Subcontracting in Public Procurement: An Empirical Investigation*

Luigi Moretti
University of Padova

Paola Valbonesi
University of Padova

March 29, 2012

Abstract

We assemble a new dataset to empirically investigate subcontracting in Italian public procurement. We use provisions of the pre-qualification system to disentangle two types of subcontracting. Under the provisions of this system, bidders in the auctions that award public contracts can be classified as either partially or fully qualified to execute the tendered project. Partially qualified bidders are required to find qualified subcontractors to execute part of the work (i.e. legally required subcontracting), while fully qualified bidders can freely choose whether to subcontract (i.e. voluntary subcontracting). We capture the effect of the terms of the subcontract on the firms' bids. We find that firms that subcontract *by choice* offer, on average, higher rebates (i.e., lower prices) than firms that are legally required to outsource. This result, which holds true after controlling for auction characteristics, firm fixed-effects, and subcontracting characteristics, indicates that firms discount their potential subcontracting position when they bid on rebates. Moreover, because subcontracting *by choice* and *by law* in the context of our study determines the role of horizontal and vertical outsourcing, our analysis provides the first test of these strategies in the public procurement supply chain.

JEL-Code: H57, L23, L24, D44.
Keywords: Public procurement, firm's production strategy, horizontal subcontract, vertical subcontract.

*We wish to thank the participants of the International Conference on "Public procurement and sustainable growth", San Servolo - Venice, 20-21 October 2011; Decio Coviello, Francesco Decarolis, Caterina Giannetti, Roberto Grandinetti, Marco Pagnozzi, Giancarlo Spagnolo, Francesca Zantomio, for their useful comments; the Osservatorio sui Contratti Pubblici, AVCP (Filippo Romano, Alberto Zaino) and the Ufficio Appalti e Lavori, Regione Valle d'Aosta (Edmund Freppa, Marisa Covolo) for providing data. The usual disclaimer applies. Address correspondence to: luigi.moretti@unipd.it and paola.valbonesi@unipd.it

1 Introduction

Public procurement constitutes an important share (15-20%) of GDP in developed economies. Local and regional governments play a significant role in purchasing goods and services through a large number of contracts of various sizes for diverse types of services and works; thus, public procurement offers a wide array of business opportunities to firms [1].

One of the main pillars of public procurement is "value for money". This principle implies that procuring entities should avoid any unnecessary costs or delays to ensure improvement in the procurement process and in the quality of works, goods or services provided. From this perspective, the contractor's production strategy is a core issue, and her subcontracting choice represents an important tool which she can use in the supply of final products (Kamien and Li, 1990)[2]. The extensive theoretical literature in economics and management on the firm's "make-or-buy" decision deals with the borders of firms and with the structure of the markets in its investigation of which activities are conducted within firms and which take place between firms[3]: in this perspective, subcontracting is an organizational mode that involves a "buy" decision. Literature distinguishes between capacity and specialization subcontracting. The former consists in disintegration of horizontal production, i.e. an agreement between rival firms "each of which is capable of producing and marketing its product independently" (Spiegel, 1993), and the latter consists in disintegration of vertical production, that is, an agreement between firms whose capabilities/assets are complementary in obtaining the final output (Webster et al., 1997). Our aim in this paper is to use an empirical investigation to improve our understanding

[1] For evidence regarding the US, see Levin and Tadelis (2010), who report that the recent spending on local public services (which is shared between public-sector organizations and private-sector contractors) amounts to approximately 1% of the US GDP. In Europe, Lember et al. (2011) show that public procurement accounts for 40% of the city budget in Helsinki and 30% in Stockholm.

[2] Sabel (1989) and MacMillan (1995), among others, explain that achieving flexibility in production through outsourcing can be regarded as a learning system in which the division of expertise helps to spread costs in the value chain.

