suppliers, the successive researchers can still use our proposed mathematical determination.

Another related limitation concerns the influential factors. Since we aimed to study the tender threshold problem in a quantitative way, factors which currently are not estimated quantitatively were disregarded.

Also, another significant limitation of the study is due to a lack of available quantified results on the effects of factors on costs and gains. This limitation restricted us from including all important factors per category and consequently to make full use of the framework application.

Lastly, because of the non-existence of a single comprehensive study that assesses the effects of various factors on costs and gains in the same context, we were required to collect information on the effects from multiple studies. These studies were based on unique samples, applied in differing geographical and situational contexts, and they used different timeframes. Consequently, the resulted functions of influential values that are based on this heterogeneous data of different studies are probably not significantly valid.

7.2 Future research

Obviously, effective and efficient spending of public money can be achieved through a sound and systematic decision-making in regard to procurement procedures. In our study we have managed to provide a framework for this important decision. However, in order to extract its full potential and to overcome the aforementioned limitations, more research is needed.

First of all, researching decision-making procedures of public authorities for a large number of projects below the EU threshold would shed a light on various approaches of choosing tendering procedures and would help to analyse the effects of these decisions on costs and gains. These insights will help to compare various ways of setting the threshold value with

our proposed decision framework.

Second of all, in addition to factors which have a quantifiable effect on the core concepts, there exists a variety of other factors, which can play a role in deciding on the procurement procedure. For instance, psychological or geographical factors. One of such studies, which examined the influence of the Hofstede's cultural dimensions on the value of national tender thresholds, was already performed by Loskutnikova and Kuperus (2017). Following this example, we advice to broaden the perspective and study other factors which might result in an unexpected interrelation with costs and gains. Additionally, we urge to pay more attention to factors which influence gains for suppliers since this category was not included in our research.

Thirdly, a study, which would estimate the effects of all important factors which we determined in the Subsection 5.1, is encouraged. Such study should account for uniform circumstances when measuring the effects of each influential factor. Only then the functions of all influential factors can be estimated with meaningful results and filled in in our proposed mathematical framework.

Moreover, in our research we have incorporated the views of the two main stakeholders in the procurement delivery chain, namely buyers and suppliers. However, public procurement involves many more parties. As a result, it is interesting to see their impact on the decision of the most beneficial contract value.

Lastly, to improve the generalisability of our decision framework, the framework should be incorporated in different settings. We advice to study the framework in different geographical and economical places to compare whether the same factors have an influence on costs and gains and consequently on determining of the threshold value.

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Appendix A

Interview guide

Interviewee name:	Date of interview:
Interview start time:	Interview end time:
Position title:	

Part 1 — Introduction

- Introduction to the research

  Thank you very much for your participation today in the interview. My name is Anastasija Sergejcuka and I am a master student at University of Twente conducting this research for my graduation project. In my thesis I aim to develop a model, which will provide the optimal threshold for contracts below the EU threshold and consequently determine the best national procedure for a particular tender. In the thesis, the distinction is made between the public procedure (i.e. similar to the open procedure but with less strict regulations) and the invited procedure (i.e. when a certain number of tenderers are directly invited to bid for the contract). The purpose of this interview is to collect expert opinion about factors that influence costs and gains associated with the public procurement for buyers and suppliers.

- Structure of the interview

  This interview will take approximately 30-50 minutes and will be divided into 4 parts. The first part will be about costs associated with both national procedures for buyers. The second part will be about gains for buyers. The third part will be again about costs but then from the suppliers' point of view. The last part will be about empirical data on costs and gains. If during the interview you have any questions, please don't hesitate to ask them.

- General remarks

All of your responses are confidential and will be used as a valuable input for the further research. I would like to ask your permission to audio tape this interview, so I may accurately document the collected information.

Part 2 — Questions

Costs of public and invited procedure for buyers

We know that there exist different factors that can influence decision of a buyer to choose either the public procedure or the invited procedure for a certain project. Now we will talk about factors that affect costs for buyers.

1. Which factors in your opinion influence costs for buyers?
2. How these factors influence costs (proportion, coefficient, decrease/increase)?
3. What is the difference in costs between the two procedures for buyers?
4. From the preliminary research, I saw these factors mentioned:
    - Number of bidders (the higher the number of bidders, the lower the final price);
    - Spread in bids (if the spread in the bids is high, receiving more tenders will be more useful than when the spread is low (having all suppliers quoting more or less the same price));
    - Type of goods;
    - Characteristics of competitors (risk averse or risky, monopoly, small- and medium-sized companies);
    - Level of competition (high with many competitors or low)
    - Type of operating sector (energy, transport, waste management, social protection, health, education services, etc.)

    What do you think about these factors?
5. What is your estimation of fixed costs associated with both procedures?
6. What is the distribution of costs per activity within the delivery chain (pre-award; award; post-award; litigation and complaint)?

Gains of public and invited procedure for buyers

1. Which factors in your opinion influence gains for buyers?
2. How these factors influence gains (proportion, coefficient, decrease/increase)?
3. What is the difference in gains between the two procedures for buyers?
4. From the preliminary research, I saw these factors mentioned:
    - Number of bidders (the higher the number of bidders, the lower quality AND higher savings AND higher expected revenue);
    - EU funds used (with EU funds, final savings decrease);

- Awarding method (the use of the lowest price method (instead of most economically advantageous tender (MEAT), increases savings);
- Subcontracts (the use of subcontracts increases savings);
- Integrity and equal treatment of participants (if not established, less interest from bidders and weaker competition, and the best value for money may not be achieved);
- Type of goods;
- Characteristics of competitors (risk averse or risky, monopoly, small- and medium-sized companies);
- Level of competition (high with many competitors or low)
- Type of operating sector (energy, transport, waste management, social protection, health, education services, etc.)

What do you think about these factors?

Costs of public and invited procedure for suppliers

1. Which factors in your opinion influence costs for suppliers?
2. How these factors influence costs (proportion, coefficient, decrease/increase)?
3. What is the difference in costs between the two procedures for suppliers?
4. From the preliminary research, I saw these factors mentioned:
    - Number of bidders (the higher the number of bidders, the lower the chance to win, which results in unnecessary costs when preparing the bid);
    - Type of procedure;

   What do you think about these factors?
5. What is your estimation of fixed costs associated with both procedures?
6. What is the distribution of costs per activity within the delivery chain (pre-proposal; proposal; post-award; litigation and complaint)?

Empirical data on costs and benefits

1. Do you have any suggestions for the sources of information on real costs and gains for buyers and suppliers (database, website, report)?

Part 3 — Closing

I think the answers that I have received from you at this moment are sufficient to carry out an extensive analysis. Do you have any questions for me?

It will take a few weeks for me to transcribe the interview. Will it be fine for you if I send the transcript to you to confirm that all your responses were interpreted correctly? Once again, thank you for your time and agreeing to take part in this interview.

