THE ROLE OF FIRMS' QUALIFICATION IN PUBLIC CONTRACTS EXECUTION: AN EMPIRICAL ASSESSMENT

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ABSTRACT. According to the Italian regulation firms must qualify to bid in auctions for public work contracts worth more than 150,000 euros. In this paper, we investigate the link between the efficiency of infrastructure provision, and the Italian regulation concerning the firm's entry and qualification system, employing a large dataset on Italian public works contracts for roads and highways. First, firm's efficiency in public contracts' execution is estimated using a smoothed data envelopment analysis (DEA) bootstrap procedure. Then, the effects of the qualification system on firm's efficiency is evaluated using a semi-parametric technique that produces a robust inference for an unknown serial correlation between efficiency scores. Our analysis shows that fully qualified firms perform better than partially qualified firms.

INTRODUCTION

Public procurement is a wide economic area, including contracts for public works, supplies and services, with marked economic differences across them. As Guccio, Pignataro, and Rizzo (2012a) have pointed out, the most important difference is that in the case of public works, the outcome of the contracts crucially depends on the implementation stage. This is a relevant issue to take into account in designing the rules to mitigate the effects of information asymmetries, such as adverse selection and moral hazard. In this paper attention is focused

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on the former, namely to the schemes for supplier qualification that, at the selection stage, aim at ascertaining the supplier's ability to comply with contract specifications. Italy, as most other countries, regulates the qualification process. The Italian system for qualifying firms is operated by a third party (Società Organismo di Attestazione - SOA) accredited and monitored by an independent Authority (*Autorità Nazionale Anticorruzione* - ANAC) to ensure that only prequalified firms can bid in public procurement procedures. At the same time, the regulation imposes market restriction and leaves room for opportunistic behaviours.

In this paper, we investigate the relationship between the execution of public works contracts and the Italian regulation on firms' qualification. We employ a large dataset on Italian public works contracts for roads and highways. First, firm's efficiency in public contracts' execution is estimated using a smoothed data envelopment analysis (DEA) bootstrap procedure that ensures consistency of our estimates. Then, the effects of the qualification system on firm's efficiency are evaluated, using as indicators of full or partial qualification, respectively, *optional* or *mandatory* subcontracting (Moretti & Valbonesi, 2015). Finally, different levels of efficiency of these two groups of firms are assessed using both non-parametric tests and a semi-parametric trouncated regression (Simar-Wilson, 2007). We obtain new and robust evidence of positive effects of fully qualification on the execution of public works contracts.

The remainder of the paper is organized as follows. Next section briefly reviews the economic rationale for a qualification system in public procurement. Then, two sections focus on the qualification systems: firstly, a comparative overview, with special attention to the European systems is offered, and, successively, the institutional features of the Italian system are analysed. Further, there are two sections focusing, respectively, on the presentation of the data set and the methodology, and on the empirical analysis and its results. Concluding remarks are offered in the last section.

THE RATIONALE FOR A QUALIFICATION SYSTEM IN PROCUREMENT

The economic analysis of public contracts deeply relies on the so-called New Regulatory Economics[1] which offers a well-established theoretical framework to define optimal incentives schemes.[2] Public procurement is a wide and important economic sector, including

contracts for public works, supplies and services.[3] There are common features as well as differences across these different types of contracts. All public contracts have in common the public nature of the purchaser and, therefore, the fact that the use of public resources aims at obtaining 'value for money', that is efficiency and effectiveness, within a framework of transparency and integrity. In such a perspective, it is widely claimed that the rules for the selection of the private contractor are similar for all public contracts: if taxpayers' interest is related with the degree of competition, regulation in public procurement aims at promoting competition. Moreover, there is the need for promoting quality, which is not guaranteed as outcome of the contract because of the existence of asymmetrical information between suppliers and tendering authorities.

The quality problem is extremely severe for public works contracts, as they exhibit the peculiar feature that their outcome crucially depends on the implementation stage since the output of the contract -public work- is not available in the market.[4] Therefore, in designing the procurement rules and in evaluating their effectiveness it is important to understand how they are able to address these issues. To this respect, rules are needed to mitigate the effects of information asymmetries, such as adverse selection and moral hazard, both at the selection stage – when the private contractor is chosen - and at the execution stage – when the contract is put in practice -. We focus our attention on the selection stage: rather than dealing with the effects of different selection procedures,[5] this paper investigates the schemes for supplier's qualification that, at this stage, aim at ascertaining the supplier's ability to comply with contract specifications.

Qualification schemes have 'shadows and lights' and the balance between them depends on how the rules are designed and implemented.[6] On one hand, these schemes imply additional direct and indirect costs to firms. Getting the qualification is costly in terms of the time and the resources directly involved, which might also imply the payment of a fee, depending on the qualification procedure.[7] Moreover, there is a medium and long term cost, which is related to the acquisition of technologies, capabilities and expertise, which are required for entering the market for any given type and size of work. To get qualification for any type of work of any size can be very costly in terms of the required investment and, therefore, each firm chooses the most convenient qualification. However, this does not exclude that a

firm can bid for tenders even if not fully qualified, forming a consortium with other firms or using subcontracting. Strategies are closely affected by the existing rules.

It is claimed that the adoption of substantive pre-qualification criteria reduces competition, increases bid prices and raises barriers to entry the market, since only the qualified firms can apply for public contracts (Hyytinen, Lundberg, & Toivanen, 2006). This would raise procurement costs further (Wan & Beil, 2009), and results also in increasing unemployment rate, above all at local level (Schwartz, Andres, & Dragoiu, 2009; Blancas et al., 2011).