[3] In their recent survey on vertical integration and market structure, Bresnahan and Levin (2012) highlight the scarce attention in the research on vertical integration paid to contractual and organizational details, as compared to issues as scale and scope economies, strategic considerations, industry patterns, etc.

of horizontal and vertical subcontracting in the production planning of firms that supply goods and services in a public procurement context. These two types of subcontracts might lead to consistent differences in the firm's production costs which, in a public procurement setting where contracts are allocated through open tenders, translate into different bidding prices. To achieve our aim, we assemble a new dataset on Italian procurement auctions for public contracts. We use provisions of the Italian pre-qualification system regarding firms' technical and financial standing[4] to disentangle the two types of outsourcing that may occur in tendered contracts. Firms interested in bidding for Italian public procurement contracts having a value higher than 150,000 euros should be qualified for the categories of work and the size (value) of the contract. According to this pre-qualification system, bidding firms can be classified as "partially" or "fully" qualified for each contract that is tendered. Partially qualified bidders must gather service providers who have the necessary qualification(s) through outsourcing, while fully qualified bidders can freely choose whether to outsource part of the contract. In other words, if the winning firm is partially qualified, it is required *by law* to vertically subcontract but if the winning firm is fully qualified, it can enter into a subcontracting arrangement *by choice*. Note that when a bidder can subcontract *by choice*, it can potentially engage in a horizontal subcontract, i.e. an agreement to allocate part of its production to a firm that is similarly qualified and is, thus, a potential rival.

For each contract that is awarded, our data allow us to assess the necessary qualifications (i.e., the categories of work) and the qualifications that are held by each bidding firm. Therefore, we are able to disentangle the bids offered by firms that will potentially engage[5] in vertical subcontracting from the bids offered by fully qualified firms that are

[4]These requirements are usually adopted to allow only those firms that appear to be capable of efficiently performing the contractual obligations to participate in public procurement auctions. Indeed, the settlement of required qualifications can reduce the asymmetric information that is available to the contracting authority in the screening process and the consequential inefficiencies that arise in executing the contracts .

[5]Our data allow us to consider all the bids offered for each tendered contract. Only the winner of the auction will actually face the decision of subcontracting, but we assume that all the participants know about their production planning when they are at the bidding stage, and take this into account in the bids they offer. However, we will also show that the main results do not change when we focus only on

able to choose horizontal subcontracting or to not subcontract at all. Considering all the bids that are offered in any auction and controlling for auction/project characteristics and firms' fixed effects, we focus on how each bidder's subcontracting options affect the bid's value.

We find that bidders who are allowed to subcontract *by choice* (i.e., those who can potentially engage in horizontal subcontracting) offer higher bidding rebates (i.e., lower prices) than bidders who are required to outsource *by law*. Interestingly, our empirical findings reaffirm the theoretical findings of Spiegel (1993), which indicated, under mild assumptions, that horizontal subcontracting facilitates improvements both in production efficiency and total welfare. To the best of our knowledge, this is the first empirical study on the effects of these two types of subcontracting in public procurement, a market where the productive efficiency that the contractor achieves through outsourcing can be directly distributed as social benefits. Indeed, in this setting, the bidding rebate is correlated with the contractor's expected costs in executing the auctioned contract: therefore, the higher the rebate in the winning bid (i.e. the lower the price for executing the contract), the larger the welfare gain for the collectivity.

The remainder of this paper is organized as follows. In Section 2, we present the relevant literature and we explain the contribution of this paper. In Section 3, we illustrate our dataset and describe the institutional setting that applies to our data. In Section 4, we present and discuss our empirical strategy and our results. Our conclusions are presented in Section 5.

2 Related literature

This paper primarily builds upon, and contributes to, two strands of economic and management literature. One strand involves the analysis of the firm's production planning and, in particular, its decisions about using outsourcing as a strategic tool in its supply chain. The other strand involves empirical investigations about public procurement and,

winning firms.

specifically, the role of outsourcing in public contracts.

Subcontracting and outsourcing[6] have been investigated in the literature as business practices chosen by firms as an alternative to executing the whole contracts using only their own resources (i.e., vertical integration). The "make-or-buy" decision has been addressed empirically in relation to different sectors of the economy (e.g., automotive, business services and electronics)[7] and in international exchanges[8]. These studies investigate the boundaries of the firm in accordance with the framework proposed in the seminal paper by Coase (1937)- which focused on the theory of transaction costs - and the subsequent developments by Williamson (1985), Grossman and Hart (1986), Grossman and Helpman (2002) who - among others - have also addressed asset specificity, incomplete contracts and property rights.[9]

The firm's specific decision to subcontract has been investigated as a response to different issues. Atamturk and Hochbaum (2001) present a model on how firms can use subcontracting as an alternative to capacity acquisition, production and inventories to solve non-stationary demand over a finite time horizon. Cachon and Lariviere (2001) offer a thought survey about the structure of contracts in the supply chain and stochastic demand. They also develop a model to investigate the role of information sharing and the verifiability of the agent's actions in a situation characterized by stochastic demand. The option value to subcontract is studied by van Mieghem (1999) in a model where the firm's decision to increase capacity is affected by uncertainty. Kamien and Li (1991) propose a model where subcontracting is used explicitly as a tool in the production planning strategy of the firm.