Appendix B

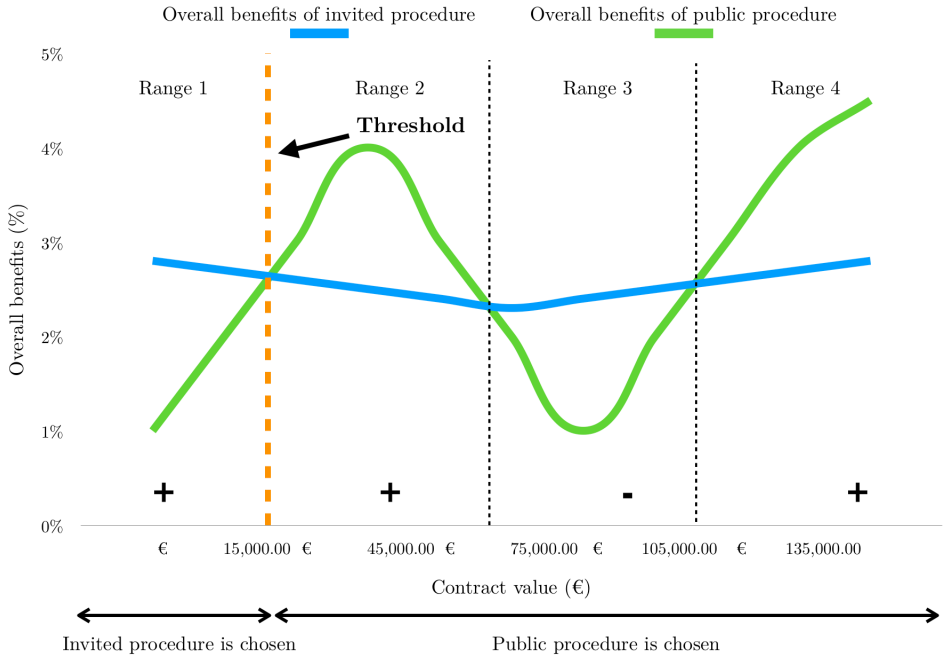
Complex scenario for finding the optimal threshold

Figure B.1 illustrates a more complex relationship of the overall benefits of the two procedures (as opposed to Figure 3.2). As we can see, the function of the overall benefits for the public procedure has a multimodal distribution, meaning that there are multiple extrema and which causes the existence of multiple intersections. Setting the threshold value at any point will result in situations (i.e. a range of contract values) where the procedure that has not the greatest overall benefit is applicable. The 2 out of 3 possible values for the threshold value are depicted in Figure B.1. Figure B.1a sets the threshold value at the intersection point with the lowest contract value. The section where the invited procedure is applicable is indeed fully beneficial for all contract values within the relevant range. However, to the right of the threshold value (i.e. public procedure), there is a part where the invited procedure would yield more overall benefits. In the figure, whether the applicable procedure yields the greatest overall benefit for the particular range is illustrated by a plus (+) or minus (-) at the bottom of such section.

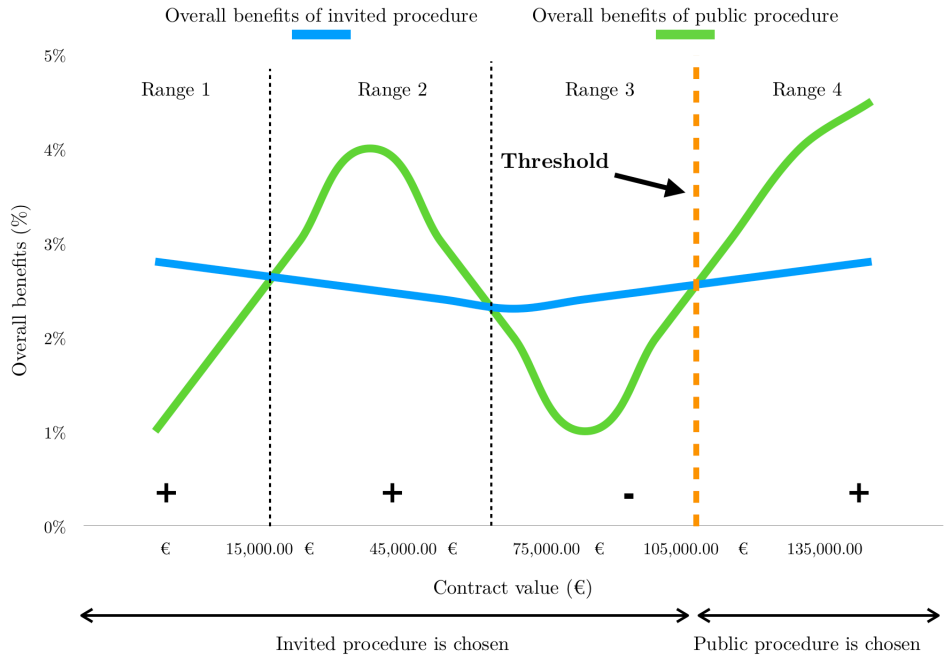
A second possibility is depicted in Figure B.1b, where the threshold is set at the last intersection point with larger contract values. In such scenario, the range where the public procedure is applicable would be fully beneficial, but in the range of the invited procedure there would also be parts where the applicable procedure would not be preferred.

On further inspection, the illustrations in Figure B.1 have an overlap in ranges where the applicable procedure is the same. Namely, at the lowest range and at the highest range, the invited and the public procedure respectively are applicable (which are also the most beneficial procedures in those ranges). On contrary, in the middle two ranges the two illustrations differ in which procedures are used according to the regulations. However, these ranges are fully symmetrical, meaning that when considering the total overall benefits of all contract values, result would be equal in both scenarios.

Note that up to this point, the example assumes that the occurrence of all contract values



(a) Scenario where the threshold is set at the intersection point with the lowest contract value.



(b) Scenario where the threshold is set at the intersection point with the highest contract value.

Figure B.1: Illustrations that show two scenarios of setting the threshold value with a multimodal function. In the blue range, the invited procedure is used according to the national regulations, and in the green range, the public procedure is used. Note that the a third scenario where the threshold value would be set at the middle intersection point is not showed.

has the same likelihood. In practice this does not hold true, as for example contracts of a very high value do not occur as often as middle-valued contracts. Figure B.2 shows the frequency distribution of contracts, illustrating that the lowest-value contracts occur the most often

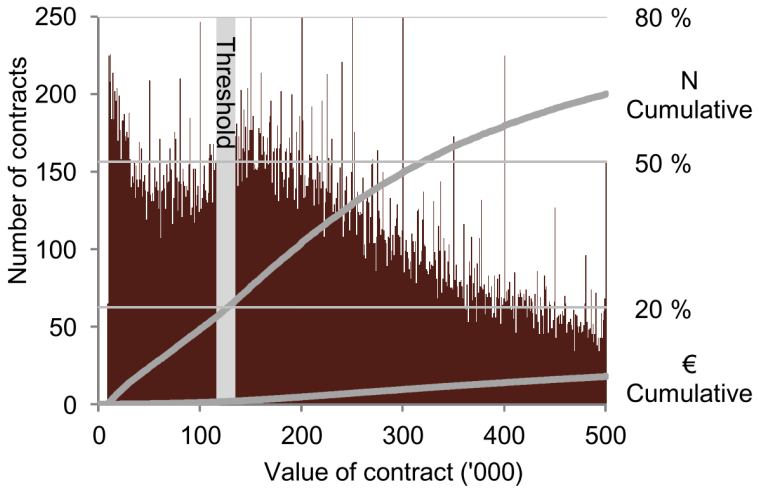


Figure B.2: Frequency distribution of contracts per contract value concluded by central government. Illustrated "threshold" concerns the EU threshold value of the study. Reprinted from *Public procurement in Europe: Cost and effectiveness* (p.69), by Strand et al. (2011), Brussels: European Commision. ©2011 PwC, London Economics and Ecorys.

with another peak near the EU threshold value and then a slow decline in occurrences. In determining the overall benefits, such frequency distribution of contract values is important, as we would not assess an overall benefit for a contract value where a limited number of projects occur as important as the overall benefit for a contract value where many projects occur.