On the other hand, supplier qualification is relevant for the success of any contract (Estache & Imi, 2012): in fact, it involves a screening process to assess ex-ante the technical, financial and economic capabilities of private contractors. Actually, qualification is considered by OECD (2010) among the criterion to assess procurement systems. The restrictions depending on qualification are essential to guarantee the functioning itself of the competitive system under incomplete information about the firms' capacities. However, this beneficial effect crucially depends on the adequateness of technical, economic and financial requirements which are imposed by the qualification scheme.

Finally, a closed relevant issue is whether the firm's reputation (in terms of its past performance) is taken into account when contracts are awarded and whether contracting authorities have discretionary power with respect to this issue (Spagnolo, 2012).

In what follows, after an overview of different qualification schemes, the paper investigates how the above issues are addressed in the Italian regulation.

AN OVERVIEW OF QUALIFICATION SYSTEMS IN THE WORLD AND IN THE EUROPEAN PERSPECTIVE

Selecting a construction contractor is one of major decisions which may influence the progress and success of any construction project. In the public sector, contractor prequalification is a commonly used process for identifying a qualified, sound and reliable construction contractor.

Among public procurers, it is widely agreed that quality should not be compromised, particularly in high-value transactions, such as infrastructure projects (Alexeeva, Padam, & Queiroz, 2008; Flyvbjerg,

Holm, & Buhl, 2004). The common practice excludes incompetent applicants from the selection process. For instance, under the prequalification process, only bidders who meet basic financial, technical, and experiential criteria are allowed to bid. Supplier qualification screening generally comprises the confirmation of a firm's financial status, references, and product and surge capacity and is commonly used in most countries. However, the qualification criteria change by country also in a dynamic fashion that evolves over time. In what follows, a short overview of the most relevant qualification screening systems adopted all over the world is reported.

Despite of having a strong tradition of centralized administrative guidance, Japan has thus far not been able to create a nationally uniform system for supplier qualification. Only recently, an unified qualifications screening system has been set up to give suppliers a one-stop solution to apply for qualification for multiple procuring entities (Griek, 2014). The screening process includes a preliminary exam that measures a firm's technological, financial and geographical status and gives them evaluation scores. Such scores pertain to the financial and technical information provided and the evaluation of works accomplished and define the matching between bidder size and project size. In fact, only large firms are qualified to participate in the tenders for large and high-end projects while are not allowed to bid on small and low-end projects, which are reserved for SMEs with a set-asides procedure (Nakabayashi, 2009). In order to place extensive emphasis on allocation of resources to local firms, the Japanese procurement regulations requires as an additional qualification that each firm can make an offer only in tenders for works in the district in which the firm's headquarter is located (Ohashi, 2009).

In USA, while each State has its own qualification system and criteria, at the federal level to be admitted to the auction a bidder must provide evidence to have adequate financial resources to perform the contract and must be able to comply with the performance schedule (Federal Acquisition Act-FAR-9.104-1/2). Moreover, the bidder must have a satisfactory performance record, a satisfactory record of integrity and business ethics, the necessary organization, experience, accounting and operational controls, and technical skills. Eventually, the bidder must have the necessary production, construction, and technical equipment and facilities, be otherwise qualified and eligible to receive an award under applicable laws and regulations (Shah,

2015). Past performance information (ratings and supporting narratives in the "Past Performance Information Retrieval System" – PPIRS) are considered relevant, even if the lack of a satisfying past performance record cannot be the only reason for excluding a bidder from the auction (Giachi, 2015).

Several countries like Cambodia, Vietnam, and Philippines in South-Eastern Asia have not a clear and transparent qualification systems and this leaves to the single administration the discretionary power to qualify or disqualify potential bidders according to opaque criteria (Jones, 2007). Like in Japan, the public bodies in South-Eastern Asia and in Australia have special rights to exclude firms that are not locally based.

In South-Africa besides the usual criteria regarding production performance, the number of employees in the bidder's work force, and the amount of its capitalization are taken into account. In the law is also expressed the need for giving preference to historical disadvantaged social groups (black people, women, disable people, etc.) and to green criteria in the pre-qualification screening systems (Bolton, 2008).

In the EU, each member country determines and specifies the qualification criteria; however, whatever the criteria are, they have to comply with the principles of objectivity, transparency, equal treatment, and non-discrimination that are the basic principles underlying procurement EU policy. An emerging practice is to negate access to suppliers when irregularities or corruption have been proven, in order to stimulate the integrity of the procurement process and discourage bidders from engaging in illegal activities (OECD, 2007).[8]

After the failure of the draft European standards for the harmonization of criteria and procedures to be used by qualification bodies for the qualification of construction enterprises (CEN TC-330), the European construction industry federation considered that it would have been useful to exchange information on the existing qualification systems in the various Member States through a dedicate survey (FIEC, 2010). According to this survey, the approaches to pre-qualification in Europe have been extremely different. There are countries in which the pre-qualification screening is mandatory (Belgium, Bulgaria, Cyprus, Greece, Italy, Lithuania, Portugal, and Spain), there are some countries that have only a voluntary approach (Czech Republic, France, Germany, Ireland, Poland, and UK), and eventually there are countries without

any system, neither mandatory nor voluntary (Austria, Denmark, Finland, Netherlands, Slovakia, and Sweden).

In the countries with mandatory systems but also in some countries with voluntary systems (France, Germany, and Poland) potential contractors are registered in classes, according to the size of the project, and in sub-categories, according to the type of activities developed. In the countries with voluntary screening systems the compliance with the requirements simplifies the application process for public tenders decreasing the number of documents necessary to qualify thus drastically reducing costs and bureaucracy.

