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Conference Paper

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50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Vlist, Arno Van Der; Hardeman, Sander (2010) : On the Design of Public Infrastructure procurements, 50th Congress of the European Regional Science Association: "Sustainable Regional Growth and Development in the Creative Knowledge Economy", 19-23 August 2010, Jönköping, Sweden, European Regional Science Association (ERSA), Louvain-la-Neuve

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On the Design of Public Infrastructure procurements

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Abstract

Public procurement of infrastructure has been subject to a long standing debate concerning the procurements' qualification requirements. Basically, it remains unclear what determines public procurement officers to vary procurements' qualification requirements. This research serves to elaborate on public procurements' procedure design. The aim of this paper is to improve our understanding of why contracting authorities choose specific requirements prior to public procurement. What determines variation in public procurements' qualification requirements? For this the procurements' procedure design is modelled as a rational choice among a set of alternatives within a random utility framework. Qualification requirements are chosen as to maximize utility of the procurements' officer. In the empirical part of the paper the procurements' procedure design is modelled as a limited dependent variable model. The data comes from the EIB Monitor Procurements covering public procurements in the Netherlands, and relates to public open procurements of civil work posted by municipalities in the first half of 2009. The model results indicate that requirements do relate to degree of professionalism of the procurement office and to the type of work. These results indicate a rational choice among qualification requirements yet explain about 15 percent of total variation, suggesting other factors at work.

Keywords: Construction industry, infrastructure, Bidding, Public Procurement Auctions, municipalities

1. Introduction

Public procurement of infrastructure has been subject to a long standing debate regarding the proportionality of qualification requirements. For many public contracts, firms may submit sealed bids in which the contract is by law awarded to the lowest qualified bidder. The issue of what defines a qualified bidder is subject to much controversy. According to many small contractors, qualification requirements prevent them from bidding, reducing competition for public work. In a recent survey, about six out of ten contractors indicated that they encounter great difficulties in meeting qualification requirements preventing them from bidding, yet would be able to carry out the specified work (Hardeman and Jansen, 2009). Table 1 shows what qualification requirements civil engineering firms' consider most restrictive.

Table 1. Qualification requirements to which contractors do not comply although they were able to perform.

<i>qualification requirements</i>	<i>share of civil construction companies</i>
<i>Reference works</i>	<i>.66</i>
<i>Annual turnover</i>	<i>.54</i>
<i>ISO 9001- or VCA-certificate</i>	<i>.05</i>
<i>Bank guarantee</i>	<i>.04</i>
<i>Other</i>	<i>.35</i>
<i>Unknown/no answer</i>	<i>.02</i>

From Table 1 one observes that two out of three mentions experience with comparable works as one of the most obstructive requirements. Firms also question the proportionality of the qualification requirement on annual turnover. This paper considers these qualifications in public procurement in greater detail, elaborating on public procurements' procedure design.

The issue arises as to what determines procurement officers to vary procurements' qualification requirements. Boes and Dorée (2007) indicate that procurement officers themselves do not consider the procedure design very important. Tenderstrategy is ranked after issues like calculation, projectmanagement and procurement legislation. Also, most economic literature on auctions does not explicitly address the issue of what determines procurement officers to vary procurements' qualification requirements. Yet, this literature forms a relevant source to draw on in this paper. The literature indicates that the value of the auction depends inter alia on the number of bids *viz.* the degree of competition (Brannman, Klein and Weiss, 1987), with new entrants bidding more aggressively winning with significantly lower bids than incumbent bidders (De Silva, Dunne and Kosmopoulou, 2003). Furthermore, the literature indicates that procurement procedures that publicly release information concerning the value of the contract (e.g. cost estimates) result in more aggressive bidding and higher values for the contracting

authority (De Silva, Dunne, Kankanamge and Kosmopoulou, 2007). This literature indicates the relevance of procurement's procedure design on the final outcome, yet systematic analysis on the determinant of qualification in public procurements' procedure design is missing. An exception is Estache and Iimi (2008, 2009). In Estache and Iimi (2008) road, water and electricity projects in less developed countries are considered. Their results indicate that procurement design is of great importance in reducing unit costs of infrastructure. In Estache and Iimi (2009) the procurement design of those electricity projects is considered in greater detail. These results suggest interactive effects among procurements' design and competition also, yet, the small number of observations, *viz.* 21 procurements, prevents the effect being statistically significant.