Translating the discussion of the importance of the frequency distribution of contract values to our example, we extend the previously used illustrations with an extra dimension of the frequency distribution in Figure B.3. Here we see that contracts from range 2 appear more frequently than of range 3. As a result, incorporating the frequency (or "probability") of occurrence of contract values in the example of Figure B.1, the scenario of Figure B.1a would ultimately have larger *total* benefits as the beneficial range (range 2) is more often occurring than the non-beneficial range (range 3). On the contrary, in the scenario of Figure B.1b the beneficial range (range 3) would be less often occurring than the non-beneficial range (range 3), meaning that this is inferior to the first scenario.

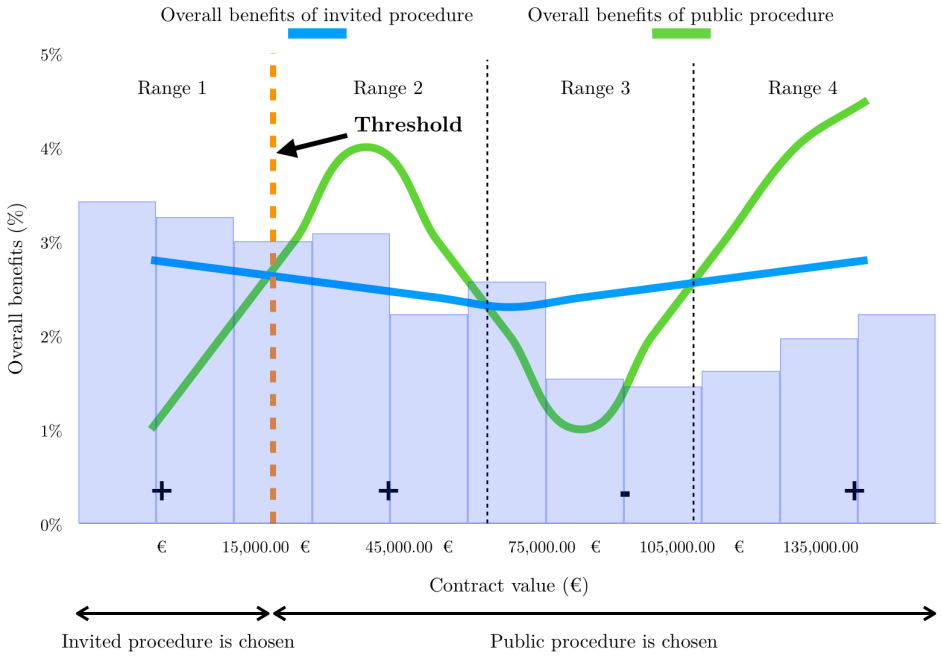


Figure B.3: A complex threshold intersection with the frequency distribution of contract values.

Appendix C

Full list of references

Table C.1: Full list of references with influential factors for costs and gains

Factor	Author & year	Results
Direct influential factors for costs for buyer		
Number of bidders	Costantino et al. (2012)	Many potential suppliers in a procurement process increase costs for the bidding process, that belong to transaction costs. The costs can exceed gains from the increased competition between a large number of bidders.
	Carbonara et al. (2015)	Ex-ante costs are higher when the number of bidders is low due to the absence of competition and, consequently, a higher probability of opportunistic behaviours, a lower quality of bids, and subsequent contract renegotiation during the project. However, ex-ante costs also increase with the number of bidders because a high number of competitors demotivates bidders to invest a sufficient amount of time in preparation of the bid.
	Onur et al. (2012)	The number of bidders significantly and negatively affects the difference between the procurement price and the estimated cost.

Project size	Carbonara et al. (2015)	Ex-ante costs for small size projects with a capital value below 25 million are significantly higher than those for larger projects in terms of the percentage of the total capital value of the project. However, these costs increase when the project size becomes bigger because of a greater effort required by the public sector in the monitoring and enforcement process.
	Chever et al. (2017)	The study proved that public buyers tend to use restricted auctions to tender small contracts. Even though, previous studies suggested to tender small contracts with many potential suppliers because such projects are usually rather simple and ex post transaction costs, which result from contractual incompleteness, will not be an issue. However, this research showed that a systematic use of open auctions may actually lead to spending a large amount of resources on a very small part of the activity itself. Therefore, a main aim of restricted auctions is to save on ex ante costs by restricting the number of submitted offers, which needs to be compared.
Product complexity	Carbonara et al. (2015)	The higher the customisation of a procured product, (i.e. uniqueness and uncertainty), the more its transaction needs the exchange and sharing of uncodified (or less codified) knowledge and information. As a result, procurement of standard supplies involves a lower amount of costs than customised supplies.
Procedure complexity	Carbonara et al. (2015)	Ex-ante costs are higher for complex procedures because of the increased level of information to be managed in each phase of the procedure. However, ex-post costs increase for simple procedures due to the lower level of information during the tendering process and a greater effort in the monitoring process and the likelihood of having ex-post adaptation and changes.

Project complexity	Carbonara et al. (2015)	Tender costs are higher during the tendering process for public-private partnerships than for conventional procurement. The previous research found a percentage of 0.48–0.62%, 0.18–0.32% and 0.04–0.15% for tender costs for private finance initiative projects, conventional procurement and traditional design-bid-build projects respectively. Other research estimated costs for public-private partnerships for up to 10% higher than for other procedures.
Opportunistic behaviour	Carbonara et al. (2015)	Due to the fact that in public-private partnerships multiple entities with diverse goals participate in the transaction, the probability of opportunistic behaviour increase. Consequently, costs are higher for negotiations.
Amount of information	Carbonara et al. (2015)	Procedures with a small amount of information ex-ante are more likely to cause a high degree of contract incompleteness, which will increase ex-post costs. The reverse effect applies to a high amount of information ex-ante.
Substitution	Raventós and Zolezzi (2015)	The greater a buyer's substitution possibilities, the lower the purchase price.
Corruption	Raventós and Zolezzi (2015)	Corruption, or what they call active waste, can add an additional 11% to purchase prices.
	Ameyaw et al. (2017)	Corruption during the tendering process for rail and road transport construction and urban and utility construction in Europe results in losses of 17% and 20% of procurement cost, respectively.
	Padhi, Wagner and Mohapatra (2016)	Corruption leads to fewer bids, less competition, and higher winning bid prices.
Indirect influential factors for costs for buyer		
Size of the project	Carbonara et al. (2015)	The number of bidders is higher in the bigger project than in the smaller one. It is assumed that the number of bidders doubles.