In UK, the Office of Government Commerce has developed a unified model of pre-qualification for each sector and category of good, service, or work to be awarded. It takes the form of a questionnaire (Pre-Qualification Questionnaire, PQQ) in which each applicants has to answer to several questions aimed at determining the eligibility of the firms.[9] In the Netherlands, like in UK, the applicants for public tenders self-declare to fulfil the requirements for participating while have to produce certificates for proving not being bankruptcy and for having paid the taxes that can be produced only once and freely available on the portal TenderNed.

In France, there are two main categories of procedures available to public buyers: non-formalised procedures, consisting only of the adapted procedure, and formalised procedures, which regroup procedures such as the open call for tenders and formalised procedures with a negotiation phase. The choice between formalised and non formalised procedures is not entirely left to the discretion of the public buyer but is linked with fixed threshold. Under the fixed threshold, the adapted procedure implies that the public buyer is exempted from requesting a number of documents as prequalification requirements[10] public buyers face less administrative burden and firms' costs related to the preparation and submission of the formal bid decrease. Therefore, this adaptation might increase both the entry of SMEs and their probability of being admitted (Boulemia & Moore, 2014).

THE ITALIAN QUALIFICATION SYSTEM

As it was said before, in Italy, the qualification screening system is mandatory in public procurement since the DPR 34/2000, which

modified the pre-existent system based on the inscription in a National list of construction firms (The 'Albo Nazionale dei Costruttori' that was active from 1962 to 1999). The present scheme has been defined with the D.L.163/2006, the D.P.R. 207/2010 and, very recently, with the D. L. 50/2016, which state that it is mandatory the prequalification process for tendered public works worth more than 150,000 Euros.[11] The Italian system is operated by the *Società Organismi di Attestazione* (SOA), a third party that is recognized and supervised by the Authority in charge of regulating the national market for public works, supplies, and services (Autorita' Nazionale Anti-Corruzione-ANAC, formerly Autorità di Vigilanza sui Contratti Pubblici AVCP).

The firms' qualifications are provided after documented 'general' and 'technical' attributes have been verified by one of the private companies certified as SOA (Decarolis, Giorgiantonio, & Giovanniello, 2011). Among the management and financial requirements there are the firms' financial standings and criminal records, while among the technical attributes there are the specific skills required to accomplish any category of works, which are usually evaluated on the basis of firms' previous works completed and other observable items. Fifty-two categories of works and ten financial levels are defined by the Italian procurement regulation. In particular, the financial levels represent the limit of admission to the tender with reference to the reserve price (i.e., the maximum price the public body is willing to pay) of the tender.[12] The certification is issued for a 5-years term, however, in the third year the firm has to renewal the qualification demonstrating it still satisfies all the requirements (Decarolis & Giorgiantonio, 2014). From the second category onward (qualification over 516,000 Euros), the firm has to get also a quality system certification UNI EN ISO 9001. For any tender, all the firms that apply and have a SOA certification, matching the type of work and equal or above the contract reserve price, must be admitted to the auction.

To get qualified, each firm has to pay a fee to the SOA to comply with the required procedures.[13] At the end of each five-years term, the firms have to apply again and bear again the same costs. Law states that the fee has to be paid before the certificate is issued and that the qualification is denied in absence of the payment. Qualified firms tend to maintain the same qualifications from year to year in order to maximize the probability of recovering their investment costs by becoming a contractor in the execution of public works.

The activities of the SOA are under the control of ANAC (previously AVCP) that communicate strengths and weaknesses of the SOA qualification system every year to the Parliament in the annual Report, where possible modifications of the system are suggested in order to overcome major problems occurred. Examining the *Reports of the Authority* from 2004 to 2014, it appears that the qualification system has been adjusted several times to address malpractices aroused in the implementation of the law.[14]

Among the main issues handled by the Authority in these years, at least two are worth mentioning. The first issue is related to the control over the SOA promotional activities to gain more customers.[15] The Authority's monitoring has been aimed at ensuring that competition among the SOAs would not induce some of them to reduce the controls, in order to be more attractive for the firms looking for qualification. The reliability of SOAs is a crucial issue, as witnessed by the number of penalties, suspensions, or cancellation of SOAs from the official list, in order to promote fair competition into the market and to avoid gaps in the screening system.

The second issue refers to the need to guarantee the independency of the SOAs and their technical and financial capability to survive in a competitive market. In terms of independency, the SOA's ownership has been defined in order to prevent conflicts of interests.[16] With reference to the organizational and financial structure, in the 2013 report, the Authority, evaluating the fragmentation of the market, has stressed the need for strengthening the SOA organizational structure, which is crucial for the effectiveness of the qualification system. This problem has been exacerbated in the last years because the market of the construction firms has increasingly witnessed processes of partial or total take-over. The concern is that these take-overs can pave the way to fake transfer of part of a firm only for getting the certification, without a real transfer of technical equipment and competencies. In these cases, the capability of the SOA to evaluate the transferability of the certification is extremely important in avoiding the creation of a market of 'virtual' firms, which are qualified only because of the transfer of the certification.

Notwithstanding the above mentioned problems, the certification system has been somehow effective in reducing the number of potential applicants. In particular, according with the 2013 Report, qualified firms were about 40,000, with a 30% reduction with respect

to the former "Albo Nazionale Costruttori" (listing more than 55,000 qualified firms). Notwithstanding such a reduction, the market appears to be fragmented on the supply side. In the same 2013 Report, it is outlined that on average each firm is qualified for about two cathegories and that the number of firms with the maximum classification (certified for contracts worth more than 15 million euro) were more than 3,000.