In the current paper we consider what determines public procurements' procedure design to vary using a much larger dataset. How can we better understand the public procurement procedure design choices? Do procurements' procedures vary in design? What determines procedure design to vary? These questions are central in this paper. The organization of this paper is as follows. In section 2 we outline the theoretical background of the paper. Section 3 consists of a description of the civil construction public procurements' design. This analysis is based on the EIB Monitor and involves public open procurements of civil work in the Netherlands awarded in the first half of 2009. In section 4 we analyze what determines variation in public procurements' qualification requirements. Conclusions and suggestions for future work are given in Section 5.

2. Public procurement design

The aim of the contracting authority is to obtain the best value conditional on the procurements' process design. The public procurements' process design includes the choice of the type of procedure to be followed, award criteria, and qualification requirements. Figure 1 indicates the various procurement designs' options.

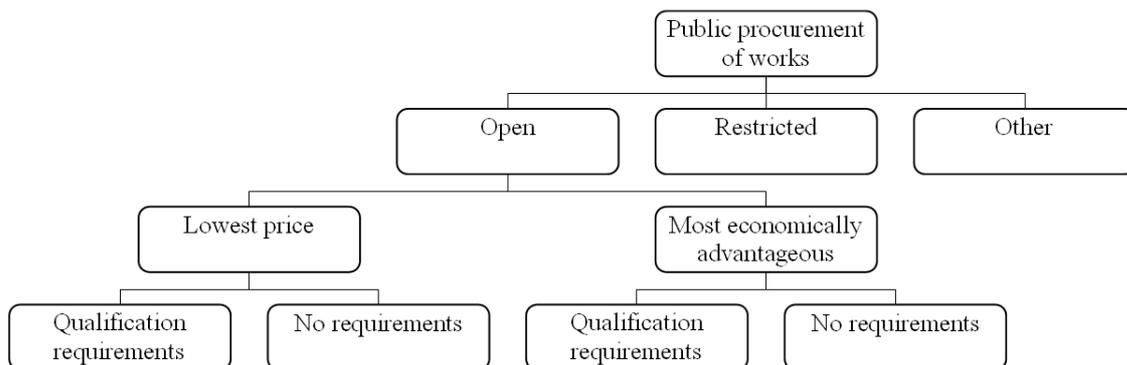


Figure 1 Public procurements' design

Figure 1 indicates that the procurements' process design starts with the choice of the type of procedure *viz.* open procurements, restricted procurements and other procurement like competitive dialogue and negotiations.

First, a choice is made between open, restricted and other procurements. Conditional on the choice of the open procurements a choice is made between award criteria *Lowest price* and *Most economically advantageous* tender. The former means that the contract will be awarded to the lowest bidder. For the latter, the contracting authority also gives a value to a number of prespecified criteria considering quality aspects like planning, or pollution reduction, and the contract will be awarded to the contractor who places the most economically advantageous bid. Subsequently, qualification requirements are considered, involving both financial - and technical requirements.

Financial qualification requirements - The most common financial requirement concerns the annual turnover of the company, which must be above some threshold, averaged over the last three years. In addition, bank guarantees are asked for to guarantee (partial) recovery of payment in case of a contractor's default.

Technical qualification requirement - Technical adequacy can usually be demonstrated by means of proper and timely execution of one or more similar works in the past (referred to as reference works). Other common requirements are the possession of special certificates, for example ISO 9001 (which certifies that formalized business processes are being applied) or VCA (concerning safe and healthy operation).

The procurement's process design is the choice among those J alternatives – conditional on open tendering – with choice set $j=1..J$ being mutual exclusive, exhaustive and finite (cf. Train 2003). The procurement i 's optimal choice is the procurement design j that provides the greatest utility U_{ij} , such that

$$(1) U_{ij} > U_{ik} \quad \forall j \neq k \text{ with } i=1,..,N \text{ and } j=1, \dots, J$$

Following the literature, we decompose utility U_{ij} into a observable and an unobservable component, such that

$$(2) U_{ij} = V(x_{ij}, s_j) + \varepsilon_{ij},$$

with $V(x_{ij}, s_j)$ consisting of observables x_{ij} and choice characteristics s_j , and ε_{ij} the error term. The error term $\varepsilon_{ij} \sim f(\varepsilon)$. The various discrete choices models relate to varying assumptions regarding the distribution $f(\cdot)$.