Strategic outsourcing was analyzed by Quinn and Hilmer (1994) as an example of the firm's profitable choice of specializing in 'core competencies'. Shy and Stenbacka (2003)

[6]In our analysis, we do not distinguish between these two terms, but we are aware of some authors who do (see, for instance, Van Mieghen (1999)).

[7]See, among others, Monteverde, K. and D. Teece, (1982), Helper, S. and M. Sako, (1998), Kotabe, M., Martin, X. and Domoto, H. (2003), Abraham and Taylor (1996).

[8]Campa and Goldberg (1997) and Hummels, Rapoport and Yi (1998).

[9]Recent contributions have investigated the role for relational contracts (i.e., informal agreements not adjudicated by the courts) on firms' decisions regarding vertical (dis)integration. In this regard, see Baker, Gibbons and Murphy (2002), Gibbons (2005) and Levin (2003).

highlight the strategic incentives to subcontract raised in an oligopolistic market where firms and subcontractors have access to identical technology. Lewis and Sappington (1991) compare the firm's choice between internal production and outsourcing in a setting where subcontractors are more efficient than contractors and where technological progress can take different forms in terms of production and effort costs.

Outsourcing production among rivals or potential rivals (i.e., horizontal subcontracting) to reduce production/service costs was investigated by Kamien, Li and Samet (1989) and Spiegel (1993). In both the Kamien et al. model and the Spiegel model, the firms' cost functions are strictly convex; thus, subcontracting makes it possible to lower costs by shifting production from the high-marginal-cost firm to the low-marginal-cost firm. Kamien et al.(1989) investigate how the specific arrangements that apply to the subcontracting process affect the contract's price in a two-stage game where two firms engage, first, in a Bertrand competition (i.e., an auction) and then have the possibility to subcontract. That study investigates two polar subcontracting arrangements. In the first arrangement, the winner of the first stage acts as a Stackelberg leader in the second stage by determining the quantity to be subcontracted and the price to be paid to the loser to maximize its (i.e., the winner's) own profit subject only to the loser's opportunity cost, which is zero. In the second arrangement, the loser of the game's first stage is the Stackelberg leader in the second stage and chooses the quantity to be subcontracted to the winner and its price to maximize its (i.e., the loser's) own profit subject to the winner's opportunity cost, which is the profit the winner can realize if he produces the entire quantity demanded. In the first arrangement, both the firms end with zero profits, while in the second arrangement, they both receive positive profits. In other words, this study shows that firms bid less aggressively when the terms of subcontracting are set by the loser of the bidding stage. Spiegel (1993) proposes a model where, in the first stage, asymmetric firms engage in a Cournot quantity competition and, in the second stage, the two firms sign a subcontract according to which one firm produces some of the rival's output in return for a transfer payment. The model investigates two different settings which differ in the order of play

for the quantity-setting stage and the subcontracting stage. Under mild assumptions, this model indicated that horizontal subcontracting is an agreement which promotes production efficiency and often enhances welfare.

Our paper contributes to this literature being - at best to our knowledge - the first which empirically documents the effects of different subcontracting terms in public procurement, i.e., by providing an empirical test of the implications of subcontracting *by law* and *by choice* in a regulated market for public contracts. We share with the paper by Kamien et al. (1989) a focus on subcontracting which follows an auction, and we share with the paper by Spiegel (1993) an interest in the effects of the outsourcing decision as they relate to production efficiency and welfare. In the situation we examined, when a firm is allowed to subcontract *by choice* and does engage in subcontracting, the arrangement constitutes a *de facto* horizontal subcontract because the firm is outsourcing to its potential rivals. On the other hand, when the firm is required to subcontract *by law*, the arrangement corresponds to a vertical subcontract with firms that have complementary abilities. From this perspective, we offer the first empirical test of the effects of horizontal *vs* vertical subcontracting in public procurement contracts.