EMPIRICAL STRATEGY AND DATA

In this Section, we provide some empirical findings on the effects of the Italian firm's qualification on the efficient provision of public works for roads and highways. For the empirical purposes, our work is strictly connected with the paper of Moretti and Valbonesi (2015) that, to our best acknowledge, is the only empirical paper investigating the qualification system and the subcontracting in public works procurement. The authors, using data for 269 public works procurement in Valle d'Aosta region, find that fully qualified firms (i.e. qualified for each category of work to complete all of the tasks in a given contract) systematically provide a lower bid than partially qualified firms, which must rely on mandatory subcontracts. However, the authors do not find significant difference of optional (for fully qualified firms) and mandatory (for partially qualified firms) subcontracting on the probability of ex-post contract renegotiation with time and cost overruns.

The main aim of our empirical investigation is to contribute to this latter issue and to provide new evidence, as we are able to assess the effects of optional and mandatory subcontracting (e.g. of full qualification and partial qualification) on ex-post contract performance, using nonparametric efficiency frontier. The efficiency of execution of public works contracts is usually defined in terms of the capacity to complete works within the costs and the time agreed on in the contract. However, considering separately cost overruns and delays does not allow to evaluate the performance of the procurer in carrying out the contract. A more significant information can be provided when cost overruns and delays are simultaneously taken into account, to develop a measure of overall efficiency of public works contracts execution (Guccio, Pignataro, & Rizzo, 2012b).

In this perspective the best way to measure the relative efficiency of the firms in the capacity of achieving both the targeted results of

time and costs, as determined in the contract, is through the benchmarking of their performance. DEA is one of the natural candidate methodologies for this. It is a nonparametric technique, generally used to estimate a production function with minimal assumptions, and it can easily handle multiple inputs/outputs situations. DEA calculates the efficiency frontier for a set of decision-making units (DMUs), as well as the distance to the frontier for each unit. DEA identifies as productive benchmarks those DMUs that exhibit the lowest technical coefficients, i.e. lowest input amount to produce one unit of output. In so doing, DEA allows for the identification of best practices and for the comparison of each DMU with the best possible performance among the peers.

Following Guccio, Pignataro, and Rizzo (2012b), in such a framework, the expected cost is equal to the winning bid -- and the expected duration - as agreed in the contract -- are used as outputs, while the final cost and the actual duration of the work are considered as inputs. To evaluate the efficiency of execution, the benchmark is the actual best firms' behaviour in terms of time completion of works of a given financial size (and vice versa). The distance (efficiency score) between observed public work contract and the most efficient public work contract gives a measure of the radial reduction in inputs that could be achieved for a given measure of output.

The simple computation of efficiency scores based on DEA does not allow, *per se*, identifying the existence of systematic difference of *optional* (for fully qualified firms) and *mandatory* (for partially qualified firms) subcontracting in firms' efficient execution of a public work contract. Thus, to identify the most efficient groups of firms (based on different qualifications) and, therefore, the best practices, we perform both nonparametric tests and a two-stage DEA regression approach. The former aims at assessing the equality of the distributions of the DEA efficiency scores for the different firms groups, while the second aims at controlling for other environmental factors that, in principle, may affect the firm's execution performance. Finally, since there is no consensus on the best method to apply for the second-stage DEA analysis, we will use both semi-parametric (Simar & Wilson, 2007) and parametric approaches (Banker & Natarajan, 2008).

For the purpose of this study, we employ two different data sources to construct our dataset. The first source is the "Osservatorio per i lavori Pubblici" of AVCP. In our dataset, the observation unit is given by

the single public work performed by the winning bid firm. The employed sample refers to 3,113 public works contracts for roads and highways, whose engineering estimated costs range from 150,000 euros to 5 million euros, awarded in the period 2000-2004 and completed by 2005. This dataset contains detailed information on the contract awarding procedure, the reserve price of the contract, the subcategories of works involved in the contract, and the final cost and duration. However, differently from the dataset employed by Moretti and Valbonesi (2015) for Valle d'Aosta region, here only information on the winning bid is available. A second source for our dataset is the *"Casellario SOA,"* that is the national register that collects the qualification status of each firm (for each category and size). As Table 1 shows, our sample consists of 3,113 public work with average reserve price of 369,980 euro (ranging from 150,000 to 5 million euros).

Some variables of this dataset have been used for the first stage of the analysis to compute the efficiency scores of infrastructures provision on the same line of Guccio, Pignataro, and Rizzo (2012b). As it has been said before, the authors measure the efficiency of execution of public work contracts using the following benchmarking model: actual time of completion and actual cost are regarded as inputs; expected duration and value of winning bid as outputs. Thus, in the next section we provide some descriptive statistics of the efficiency estimates and refer to Guccio, Pignataro, and Rizzo (2012b) for a more detailed discussion.

As for the presence of subcontracts, a large part of the sample (75.55%) of the firms employ subcontractors: the largest part (75.34%) refers to fully qualified firms (that already own all the necessary qualifications and, therefore, voluntarily opt for subcontracting part of the work). These also include a small number of temporary consortia between firms "Associazioni Temporanee d'Impresa." These temporary consortia are created *ad hoc* to bid for a given contract and, following Moretti and Valbonesi (2015), we assume that consortia are fully qualified to perform all the categories of work involved in a project. Table 1 shows that only 24.66% of the firms that employ subcontractors are not qualified for some of the secondary categories of work and, therefore, would be obliged to subcontract part of the work to other qualified firms. Finally, in terms of the geographical distribution, the contracts of our sample refer to the North (43.24%), Centre (34.56%), and South (22.2%) of Italy. Maintenance works are

more than new works. In Table 1, further summary statistics are also included.