Procurement design j is chosen by agent i with probability P_{ij} with

$$(3) P_{ij} = \Pr(\varepsilon_{ik} - \varepsilon_{ij} < V_{ij} - V_{ik} \quad \forall j \neq k).$$

In the empirical part of the paper we consider what determines procurement officers' procedure design choice. For this we relate observed choices to observables. Before turning to the empirical specification we describe the data first. This is the topic of the next section.

3. Data

The data comes from the EIB Monitor Procurements covering public procurements of civil work in the Netherlands. The EIB Monitor Procurements includes information on the name, address and contact data of the contracting authority, the agency that may provide further information, procedural information on qualification requirements, and attributes of the civil work such as type of work, location and duration. In addition, the data includes information on the number of bidders, details of the bidders, and the associated bids. The data we use involve public open procurements of civil work posted in the first half of 2009. We have 456 procedures of 182 different contracting authorities with 4189 bids. Here, we select procurements by municipalities for which we have 289 procedures and 2820 bids for 120 of 441 municipalities. Table 2 gives information on qualification requirements, in totals and by procurement award.

Table 2. Qualification requirement by type of procurement award, shares

	<i>Total</i>	<i>Most economically advantageous</i>	<i>Lowest Price</i>
Technical Qualifications			
<i>Reference works</i>	.98	.90	.99
<i>ISO 9001</i>	.56	.43	.58
<i>VCA</i>	.47	.40	.47
Financial Qualifications			
<i>Turnover</i>	.84	.87	.84
<i>Bank guarantee</i>	.97	.97	.97
<i>N</i>	289	30	259

From table 2 one observes that the majority of contracts is awarded on lowest price criterion. For one out of ten procedures, the contract is awarded to the bidder who has the most economically advantageous tender. Nine out of ten procedures are on lowest price. Regarding the qualification requirements, there are no clear differences between award criteria categories. With Fisher's exact test we cannot reject the null hypothesis that the use of the qualification requirements is unrelated to the award criteria at a significance of $\alpha=0.05$. Contracts typically include requirements concerning the timely and correct delivery of projects. For five out of ten procedures, technical capacities must be proved by ISO 9001 or VCA certifications. Requirements concerning the annual turnover of bidders are absent for two out of ten procedures.

In practice, procurement designs include combinations of qualification requirements. Based on table 2, we constructed four mutually exclusive packages of qualification requirements. We used requirements relating to annual turnover as the distinctive financial requirement, and requirements relating to technical certificates are used as the distinctive technical requirement. All procurement procedure designs are assigned to one of the packages. Note that, because bank guarantees and reference works are so commonly required (more than 95%), we do not use them in this classification. Table 3 gives information on qualification requirement packages.

Table 3: Packages of qualification requirements

<i>Financial qualification requirements on annual turnover</i>	<i>Technical qualification requirements on ISO 9001 and/or VCA certification</i>	<i>Share</i>
<i>No</i>	<i>No</i>	<i>.06</i>
	<i>Yes</i>	<i>.10</i>
<i>Yes</i>	<i>No</i>	<i>.26</i>
	<i>Yes</i>	<i>.58</i>
<i>N</i>		<i>289</i>

From Table 3 one observes that in one out of sixteen procurements no specific financial or technical qualifications are required. In six out of sixteen procurements either financial or technical qualifications are indicated. Most procurements request financial and technical qualifications.

These procurement procedures may vary with degree of professionalism of the procurement office, the type of work and type of bidders.

Degree of Professionalism

An important attribute in procedure design is the procurement officers' degree of professionalism. Professionalism relates to knowledge, experience and expertise be it internal, or external. The degree of professionalism can be indicated by various proxies. First, the degree of professionalism relates to the size of the organisation. Contracting authorities with more inhabitants, will on average have larger organisations with more specialised employees. We use the total length of roads as a proxy for size too. Professionalism also relates to the available budget for construction and maintenance of roads, playing fields and sewerage. The larger the budget, the larger the organisation and the more specialized the personnel. Second, the degree of professionalism relates to the degree of experience with public procurement in the organisation. We use the number and total volume of public procurements of civil engineering works by municipalities in the period 2000 to 2006, as an indication of the degree of experience with public procurement. Third, professionalism relates to experience external to the contracting authority. For this we use information on whether external professionalism is hired.