Characteristics of competitors	Elmaghraby (2005)	Auctions with global and small bidders will decrease buyer's costs more than auctions with small bidders only. The involvement of global bidders not only increases the number of bidders in the auction, but also encourages small bidders to bid more aggressively. In regards to the comparison of the combined auctions and auctions with global bidders only, may increase or decrease costs. When number of global and small suppliers is low, presence of additional (small) bidders increases the probability of having a lower cost supplier, decreasing the procurement costs. However, if there is a moderate to large number of small bidders and many global bidders, the buyer will be in a less advantageous position. The reason for that is that most probably global bidder will both win and define the payment, and the buyer will receive higher bids from global bidders, because they fail to bid away all of their synergy term.
Number of bidders and quality	Milne et al. (2012)	The higher the number of bidders, the lower the quality.
Type of structure and number of bidders	Hanák and Muchová (2015)	The number of bidders in the tender is dependent on the type of structure.
Economic conditions and number of bidders	Azman (2016)	In good economic conditions, when suppliers' firms have plenty of projects, fewer bidders are interested in bidding. That results in increase of bid prices.
Aggregation of purchases and e-procurement	Carbonara et al. (2015)	Multiplying the estimated coefficient of the volume variable with the change in mean volume after the implementation of Chilecompra, results in aggregation savings of 2.8%.

E-procurement and corruption	Raventós and Zolezzi (2015)	E-tendering reduces costs directly because of less corruption and less supplier collusion.
Direct influential factors for gains for buyer		
Number of bidders	Hanák and Muchová (2015)	The higher the number of bidders, the lower the final price.
	Grega and Nemec (2015)	With every additional candidate, there is a 2.63% increase in savings.
	Gupta (2002)	Calculated savings with increase in bidders from 2–8 are 12–14%; from 2–6 they are 9–10%.
	Raventós and Zolezzi (2015)	The price of drugs and medical devices decreases with the number of bidders. An increase in number of bidders leads to lower prices.
	Ballesteros-Pérez et al. (2016)	The level of correlation between the average bid and the highest and lowest bids in bid tender forecasting models is higher on average when N is higher. Moreover, the range of the bid standard deviation is also proportional to N.
	Janke and Packova (2016)	Each new competitor will mean that contract savings will increase for about approximately 2.852% and each bid will increase the savings by more than approximately 0.134%.
	Skitmore (1981)	An increase in number of bidders increases the correlation between the average bid and the highest and lowest bids.
	Azman (2016)	Due to the fact that increase in competition causes bidders to bid more aggressively, the bid price declines when more bidders exist. However, such a behaviour occurs less frequently when fewer than 10 bidders participate in a non-ABA and does no occur at all when more bidders participate in ABAs. Bidders place bids higher than the mean bid to cost ratio.

Carr (2005)	When 1 bidder participates in an auction, the price is approximately 15% higher (deviation from the estimate) than when 2 bidders compete. This figure is reduced by 27% when eight bidders enter the auction and stagnates when more than eight bidders enter the auction.
Costantino et al. (2012)	The research showed that the pre-qualification condition only holds if the number of bidders is higher than 39. Therefore, reducing the number of bidders to the optimum is convenient only for an original number of candidates N > 39, according to the contracting authority (the society) perspective.
Hanák (2016)	There is a high correlation between the relative savings and number of change of bids per one submitted bid. It can be expected that each change of a submitted bid contributes to a decrease in the bid price and therefore results in higher savings.
Amaral, Saussier and Yvrande-Billon (2013)	Tendering reduces bid prices as the expected number of bidders increases. Significant cost reductions can be achieved by unbundling the procured project, because then small operators are more likely to participate and it contributes to creating the conditions for competitiveness. However, to ensure competitiveness additionally several factors have to be taken into account. More precisely, the transparency of the tendering process, the capacity of expertise and control of the regulator.
Soliño and Gago de Santos (2016)	The higher the number of bidders, the higher the expected revenue.
Onur et al. (2012)	Every additional bidder results in around a 3.9% decrease in procurement price relative to the estimated cost.

	Gómez-Lobo and Szymanski (2001)	Based on the OLS results, the presence of two bidders reduces expenditure by about 12–13% compared with the single bidder case. The average saving from CCT over the sample is between 20–22%. For the case of 4 bids, the cost savings would be about 13% of the original level.
Type of procedure	Costantino et al. (2012)	By introduction of the pre-qualification phase and limiting the number of bidders, the contracting authority and bidders are able to save money.
	Skuhrovec and Soudek (2013)	The use of an open tender decreases the final price by 7%.
	Grega and Nemec (2015)	The use of restricted procedure increases final price by 11.56%.
New suppliers	Raventós and Zolezzi (2015)	In repeated auctions for highway contracts, new participants bid more aggressively.
	Onur et al. (2012)	When auction is open for foreigners, there are more bidder1s participating. Opening auctions to foreign participation negatively affects the natural logarithm of the winning bid minus the natural logarithm of the estimated cost. Therefore, it leads to more cost-effective procurement auctions.
Innovation	Koh (2017)	The research identified 7 types of effects - incentive and sampling. If there are many competitors, participants may be not willing to invest for fear of losing the entire investment in case they do not win. That is called an incentive effect. On the contrary, because of the randomness on the quality realisation, the more firms the buyer invites to tender, the higher the chance is to have a high quality innovation. That is a sampling effect.
The lowest price award method	Grega and Nemec (2015)	The use of the lowest price method (instead of MEAT), increases savings for 1.06%.

Aggregration of purchases	Karjalainen (2011)	Economies of scales in the central framework agreements result is significant savings between different individual products. For instance, for toner cartridges savings varied from 8% and for flights to 37%.
	Carbonara et al. (2015)	Aggregation of purchases leads to lower prices.
Higher tender frequency	Raventós and Zolezzi (2015)	More frequent tenders lead to lower prices for medical devices.
Characteristics of competitors	Chever et al. (2017)	Suppliers that frequently post unsuccessful low bids usually are more aggressive bidders, while suppliers that frequently decline invitations for participation post higher bids. Therefore, the latter suppliers might not be that interested in participating in the tenders and will not bid competitively.
	Azman (2016)	The size of the company determines their choice for the size of the contract. Larger firms are more competitive in auctions for large contracts. Small- and medium-sized firms choose small and medium contracts.
E-procurement	Raventós and Zolezzi (2015)	The use of the procurement platform Chilecompra results in direct price saving of 8.3% for drugs and 9.1% for medical devices.
	Hanák (2016)	The study showed that a really high portion of electronic reverse auctions results in a very small amount of savings.
EU funds	Grega and Nemec (2015)	If public procurement was (at least partly) financed by EU funds, final savings would decrease by 1.54%.
Project size	Hanák (2016)	There is no relationship between the attractiveness of the contract expressed by its value, which corresponds to the best bid before electronic reverse auction, and savings.