TABLE 1
Some Descriptive Statistics of the Employed Sample of Public Works

Variable	Number of obs.	Mean (St. Dev.)
Reserve price	3,113	369.98 (369.85)
No. of bidders	3,113	32.91(33.44)
Open procedure (dummy variable)	3,113	0.80 (0.40)
Rebate (percent)	3,113	13.78 (9.88)
Value of winning bid	3,113	318.15 (318.39)
Actual cost of infrastructure completion	3,113	345.01 (356.10)
Expected duration (days)	3,113	176.65 (123.45)
Actual time of infrastructure completion(days)	3,113	277.07(184.60)
Other statistics		**Percentage**
With subcontracting (%)	2,352	75.55
Optional subcontracting (%)	*1,772*	*75.34*
Mandatory subcontracting (%)	*580*	*24.66*
New work (%)	970	31.16
North (%)	1,346	43.24
Centre (%)	1,076	34.56
South (%)	691	22.20

Note: Monetary values in thousand Euros at current prices. Standard deviation in parenthesis.
Source: Our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture.

RESULTS AND DISCUSSION

Preliminary Findings

In this Section, we first analyse the firm's performance in term of cost and time overruns for different groups of firms in connection with the use of subcontractors. Then, we employ a more robust assessment of firm's performance using DEA. Table 2 reports statistics of time and

cost overruns for each group of firms. As reported, on average, time overruns and cost overruns are widespread: 69% of the firms experience delays and almost 74% experience extra-costs. On average, time overruns are more widespread for firms with subcontracting, especially if they are mandatory. No major differences seem to occur for cost overruns.

TABLE 2
Time and Cost Overruns for Different Groups of Firm

Firm groups	Number of obs.	Time overruns		Cost overruns	
		Mean	% of PW with time overruns		
All firm	3,113	0.77	69.00%	0.08	73.63%
Without sub-contracting	761	0.62	62.81%	0.09	72.14%
With sub-contracting	2,352	0.81	71.00%	0.08	74.11%
Optional subcontracting	*1,772*	*0.79*	*69.91%*	*0.07*	*75.06%*
Mandatory subcontracting	*580*	*0.82*	*73.21%*	*0.08*	*72.18%*

Source: Our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture.

To assess further differences in firms' performance, according to the role of different types of subcontracting, DEA efficiency scores are estimated. Here, detailed DEA first stage computations are not included as the results of Guccio, Pignataro, and Rizzo (2012b) are used. The authors measure the efficiency of the execution of public works contracts using an input-oriented DEA model. To check for the robustness of the DEA findings with respect to the sampling variation, a bootstrap procedure with 1,000 bootstrap draws is implemented (Simar & Wilson, 1998) to correct the bias in the DEA estimators and to obtain the confidence intervals. The distribution for the DEA efficiency scores by group of firms are shown in Table 3, which also reports the statistics of the bias corrected DEA efficiency estimates.

The estimates show that, on average, the overall efficiency in the execution of public works is relatively high. The mean efficiency of the DMUs in the sample is about 93%. However, it is worth noting that the

TABLE 3
Efficiency Estimates for Different Groups of Firm

Firm groups	Number of obs.	Efficiency scores		Bias corrected efficiency scores	
		Mean	St. Dev.	Mean	St. Dev.
All firm	3,113	0.9274	0.0870	0.9256	0.0872
Without subcontracting	761	0.9276	0.0846	0.9265	0.0850
With sub-contracting	2,352	0.9262	0.0940	0.9243	0.0938
Optional subcontracting	*1,772*	0.9329	0.0788	0.9313	0.0792
Mandatory subcontracting	*580*	0.9241	0.0872	0.9228	0.0876

Source: Our elaboration on data provided by Autorità di vigilanza sui contratti
    pubblici di lavori, servizi e forniture.

relatively high efficiency scores do not mean that public contracts for roads and highways in Italy are overall executed in an efficient way. As Guccio, Pignataro, and Rizzo (2012b) underline, the fully efficient observations, those on the DEA frontiers, are not necessarily the ones that simultaneously fulfil time and cost efficiency. Moreover, they also show that efficiency scores exhibit a high variability. Overall, differences in the mean efficiency across the different subsamples appear to be small. However the group of firms with optional subcontracting show on the average the best performance with small standard deviation. Conversely firms with mandatory subcontracting show to be the less efficient.

To identify the most efficient groups of firms and, therefore, the best practices, the first step is to assess the equality of the distributions of the DEA efficiency scores for the different groups of firm according to different role of subcontracting. To test for significant differences in the DEA efficiency estimates of the firms' groups, we perform several tests often used in related literature (i.e., the Mann-Whitney and Kolmogorov-Smirnov tests). In addition, for the DEA bias-corrected efficiency scores, the bootstrap-based procedure proposed by Simar and Wilson (2008) is used (Table 4). In general, there is no large evidence to suggest significant differences in mean efficiency levels between the firms that do not employ subcontracting and those that employ it. In fact, the null hypothesis that the two samples are drawn from the same distributions cannot be rejected at any conventional

level of significance both for Mann-Whitney and Kolmogorov-Smirnov tests. However, the bootstrap-based test proposed by Simar and Wilson (2008) rejects the null hypothesis only at 10 percent level of significance. Conversely, the performance of the group of firms with *optional* subcontracting consistently has higher average levels of efficiency than firms with *mandatory* subcontracting and differences are highly significant. In fact, Table 4 shows that, in all cases, the null hypothesis is rejected at any conventional level of significance. Therefore, it seems that, on average, the public works contracts performed by the firms with *optional* subcontracting, e.g. by the fully qualified firms, are executed more efficiently.