Characteristics of the work

Properties of the work itself may influence the procurements design. First, the type of work may be an indicator. Some types of work will be more complex than others, and subsequently require more expertise and knowledge from the contractor in order to be fulfilled properly. We use the CPV code (Common procurement vocabulary) given by the procurements' officer to distinguish between types of work. We consider 7 types of infrastructure work, based on the first digits of the CPV code (Common Procurement Vocabulary) as shown in table 4. Note that there might be some heterogeneity in types as many contracts contain components that belong to multiple CPV codes. Some procurement officers therefore used the code of the most important component, others referred to the more general code (like 4500 for all types of construction) in their announcement.

Table 4. Types of work

	<i>CPV main classification</i>	<i>Type of work</i>
<i>A</i>	<i>45221</i>	<i>Bridges and tunnels</i>
<i>B</i>	<i>45220, 45222, 45223</i>	<i>Other civil engineering</i>
<i>C</i>	<i>45231, 45232</i>	<i>Pipes and drains</i>
<i>D</i>	<i>45233, 45234</i>	<i>Road construction and maintenance</i>
<i>E</i>	<i>45236</i>	<i>Flatwork (playing fields)</i>
<i>F</i>	<i>4524, 4525</i>	<i>Water projects</i>
<i>G</i>	<i>Other</i>	<i>Other</i>

Second, the procurement design relates to size of the work. The size of the project is typically indicated using engineers' cost estimates provided by the contracting authority. This information is typically not available in the Netherlands. For 30 out of 289 observations we have information on the engineers cost estimate. We therefore use the lowest bid as a proxy for project size. Third, procurement design relates to the urgency with which the work has to be performed. We use the time (expressed in a number of days) between the first announcement and the award date as a proxy for urgency. Note that this proxy for urgency is influenced by changes in plan, questions from potential bidders, or procedural mistakes and rectifications also. We define the number of days between the opening of the tender, and the date the work starts, as a second proxy for urgency.

Expectations about the number of bidders

Procurement design may depend on a procurement officer's expectation regarding the number of bidders. These expectations may be based on backward looking (where one uses information about past procurements) or forward looking. We have no knowledge about the procurement officers' expectations regarding the number of bidders. We assume perfect foresight with

procurement officers having perfect information regarding the expected number of bidders. For this we use the number of bidders ex-post.

The summary statistics of the data are given in Table 5. Monetary values have been deflated to 2006 values.

Table 5. Summary statistics

<i>Variable</i>	<i>Average</i>	<i>Stdev</i>	<i>min</i>	<i>max</i>
Professionalism				
<i>Size of municipality (number of inhabitants)</i>	97,588	130,075	8,193	587,134
<i>Length of municipal roads (km)</i>	508	397	47	1803
<i>Municipal budget for roads, playing fields and sewerage (x €1000 averaged over last 5 years)</i>	22,736	45,004	1,383	204,202
<i>Number of public procurements by authority (2000-2006)</i>	44	48	1	157
<i>Volume of publicly procured works (2000-2006 in 1000 €)</i>	26,700	30,500	58	121,000
<i>Dummy external advisor</i>	.38	.49	0	1
Type of work				
<i>Dummy Bridges and tunnels</i>	.05	.22	0	1
<i>Dummy Other civil engineering</i>	.44	.50	0	1
<i>Dummy Pipes and drains</i>	.09	.29	0	1
<i>Dummy Road construction and maintenance</i>	.19	.40	0	1
<i>Dummy Flatwork</i>	.05	.22	0	1
<i>Dummy Water projects</i>	.02	.15	0	1
<i>Dummy Other</i>	.15	.36	0	1
<i>Contract size (lowest bid, €) (ex post)</i>	748,466	933,239	44,700	7,333,00
<i>Announcement period (number of days between first publication and award date)</i>	38	19	23	307
<i>Start time (number of days between award date and start of job)</i>	21	26	0	146
Expectations				
<i>Number of bidders (ex-post)</i>	9.8	3.8	2	23

One observes from table 5 that the contracting organisations are rather heterogeneous. Municipalities vary in number of inhabitants, ranging from 8 thousand to 587 thousand, and in length of roads in their jurisdiction, ranging from 47 to 1803 km. This variety is also reflected in the budget, in the number and volume of procurement procedures between 2000 and 2006, and in whether external advisors are hired. We expect this variation to be reflected in the degree of professionalism and as a result, in the procurement design.