Subcontracts	Grega and Nemec (2015)	The use of subcontracts increases savings by 1.05%.
Spread in bids and number of bidders	Heijboer and Telgen (2002)	If the spread in the bids is high, receiving more tenders will be more beneficial than when the spread is low.
Indirect influential factors for gains for buyer		
Duration of the contract and the lowest price criterion	Lundberg and Bergman (2017)	The lowest price is more common for contracts with long duration, but less common for contracts that include an optional extension period. When increase of the duration of the optional extension period with one year, decreases the log odds of lowest price by about 0.5.
Integrity and impartiality and number of bidders	Sidwell et al. (2001)	If integrity and impartiality are not established, potential suppliers may be hesitant to make a bid as the formulation of it takes a significant amount of time and resources. As a result, fewer bidders will participate in tender and the best value for money may not be achieved.
Type of procured goods and number of bidders	Onur et al. (2012)	The auction type and the type of procured goods significantly affect the number of participants. For instance, in a construction auction there is a significant increase in the number of participants in comparison to the auctions for services. For goods auctions the coefficient is again positive but not significantly higher. Moreover, services and goods auctions are more sensitive to changes in the number of bidders than construction sector.
Higher tender frequency and e-procurment	Raventós and Zolezzi (2015)	The implementation of the Chilecompra platform leads to more frequent tenders and consequently to lower time between them. Due to that, this platform leads to indirect savings through more frequent tenders.

New bidders and e-procurement	Raventós and Zolezzi (2015)	Multiplying the coefficient of the One Bidder variable by the reduction in the mean level of that variable, results in indirect price saving of 1.4%.
Procedure length and e-procurement	Raventós and Zolezzi (2015)	After the implementation of e-procurement, the time between the posting and the award of tenders is extended by half a day, leading to indirect price savings of 0.4%.
Type of operating sector and number of bidders	Hanák (2016)	The research found a difference in the amount of correlation between the best bid before electronic reverse auction and number of submitted bids for different types of sectors. The highest correlation was found for the category Buildings, while the lowest was found for the category Schools. The high correlation can be attributed to a high sensitivity to the amount of the contract. Therefore, it can be expected that when increasing the best bid before the electronic reverse auction, there is stronger potential for a competitive environment.
Uncertainty of costs and quality and the lowest price criterion	Lundberg and Bergman (2017)	When a buyer is uncertain about the cost of different levels of quality, he is more likely to use the lowest-price supplier-selection method. This is also the case when quality is highly non-verifiable. For each unit change in price or quality uncertainty the log odds of lowest price decreases by about 0.2. When the municipality's uncertainty about quality increase from a little bit less than 2 to just above 5 on the nine-point scale, the probability that lowest price is used falls from 45 to just below 30%.
Direct influential factors for costs for suppliers		

Number of bidders	Esmaeeli et al. (2007)	The increase in the number of bidders results in decreased project bid prices. The study showed that there is a meaningful relation between number of bidders and (lowest bid)/(design estimate) or (mean bid)/(design estimate). More precisely, when increasing number of bidders (lowest bid)/(design estimate) or decreasing (mean bid)/(design estimate), it means decrease in contractor's mark-up.
The lowest price award method	Costantino et al. (2012)	The lowest price method usually requires a limited effort from potential suppliers in formulating the bid since this tendering awarding mechanism is typically used for products or services which cannot be differentiated by quality between products of competitors. Consequently, in a tender awarded with the lowest price criterion, a large number of potential suppliers can easily participate (e.g. in case of an open procedure) or can be invited to participate (e.g. restricted procedure).
Familiarity of bidders	Ballesteros-Pérez et al. (2016)	If a contractor is able to quantify and identify bidders who are likely to submit a bid, this practice can provide a useful information when deciding whether to bid or not. This practice also helps to strategically set a bid price to optimise the likelihood of winning the contract.
Supplier's bidding past performance	Chever et al. (2017)	The past failures of firms affect the buyer's choice for the invitation of suppliers. If a firm frequently turns down invitations or frequently posts unsuccessful low bids, the buyer will less likely invite this supplier again.

Appendix D

Analysis of individual functions per factor

In this appendix we present a detailed description of functions per factor, which we estimated based on the available quantitative results from various studies. In order to estimate the aggregated costs and gains for buyers and suppliers, as well as to find functions of the differential costs and gains, we needed to standardise original findings to a uniform format. Therefore, here we present a standardised output per factor.

D.1 Quantified factors affecting costs for buyers

D.1.1 Number of bidders

The costs for buyers that change in regard to the number of bidders were estimated based on two studies, namely the study of Costantino et al. (2012) and de Boer et al. (2000). In their research, Costantino et al. (2012) studied the total cost of purchasing in relation to the number of bidders. The authors presented results of 5 different scenarios with a varying standard deviation of the cumulative distribution of the production cost. For our model testing, we chose to use a function of 1% as a standard deviation. Table D.1 presents the standardised values of costs in relation to bidders based on a varying contract value. From Figure D.1, we can see that due to the fact that the number of bidders within the public procedure increases with the value of contract from 5 bidders to 35 bidders, the costs for the buyers increase exponentially. The costs of the invited procedure are relatively stable as the number of invited bidders stays within the range of 2–5.

In the study of de Boer et al. (2000), which we have also included in the model test, it was estimated that tendering costs, which consist of direct and indirect costs, increase linearly with the number of bidders. Even thought the study did not include any specific data points, we have used the presented in the study graph. This graph outlined the trade-off between the costs of inviting a number of suppliers to submit a tender, and the costs of the best

Table D.1: The summary of standardised values for the number of bidders based on the study of Costantino et al. (2012).

Contract value	Number of bidders		Costs	
	invited	**public**	**invited**	**public**
€1000	2	5	137 933	138 075
€15 000	2	8	137 933	138 300
€30 000	3	11	137 967	138 600
€45 000	3	14	137 967	138 950
€60 000	3	17	137 967	139 400
€75 000	4	20	138 000	140 000
€90 000	4	23	138 000	140 750
€105 000	4	26	138 000	141 500
€120 000	5	29	138 075	142 250
€135 000	5	32	138 075	143 000
€150 000	5	35	138 075	143 750

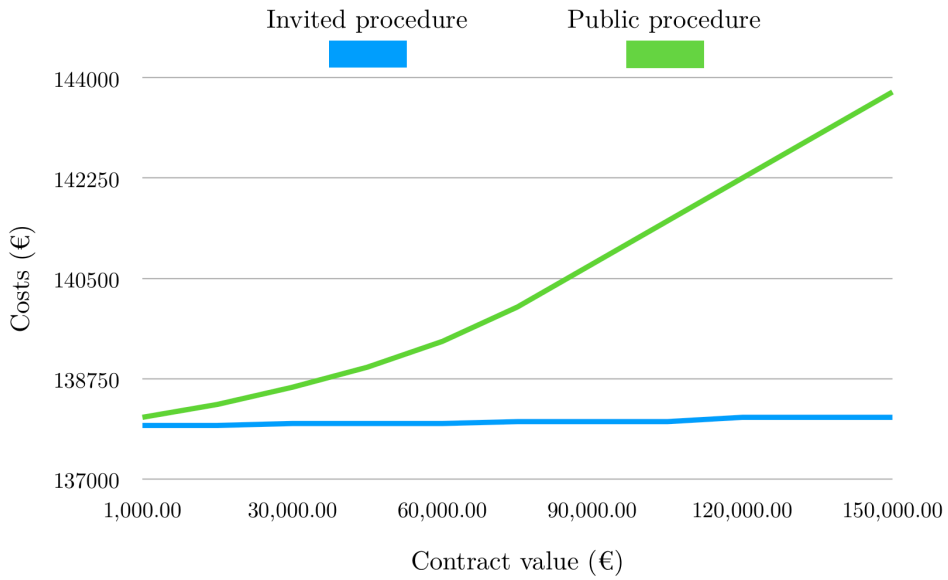


Figure D.1: Results of the distribution of costs per number of bidders based on the study of Costantino et al. (2012).