TABLE 4
Testing for Differences on the Average Efficiency Scores of the
Different Groups of Firms

Efficiency estimates	Without subcontracting *vs.* With subcontracting			Optional subcontracting *vs.* Mandatory subcontracting		
	MW	KS	SW	MW	KS	SW
DEA	1.540	2.317		4.855	23.570	
	(0.1236)	(0.1273)		(0.0000)	(0.0001)	
Bias corrected DEA efficiency scores			(0.0972)			(0.0000)

Note: Mann–Whitney (MW) test; Kolmogorov–Smirnov (KS) two-sample test; (SW) mean equivalence test proposed by Simar and Wilson (2008, 471-476). p-values in parentheses.
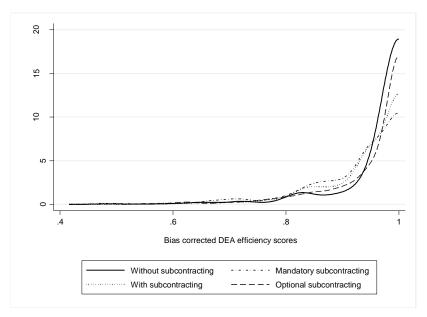Source: Our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture.

In addition, the kernel density functions for the DEA efficiency estimates by group of firms, in connection with the different role of subcontracting and qualification, are displayed in Figure 1. These density functions confirm the above-mentioned results on the performance of the group of firms that use optional subcontracting.

Robustness Checks

Previous Section shows that, on average, the public works performed by the firms that employ *optional* subcontracting are executed more efficiently. In this Section, in order for these differences

FIGURE 1
The Kernel Density Distribution of DEA Efficiency Scores by
Group of Firms

Note: Kernel density functions of public works contract efficiencies derived
      from both uncorrected and bias corrected DEA efficiency scores using
      univariate kernel smoothing distribution and the appropriate bandwidth
      (Simar & Wilson, 2008).
Source: Our elaboration on data provided by Autorità di vigilanza sui contratti
      pubblici di lavori, servizi e forniture.

in performance to be significantly attributed to the role of qualification
in subcontracting, we must control for other environmental factors
that, in principle, may affect the execution performance. Therefore, we
follow the two-stage approach suggested by Coelli, Prasada Rao, &
Battese (1998) to regress DEA efficiency estimates against a set of
covariates. The two-stage analysis is usually implemented after
conducting traditional DEA analyses. However, different estimators
have been proposed (Simar & Wilson, 2011). Here, we apply both semi-
parametric (Simar & Wilson, 2007) and parametric estimators (Banker
& Natarajan, 2008).

Table 5 shows the covariates used to perform the two-stage analysis, as well as their meanings and descriptive statistics. To capture the effects of subcontracting and firms' qualification, we first differentiate the firms on the use of subcontracting (SUBCONTRACT). Then, to take into account the role of qualification on subcontracting, we distinguish those firms that are fully qualified and opting for subcontracting (OPTIONAL).

TABLE 5
Descriptive Statistics of the Variables Employed in DEA Two-Stage Analysis

Variables	Definition	Mean	St. Dev.
DEA	Efficiency scores	0.9274	0.0870
DEA_BC	Bias corrected DEA efficiency scores	0.9256	0.0872
SUBCONTRACT	Dummy for subcontracting (=1 when subcontract is reported and 0 otherwise)	0.7555	0.4298
OPTIONAL	Dummy for *optional* subcontracting (=1 when subcontract is optional and 0 otherwise)	0.5349	0.3418
BIDDERS	Number of bidders	32.9214.	33.4422
REBATE	Rebate of the winning bid	0.1378	0.0988
NEW_PW	Dummy for type of infrastructure work (new/repair) (=1 when public work is new and 0 otherwise)	0.3116	0.4632
PW_CLASS_1	Dummies for the class of reserve price (= 1 when reserve price is between 150,000 - 500,000 euro and 0 otherwise)	0.8420	0.3648
PW_CLASS_2	Dummies for the class of reserve price (= 1 when reserve price is between 500,000 - 1,500,000 euro and 0 otherwise)	0.1128	0.3163
PW_CLASS_3	Dummies for the class of reserve price (= 1 when reserve price is between 1,500,000 - 5,000,000 euro and 0 otherwise)	0.0453	0.2080
DISPUTE	Dummy for legal dispute between firm and contracting authority (=1 when legal dispute and 0 otherwise)	0.0177	0.1318

TABLE 5

Variables	Definition	Mean	St. Dev.
PROJECT	Dummy for the completion of the project design by the firm (=1 when project completed by the firm and 0 otherwise)	0.8304	0.3754
RELATIONSHIP	Relationship between firm and contracting authority (numbers of contract relationships in time span period)	2.7677	3.7349
FINANCE	Dummy for the financial source of the work (=1 when the prevailing source is the budget of the contracting authority and 0 otherwise)	0.4128	0.4924
REGION$_j$	Dummies for region in which the infrastructure takes place: $j = 1$ to 20		
YEAR$_i$	Dummies for year of public work award: $i=2000, 2001, 2002, 2003.$		

Source: Our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture.

As for the other covariates, previous studies on public works execution find that competition exerts a positive effect on infrastructures provision. The rationale is that when the level of competition is higher the most efficient firm is likely to be chosen, with positive effects on the performance of public works execution. To capture this influence we employ the number of bids (BIDDERS) and the rebates of the winning bidder (REBATE).

To control for public work complexity, we first differentiate between "new" works (NEW) and repair/restructuring works. We expect that the degree of complexity and, thus, the likelihood of waste of time and costs are higher for new works than for repair/restructuring ones. As a further control for complexity, we have used the classes of work values (PW_CLASS). Also in those cases, we expect that complexity negatively affects efficiency. However in this paper, we do not use the total value of the work and duration of the work, as estimated by the contracting authority at the bidding stage, since such variables are strictly correlated with the variables used in DEA first stage.