Regarding type of work one observes that two types dominate *viz.* road construction/maintenance, and other civil engineering relating to (re)development of public space and site preparation. On average the contract size amounts nearly 750 thousand euros. Differences in complexity and size may result in different qualification requirements.

We proposed urgency as yet another characteristic of the work. From Table 5 one observes that most projects are announced 20 to 40 days before the award date. In a few cases, the number of days is more than 100, indicating that the procedure may have been interrupted and later resumed. Regarding the second proxy for urgency one can observe that on average the start time is 21 days after the opening of the tenders. In 42% of the procedures the contractor may start immediately after the contract has been awarded, in 20% of the cases, the start date is between 20 and 30 days after the opening of the tenders. For the remaining 38%, the start date is more than 30 days after the tender opening.

The number of bidders varies from 2 to 23, with an average of 9. The expected number of bidders may be an important determinant in the procedure design process, as the procurement officer may use qualification requirements in an attempt to limit the number of participants.

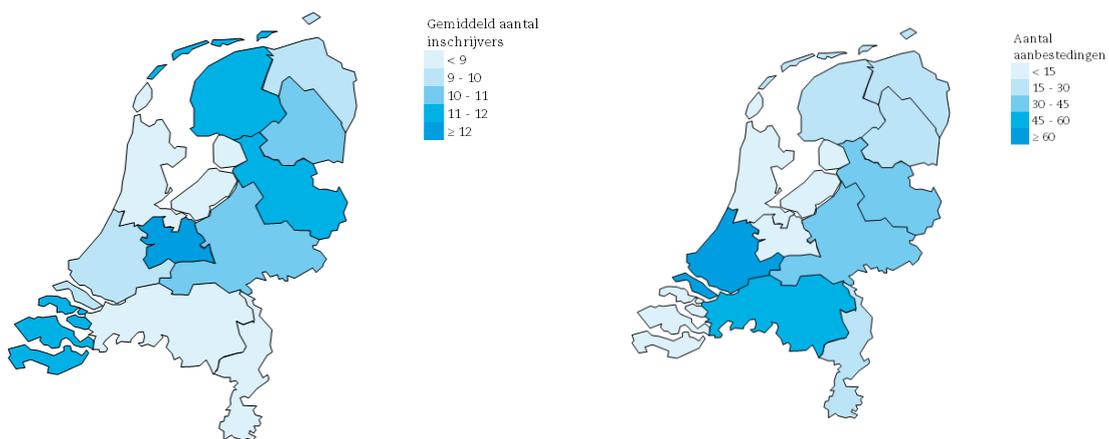


Figure 2. Number of Bidders (left) and number of Public Procurements (right)

4. Empirical methodology

The empirical specification of equation (3) reads as

$$(4) \quad V(x_{ij}, s_j) = f(\text{PROF}, \text{WORK}, E(\text{bidders})),$$

where *PROF*, *WORK* and *E(bidders)* indicate properties of contracting authority and infrastructure work. We present now the estimation results for the parameters concerning professionalism, type of work and expectations about the number of bidders on the decision to set qualification requirements. We estimate a multinomial logit model thereby controlling for a

large number of characteristics (cf. Maddala, 1983). In table 6 the results for the multinomial logit model are summarized with procurements' design package the dependent variable.

Table 6. Estimation results for a multinomial logit model

Package 1: only technical requirements	<i>Coefficient</i>	<i>Standard deviation</i>
<i>LOG municipal budget</i>	-.77***	.28
<i>DUM external advisor</i>	-.35	.76
<i>DUM road construction</i>	-1.21	.86
<i>DUM pipes and drains</i>	-.67	1.11
<i>DUM flatwork</i>	-1.37	1.19
<i>LOG contract size</i>	-.19	.40
<i>LOG announcement period</i>	.51	.98
<i>LOG number of bidders</i>	.25	.90
<i>Constant</i>	9.48	6.98
Package 2: only financial requirements		
<i>LOG municipal budget</i>	-1.46***	.30
<i>DUM external advisor</i>	-1.38*	.75
<i>DUM road construction</i>	-2.20***	.84
<i>DUM pipes and drains</i>	-1.86*	1.13
<i>DUM flatwork</i>	-3.23***	1.22
<i>LOG contract size</i>	-.44	.39
<i>LOG announcement period</i>	-.45	1.16
<i>LOG number of bidders</i>	-.32	.85
<i>Constant</i>	25.55***	7.44
Package 3: technical and financial requirements		
<i>LOG municipal budget</i>	-1.50***	.28
<i>DUM external advisor</i>	-.63	.71
<i>DUM road construction</i>	-2.34***	.81
<i>DUM pipes and drains</i>	-1.64	1.07
<i>DUM flatwork</i>	-3.07***	1.12
<i>LOG contract size</i>	.00	0.37
<i>LOG announcement period</i>	-1.42	1.13
<i>LOG number of bidders</i>	-.29	.83
<i>Constant</i>	24.19***	7.10

^o LOG indicate logarithmic transformations of the variable

^o Estimated with package 0 (no financial and technical requirements) as the reference outcome.