offered bid. From the graph we were able to determine the relationship between the costs and the number of bidders and translate those to our standardised format. Table D.2 shows the standardised values which we have used to estimate the costs. Based on the standardised values, the functions of costs for buyers were estimated as they can be seen in Figure D.2. The functions are similar to the ones presented above. However, the costs of the public procedure used from the research of de Boer et al. (2000) increase linearly in comparison to

Table D.2: The summary of standardised values for the number of bidders based on the study of de Boer et al. (2000).

Contract value	Number of bidders		Costs	
	invited	public	invited	public
€1000	2	5	2000	5000
€15 000	2	8	2000	8000
€30 000	3	11	3000	11 000
€45 000	3	14	3000	14 000
€60 000	3	17	3000	17 000
€75 000	4	20	4000	20 000
€90 000	4	23	4000	23 000
€105 000	4	26	4000	26 000
€120 000	5	29	5000	29 000
€135 000	5	32	5000	32 000
€150 000	5	35	5000	35 000

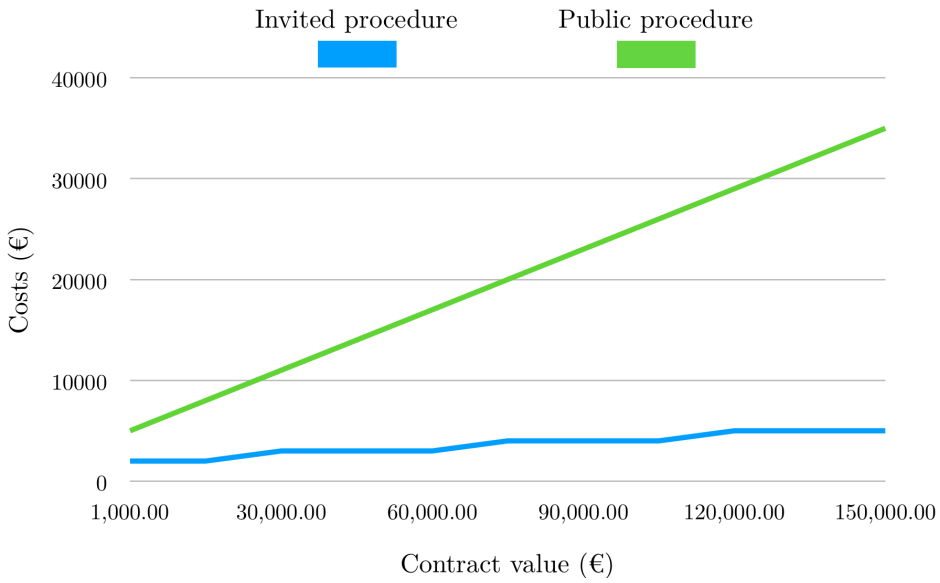


Figure D.2: Results of the distribution of costs per number of bidders based on the study of de Boer et al. (2000).

an exponential growth of costs presented earlier.

D.1.2 Project size

The effect of project size on costs for buyers was also estimated by Carbonara et al. (2015). The standardisation of values from the study was performed in the same way as for the factor

Table D.3: The summary of standardised values for the project size based on the study of Carbonara et al. (2015).

Contract value	Level of information		Costs	
	invited	**public**	**invited**	**public**
€1000	4	1	5.8	9.5
€15 000	4	1	5.8	9.5
€30 000	5	2	4.9	8.2
€45 000	5	2.5	4.9	7.5
€60 000	5.5	3	4.5	6.9
€75 000	6	3.5	4.2	6.4
€90 000	6.5	3.5	3.8	6.4
€105 000	6.5	3.5	3.8	6.4
€120 000	6.5	4	3.8	5.8
€135 000	7	4	3.5	5.8
€150 000	7	4	3.5	5.8

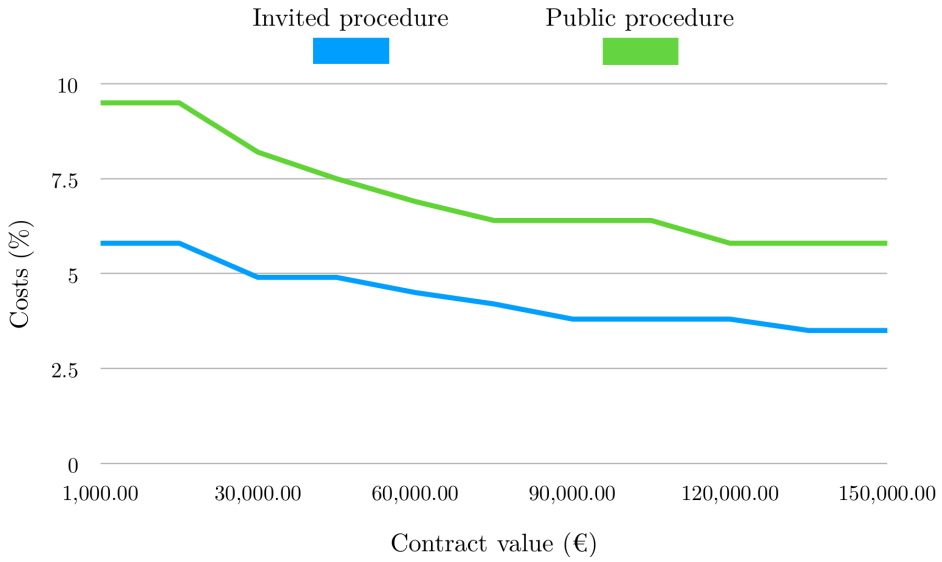


Figure D.3: Results of the distribution of costs per level of project size based on the study of Carbonara et al. (2015).

of project complexity. Table D.3 presents the summary of the standardised values. Figure D.3 shows the functions of costs per procedures based on the change in project size. Both functions show a decrease in costs when a project becomes bigger. According to Carbonara et al. (2015), ex-ante costs for small-sized projects are higher than those for larger projects as a percentage of the total capital value of the project. The authors explain that with the fact that many transaction activities remain the same despite the change in the size of the project. As a

result, the change in the project size does not have a significant effect on ex-ante costs.

In contrast to ex-ante costs, ex-post costs increase with the increase in the project size because of the required effort in the monitoring process and enforcement. Consequently, when the the project becomes bigger, ex-post costs increase more for simple procedures (i.e. in our case for the public procedure) than for the more complex procedure (i.e. the invited procedure). In Figure D.3 it is seen that costs for the public procedure are lower than for the invited procedure, but for both of the procedures there is a decrease in costs with the increase in the project size.