The other features of public works that can significantly affect their performance at the execution stage are the following: the existence of legal disputes between the firm and the contracting authority (DISPUTE); whether the contractual obligation of the firm includes the completion of the design of the project, what is known in Italy as executive project (PROJECT). We assume that such variables tend to affect both time and cost overruns and the likelihood of a low performance in infrastructure provision. We also control for the long-term relationship between the firm and the specific contracting authority, computed as the number of contracts awarded to each firm by the same authority (RELATIONSHIP) in the time span period. Moreover, we control for the financial effort of the contracting authority in financing the public work using a dummy variable with value 1 when the public work is mainly financed out of the contracting authority's own resources (FINANCE). Finally, we control for region and year of award fixed effects. We have introduced fixed time effects since the database is time truncated and it includes the contracts awarded in the period 2000-2004 and completed by 2005.

Table 6 provides the results of the estimates obtained following the Simar and Wilson (2007) procedure. Table 7 report the estimates computed according to Banker and Natarajan (2008). In each group of estimates, the first column is baseline specification that does not include the variables connected with subcontracting.

TABLE 6
Results for Bootstrap Truncated Two-Stage Estimates

Variables	Truncated Regression – DEA bias-adjusted coefficient		
	(1)	(2)	(3)
Intercept	0.9432***	0.9483***	0.9518***
	(0.0134)	(0.0138)	(0.0133)
SUBCONTRACT	-	-0.0041	-
	-	(0.0038)	-
OPTIONAL			0.0139***
		-	(0.0041)
BIDDERS	0.0003***	0.0003***	0.0003***
	(0.0000)	(0.0000)	(0.0000)

TABLE 6

Variables	Truncated Regression – DEA bias-adjusted coefficient		
	(1)	(2)	(3)
REBATE	-0.0028***	-0.0023***	-0.0023***
	(0.0002)	(0.0002)	(0.0002)
NEW_PW	0.0013	0.0013	0.0012
	(0.0033)	(0.0033)	(0.0033)
PW_CLASS_1	0.0185**	0.0192**	0.0170**
	(0.0075)	(0.0076)	(0.0075)
PW_CLASS_2	0.0065	0.0069	0.0061
	(0.0085)	(0.0085)	(0.0084)
DISPUTE	-0.0006	-0.0005	0.0005
	(0.0004)	(0.0004)	(0.0004)
PROJECT	0.0108**	0.0109***	0.0091**
	(0.0042)	(0.0042)	(0.0042)
RELATIONSHIP	-0.0076	-0.0078	-0.0091
	(0.0117)	(0.0117)	(0.0116)
FINANCE	0.0107***	0.0108***	0.0087**
	(0.0034)	(0.0034)	(0.0034)
Control for region	yes	yes	Yes
Control for year of award	yes	yes	Yes
Observation	3,113	3,113	3,113

Notes: * significant at 10%; ** significant at 5%; *** significant at 1% Table report double bootstrap truncated estimates (n=1000, Algorithm 2), proposed by Simar and Wilson (2007).

Source: Our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture.

Table 6 and 7 show rather similar results. It is worth noting that the variable SUBCONTRACT is not significant, suggesting that sub-contracting as such, as in Finocchiaro Castro, Guccio, and Rizzo (2014) does not affect the firms' capability of executing the contract. Instead, the variable OPTIONAL is significant and with a positive sign, with both procedures. This result suggests that full qualification, as represented by OPTIONAL, matters and affects positively the efficiency of contracts execution. In evaluating such a result it should be considered that we are not able to control for the firm's dimension; so, we are assuming that differences in the size of fully qualified and partially qualified firms are not relevant and only full qualification affects the performance.

TABLE 7
Results for Robust OLS Estimates

Variables	Robust OLS - DEA second stage regression		
	(1)	(2)	(3)
Intercept	0.9136***	0.9116***	0.9321***
	(0.0631)	(0.0629)	(0.0597)
SUBCONTRACT	-	-0.0051	-
	-	(0.0067)	-
OPTIONAL		-	0.0205***
		-	(0.0060)
BIDDERS	0.0003***	0.0003***	0.0003***
	(0.0000)	(0.0000)	(0.0000)
REBATE	-0.0022***	-0.0023***	-0.0023***
	(0.0004)	(0.0004)	(0.0004)
NEW_PW	0.0010	0.0012	0.0010
	(0.0032)	(0.0032)	(0.0033)
PW_CLASS_1	0.0150*	0.0157*	0.0136*
	(0.0080)	(0.0080)	(0.0075)
PW_CLASS_2	0.0035	0.0039	0.0031
	(0.0092)	(0.0092)	(0.0085)
DISPUTE	0.0007	0.0006	0.0006
	(0.0005)	(0.0005)	(0.0004)
PROJECT	0.0106**	0.0107**	0.0089**
	(0.0045)	(0.0045)	(0.0042)
RELATIONSHIP	-0.0088	-0.0092	-0.0104
	(0.0149)	(0.0150)	(0.0117)
FINANCE	0.0104***	0.0104***	0.0084**
	(0.0038)	(0.0038)	(0.0034)
Control for region	yes	yes	Yes
Control for year of award	yes	yes	Yes
Observation	3,113	3,113	3,113
Adj R-square	0.0957	0.0973	0.1188

Notes: * significant at 10%; ** significant at 5%; *** significant at 1%. Table reports DEA two-stage OLS algorithm proposed by Banker and Natarajan, (2008).
Source: Our elaboration on data provided by Autorità di vigilanza sui contratti pubblici di lavori, servizi e forniture.

Most of the other control variables which are significant also exhibit the expected sign, in line with previous literature (Finocchiaro Castro, Guccio, & Rizzo, 2014): the positive sign of the variable BIDDERS

confirms that competition exerts a positive effects on public contracts performance. The variable REBATE is significant and with a negative sign, suggesting that higher rebates might imply opportunistic behaviours of winning firms, offering low bids to get the contract but with the perspective of renegotiation once the contract has been awarded.