^o * Significant at 10%, ** significant at 5%, *** significant at 1%

From Table 6 one observes that 11 parameters are significant of which nine are significant at the 1% level. The R^2 is 15 percent. This is not at odds in micro-level data, yet indicate other factors at work as well.

The coefficient for LOG municipal budget is negative for all three packages, with a strong significance, indicating that the contribution of this determinant to the relative probability a procurement officer chooses to adopt any of these requirements, decreases with budget. The relation is stronger for financial requirements than for technical requirements. Replacing the indicator for budget by the indicator length of roads, also results in a significant negative relation between professionalism and procedure design. Using the total number of inhabitants as an indicator for size, yields comparable results. This suggests that professionalism is negatively related to the application of qualification requirements.

Although not significant in all three specifications, the coefficient relating to the hiring of an external advisor is negative for all packages, indicating that procurement officers using externally hired professionalism, use less restrictive requirements than procurement officers without external advisors.

The procurement officers' choice appears to relate to type of work as well. For road construction contracts, pipes and drains and flatwork the probability of choosing package 2 or 3 is relatively smaller, compared to the categories bridges and tunnels, water projects and other civil engineering.

Contract size and the expected number of bidders do not relate to the design choices. Both coefficients are small, insignificant and have varying signs. Urgency, indicated in table 6 by the number of days between announcement and award, do not relate to the procurement officers' procedure design choice.

The estimation results indicate that professionalism induces decision makers to release qualification requirements, both technical and financial. Smaller municipalities design their procedures on average with more requirements. One explanation may be that experienced procurement officers are more capable of absorbing and handling risks in a later stage.

Moreover, the type of work appears to be an influential factor. This finding is in line with our theoretical exposition where we argued that the requirements are a rational choice and not randomly set. Road construction work may be relatively easy to manage, compared to other civil engineering projects which may be more complex.

5. Conclusions

In this paper we considered what determines public procurements' procedure design to vary. We considered public procurement procedure design choices, considering whether procedures vary in design, and if so, what determines these differences among procurements.

The procurements' process design is modelled as a rational choice among a set of alternatives within a random utility framework. Qualification requirements are chosen as to maximize utility of the procurements' officer. In the empirical part of the paper the design choice is modelled as a limited dependent variable model. The data comes from the EIB Monitor Procurements covering public procurements in the Netherlands, and relates to public open procurements of civil work posted in the first half of 2009. For this paper we selected procurements by municipalities for which we have 289 procedures for 120 municipalities.

We observed that the majority of contracts is awarded on lowest price criteria. For nine out of ten procedures, the contract is awarded to the bidder who has the lowest price. One out of ten open procedures is awarded on most economically advantageous tender. Regarding the qualification requirements, we found no clear differences between both award criteria categories. Requirements concerning the timely and correct delivery of similar projects do not vary with award criteria. For seven out of ten procedures, technical capacities must be proved by ISO 9001 or VCA certifications. Requirements concerning the annual turnover of bidders are absent for two out of ten procedures.

The estimation results indicate that requirements do relate to degree of professionalism of the procurement office and the type of work. Using the municipal budget for road construction, playing fields and sewerage as an indicator for professionalism, we showed that procurement officers in more professional organisations, in general apply less strict qualification requirements. With regard to the type of work, we showed that the procedure design differs between road construction, pipes and drainage and flatwork projects. We could not find a relation between the expected number of bidders and the qualification requirements.

These results indicate a rational choice among qualification requirements yet explain about 15 percent of total variation, suggesting other factors at work. Also, in our analysis, we assumed perfect foresight in the expected number of bidders. Further research may formulate a dynamic model in which other expectation formation processes are formulated with qualification requirements and the number of bidders interacting. These issues are left for future research.

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