D.2 Quantified factors affecting gains for buyers

D.2.1 Number of bidders

The effects of the number of bidders on gains for buyers is the most widespread research topic within the academic literature. Therefore, there was the highest number of studies, where the effect was quantified. We categorised 8 available studies with numerical results into two groups. The first group consists of studies which estimated a constant increase in gains with every additional bidder. The second group of studies found that gains increase with every additional bidder until a certain number of bidders is reached. Then gains stagnate. In the following paragraphs we present a detailed description of the standardisation of the values and the estimated functions for both groups.

The first group of multiple studies, namely the studies of Grega and Nemec (2015); Janke and Packova (2016); Pavel and Sičáková-Beblavá (2013); Yakovlev et al. (2014); Onur et al. (2012), found a constant percentage by which savings for buyers increase when an additional bidder joins the tender. These percentages varied from 2.63% to 5.2%. Due to the fact that all of these studies are comparable and they describe the effect of the same factor, we wanted to take all of their output into account. Therefore, we calculated the average of the percentages and used it as an increment to calculate the effect.

In Table D.4 we present a summary of the standardisation of values for the effect of number of bidders on buyers' gains. Due to the fact that none of these studies estimated a number of bidders at which gains stagnate, Figure D.4 presents the functions of the effects for both procedures where gains increase until the contract value, which we specified earlier. The gains for the public procedure increase linearly and are higher than for the invited procedure because the number of bidders participating in this procedure is greater.

The second group, which consists of studies from Gupta (2002); Carr (2005), estimated a stagnation point in the number of bidders after which there is no more an increase in gains for buyers. Gupta (2002) stated that the increment is equal to 2.63% and it stagnates at 8 bidders. While Carr (2005) found that the increment is not constant and it stagnates after more than 10 bidders take part in the tender. For the standardisation of the values we

decided to calculate the average of the increments from these two studies, which are presented in Table D.5. Similarly to the first group, the gains for buyers are presented as percentage. Figure D.5 visualises the effects of the number of bidders with the standardised values. As we can see, due to a relatively small range of the number of bidders participating in the invited procedure, the gains increase in a step-wise way. Gains for the public procedure start at a higher level than gains from the invited procedure and they stagnate when a contract value reaches €15 000.

Table D.4: The summary of standardised values for the number of bidders based on multiple studies.

Contract value	Number of bidders		Gains (%)	
	invited	**public**	**invited**	**public**
€1000	2	5	3.6	14.4
€15 000	2	8	3.6	25.2
€30 000	3	11	7.2	36.0
€45 000	3	14	7.2	46.8
€60 000	3	17	7.2	57.5
€75 000	4	20	10.8	68.3
€90 000	4	23	10.8	79.1
€105 000	4	26	10.8	89.9
€120 000	5	29	14.4	100.7
€135 000	5	32	14.4	111.5
€150 000	5	35	14.4	122.3

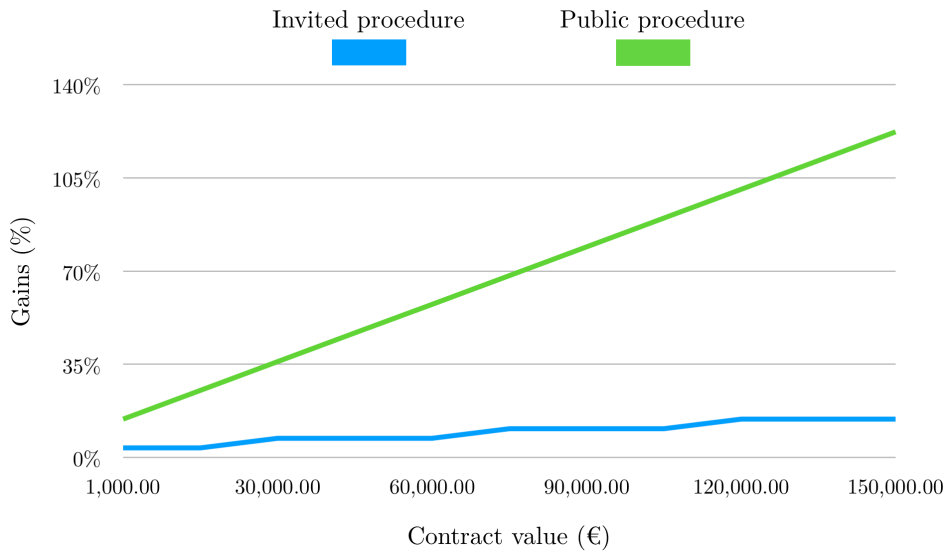


Figure D.4: Results of the distribution of costs per number of bidders based on multiple studies.

Table D.5: The summary of standardised values for the number of bidders based on Gupta (2002); Carr (2005).

Contract value	Number of bidders		Gains (%)	
	invited	public	invited	public
€1000	2	5	3.32	15.26
€15 000	2	8	3.32	20.08
€30 000	3	11	6.63	20.08
€45 000	3	14	6.63	20.08
€60 000	3	17	6.63	20.08
€75 000	4	20	10.95	20.08
€90 000	4	23	10.95	20.08
€105 000	4	26	10.95	20.08
€120 000	5	29	15.26	20.08
€135 000	5	32	15.26	20.08
€150 000	5	35	15.26	20.08

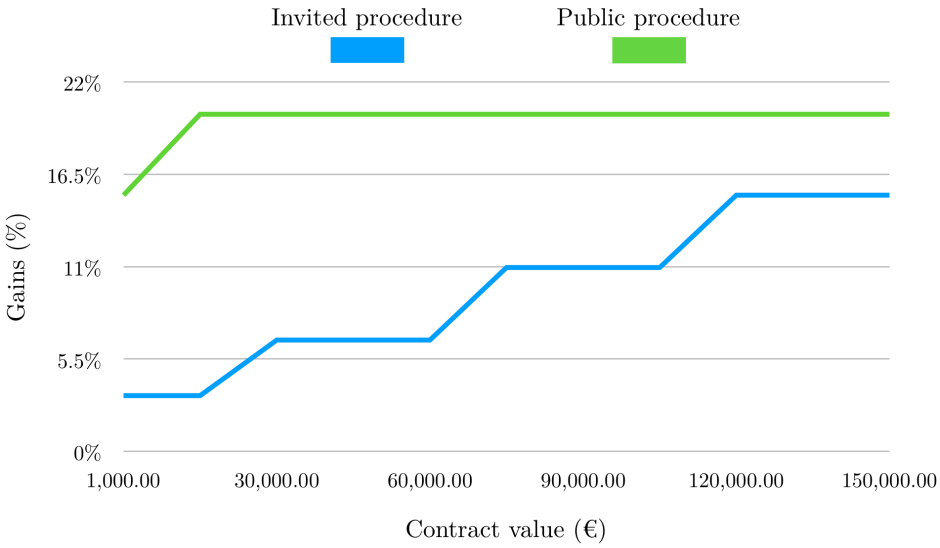


Figure D.5: Results of the distribution of costs per number of bidders based on Gupta (2002); Carr (2005).