Two interesting results refers to variables PROJECT and FINANCE, which are both significant and with positive sign. The former result suggests that when the firm is entrusted with the completion of the project, contracts are executed more efficiently; the latter implies that the financial source of the public work provides incentives to the contracting authority toward the efficient execution of the contract. Looking at complexity, only the PW_CLASS1 variable is significant; its positive sign would suggest that small dimension, e.g. low complexity, affects positively the execution of the contract.

Summing up, the above estimates provide new results suggesting that qualification exerts a positive effect on the performance of public contracts, providing the first empirical evidence in this direction.

CONCLUDING REMARKS

The qualification systems for public procurement contracts are widely used all over the world in order to provide an ex-ante screening of the technical, financial and economic capabilities of private contractors. The qualification is considered pivotal to guarantee that the firms have the capability to complete the contracts adequately. While in many countries the certification system is optional, in Italy, since 2000, it is mandatory. This means that the firms that want to apply for a public tender have to be certified according to the main cathegory of work and for the amount of the reserve price of the contract to be awarded.

In the literature there is only scant evidence of the impact of the qualification systems of the performance of the contract in terms of efficiency. In order to fill this gap, in this paper, using the case of the public works for roads and highways, we have investigated the effects of firms' qualification on the performance of public works contracts, measured in terms of costs and time overruns. Following Moretti and Valbonesi (2015), we have used, as indicators of full or partial qualification, respectively *optional* or *mandatory* subcontracting and

obtain robust evidence of the effects of qualification on the execution of public works contracts. Our analysis provides new evidence of this impact showing that fully qualified firms perform better than partially qualified firms do. Moreover, the analysis identifies the role of competition, low complexity and internal source of financing as variables positively affecting the execution of the public works contracts.

Though caution is needed, the above results might have interesting implications for policy makers as they suggest that the potential beneficial effects of the qualification system seem to be able to overcome their claimed shortcomings. Moreover, our results might be considered not strictly country-specific since the crucial concept of qualification is expressed by a rather general variable, referring to a wide concept such as subcontracting.

Some limitations have to be acknowledged. Firstly, being not able to control for the firm's dimension, we assume that the differences in the size of fully qualified and partially qualified firms are not relevant for performance and only full qualification affects the performance. Indeed, the firm size may affect the capability of the firms of operating in terms of team-work; this may play an important role in determining the success in the execution of the contract as a single contractor or in consortium with others.

Moreover, since our data refer to the period 2000-2004, our results do not take into account the changes eventually occurred in the public works market in terms of firms mergers, vertical integration, which impact on the level of subcontracting. performance, like the capability of the firms in terms of team-work that may play an important role in determining the success in the execution of the contract as a single contractor or in consortium with others.

Next step of the research may focus on addressing the above limitations, updating our data set to catch the changes occurred through time in the public works market. Enlarging the time span period would also allow to try to investigate whether qualification maintains its strength through time or whether changes occur in firms' capabilities during the validity period of qualification or without being certified, and impact on performance.

NOTES

1. The New Regulatory Economics starts in the eighties and investigates the strategic interaction of agents with asymmetric information. The pionieristic work of Laffont (1994) has analysed the definition of optimal regulatory policyes under institutional, technological and informational constraints.

2. Laffont - Tirole (1993) is the classical reference for the application of optimal incentives schemes to public contracts.

3. The dimension of the market is quite relevant: every year, over 250 000 public authorities in the EU spend around 14% of GDP on the purchase of services, works and supplies (http://ec.europa.eu/growth/single-market/public-procurement/index_en.htm).

4. In the supplies contracts, the goods procured are usually ready and available in the market and the fulfilment of the contract implies the exchange of the good for a market price. A notably exception is given by those goods which do not exist in the market because they are produced just to satisfy public demand, such as the defense supplies; for these supplies, however, usually the selection process is not competitive.

5. On auctions see Klemperer (2004).

6. An overview of the various qualification systems is offered in Section 3.

7. These costs are labelled as 'administrative costs' by Moretti and Valbonesi (2015).

8. The basis for rejection of access in a tender may take different forms, such as the exclusion of a firm to take part in a specific procurement, with the permanent or temporary ineligibility to participate in future public procurements (in Belgium); the removal from the list of entrepreneurs (Slovak Republic); the ineligibility based on criminal activities in the past.

9. The questionnaire is based on a self-certification and the requirements are verified only for the awarded firm, but until now while the PQQ is adopted by all the public bodies, the adoption of the standardised form "PAS91" is not yet mandatory thus

determining the need for the bidders to compile a different form for each auction in which they participate.

10. For instance, the proofs of competences to be asked need not be the ones listed within the law but any other substitutes can be accepted; technical requirements can be reduced to a minimum.

11. The D. L. 50/2016 has reformed the 2006 Code of public contracts for works, services and supplies to transpose EU Directives.

12. The first level allows for participating to tender up to 258,000 Euros (plus 20%) while the tenth over 15,494,000 Euros.

13. The total amount of about 4,400 Euros + VAT is required for the first level (for the other levels the fees are slightly higher) for the first three years, while about 2,600 Euros +VAT are required for the renewal for two more years.

14. The 'Manual of Qualification', issued in 2014, contains the guidelines for the qualification for public contracts above 150,000 Euros, taking into account all the Authority's decisions in the last 15 years.

15. In a first phase, this activity was undertook by individuals external to the SOA and this was prohibited by the Authority to prevent distortions in the qualification system.

16. It is prohibited that SOAs might have, as shareholders, public bodies, individuals and organizations with any interest in construction firms, or any other organization potentially interested in soften the qualification screening system.

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