D.3 Quantified factors affecting costs for suppliers

D.3.1 Number of bidders

During the literature review, we found two studies which estimated effects of the number of bidders on costs for suppliers in a quantitative way. The study of Costantino et al. (2012) provided not only numerical finings on the relationship between the number of bidders and costs for buyers, but also for the society. In their study, the society is referred to buyers and suppliers together.

In Table D.6 we present the standardised values for the effect on costs for suppliers from the change in the number of bidders. Since the values presented in the original study referred to society (i.e. public buyers and suppliers), during the standardisation we deducted the values for the buyers from the combined values for the society. This resulted in values only for suppliers. Moreover, to keep the standardisation constant, we chose results from the study based on the same scenario as we did for the costs for buyers, namely with a standard deviation of 5% of the cumulative distribution of the production cost. Figure D.6 shows that costs for suppliers increase with the number of bidders. Due to the fact that the number of competitors within the invited procedure is low, the costs do not vary significantly. However, because in the pubic procedure we assume that competition can reach up to 35 bidders, the costs for suppliers become greater.

A similar effect of the number of bidders on costs for suppliers was found by Esmaeeli et al. (2007). The authors estimated the financial effect for suppliers in a mark-up, which is

Table D.6: The summary of standardised values for the number of bidders for the suppliers based on the study of Costantino et al. (2012).

Contract value	Number of bidders		Costs	
	invited	public	invited	public
€1000	2	5	2400	3675
€15 000	2	8	2400	5700
€30 000	3	11	2700	6150
€45 000	3	14	2700	7550
€60 000	3	17	2700	9100
€75 000	4	20	3000	10 000
€90 000	4	23	3000	10 750
€105 000	4	26	3000	12 500
€120 000	5	29	3675	14 250
€135 000	5	32	3675	15 000
€150 000	5	35	3675	15 000

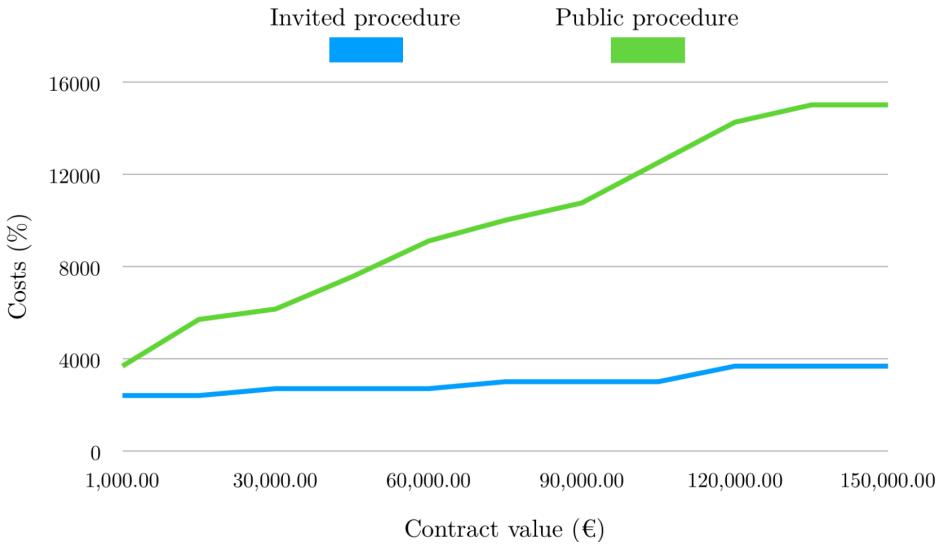


Figure D.6: Results of the distribution of costs per number of bidders for suppliers based on Costantino et al. (2012).

denoted by an appropriate margin added to the estimated cost of a project. The conclusion, which was made by Esmaeeli et al. (2007), is that with an increase in the number of bidders, supplier's mark-up decreases. By translating these findings to costs, it means that costs fr suppliers increase if there are more competitors. In Table D.7 we provide the values from the original study which we standardised based on the required format. Since the results from the study estimate the effect on the mark-up, in our case they are seen as both costs and gains depending on the contract value. For instance, in the table the costs in the invited procedure are negative, which means that those are gains. Suppliers actually profit from competing in a tender with a low contract value and a low number of bidders. With the increase in contract value and number of bidders, the costs increase as well and become positive. When they reach positive values, they are not considered as gains anymore, but as costs. Figure D.7 provides a visual presentation of the standardised values in a graph. Clearly, for suppliers it is more beneficial to take part in a tender where a number of bidders is low.

Table D.7: The summary of standardised values for the number of bidders for the suppliers based on the study of Esmaeeli et al. (2007).

Contract value	Number of bidders		Costs	
	invited	**public**	**invited**	**public**
€1000	2	5	−0.200	−0.100
€15 000	2	8	−0.200	−0.060
€30 000	3	11	−0.175	−0.018
€45 000	3	14	−0.175	0.012
€60 000	3	17	−0.175	0.018
€75 000	4	20	−0.150	0.050
€90 000	4	23	−0.150	0.095
€105 000	4	26	−0.150	0.140
€120 000	5	29	−0.100	0.185
€135 000	5	32	−0.100	0.230
€150 000	5	35	−0.100	0.275

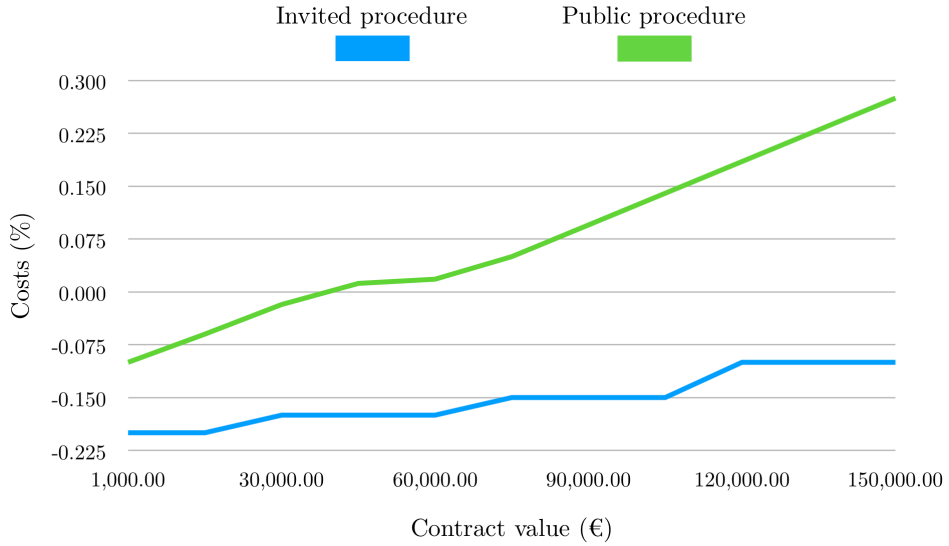


Figure D.7: Results of the distribution of costs per number of bidders for suppliers based on Esmaeeli et al. (2007).