Our paper also refers to the applied literature on public procurement which has relevant findings on the optimal awarding procedures and contractual rules in Bajari and Tadelis (2001 and 2006), Bajari et al. (2008) and Bajari and Lewis (2009). Investigations on subcontracting in public procurement are relatively scarce compared to research on other topics such as efficiency in awarding procedures and in monitoring contract performance. Only a few recent empirical papers study the contractors' decisions to outsource in procurement. Relying on the recent theoretical findings on relational contracts (i.e., Baker, Gibbons and Murphy [2002], Gibbons [2005] and Levin [2003]) Gil and Marion (2011) and Kellogg (2011) both investigate the value of the outsourcing relationship. The Gil and Marion (2011)study focuses on contractors and subcontractors in California highway procurement auctions, and Kellogg (2011) focuses on the interaction between an oil production company and its drilling contractor in Texas. Both studies found empirical evidence that

the experience of repeated interactions between the same actors makes the contracts more productive. Miller (2011) studies how contractual incompleteness affects the probability of subcontracting *vs* in-house arrangements in bridge construction contracts procured by the California Department of Transportation. He found that subcontracting for heavy construction jobs often results in hold-up costs which are mitigated if the work is performed in-house, and he also provides other empirical results on reputational effects.

We add a new result to this empirical literature on outsourcing in public procurement. Our empirical approach utilizes the existing "entry rules" (i.e. pre-qualification criteria), which have been adopted in the Italian public procurement system and in many other countries, to disentangle two types of subcontracting (i.e., by choice and by law) and to assess their anticipated effects on firms' bidding strategy.

3 Data and descriptive statistics

3.1 Auctions and contracts' characteristics

To study the differences in the bidding strategy between firms that are potentially free to choose whether to subcontract and those that are required by law to subcontract, we assembled a new dataset by collecting more than 400 transcripts of competitive auctions conducted during the period from 2000 to 2009 for the award of public works contracts by the Regional Government of Valle d'Aosta.[10] Each transcript includes the auction ID, the number of bidders, the names of the bidders, and the relative rebates. The auction ID made it possible for us to collect other information from a national dataset provided by the Italian Authority for the Surveillance of Public Procurement (AVCP)[11] about each contract that was tendered including information on the procedure for issuing awards, the participation rule that had been adopted, and the size and categories of works to be

[10] Valle d'Aosta is a small Italian region of 128 thousand inhabitants located along Italy's North-west border with France and Switzerland. It is characterized by mountainous land.

[11] *Autorita' per la Vigilanza sui Contratti Pubblici di Lavori, Servizi e Forniture.*

executed[12].

Descriptive statistics about our sample give us a clear idea of the local dimensions of the market for public procurement works in Valle d'Aosta. Approximately 36% of the participants (32% of the bids) are firms located in the region, 20% of the participants (24% of the bids) are from the larger neighbor region of Piedmont, and approximately 18% of the participants from other parts of the North; the remaining 26% come from the Center or South of Italy. In terms of bidding rebates, local firms do not differ significantly from non-locals: the former show an average rebate of 16.74%, which is just slightly below the 17.01% average observed in the bids of the latter.

In the Italian public procurement system, public contracts can be awarded by the contracting authority (CA) through open tenders[13]: a firm can participate in an auction by offering a percentage rebate with respect to the reserve price set by the CA in the tender. Once the CA has identified the participants who meet the legal, fiscal, economic, financial and technical requirements, the contract is awarded according to the auction's rules[14]. In our dataset, we focus on public contracts awarded by the Valle d'Aosta Regional Government through open tenders, distinguishing between two different mechanisms adopted: first price auctions (representing only the 0.5% of our sample)[15] and average price auctions (representing the remainder of our sample)[16].

[12]This national dataset contains extensive information at the auction/project level about contracts with a reserve price greater than 150,000 euros.

[13]According to EU directives, in Italy public procurement can be released through four types of awarding procedures: open procedures, restricted procedures, negotiated procedures, and competitive dialogue. In our study, we consider only cases involving open tenders (*Pubblico incanto*). Participants in restricted and negotiated tenders are invited by the CA, and including such cases might create a bias in our results because the CA might choose to select firms that hold particular characteristics and qualifications. Note we have no data on competitive dialogue.

[14]According to EU directives and the Italian regulation on public procurement contracts, firms must fulfill general requirements to participate (i.e., requirements relating to a candidate's professional conduct and standing and financial or economic standing) and also specific requirements relating to the technical capability that is necessary to perform a particular contract (i.e., the candidate must have the capability and expertise to execute a project of a certain size in a specific category - See Section 3.2 for more details).

[15]We call this mechanism '*Max rebate*'; see, Appendix A for a description of the variables.

[16]This average price mechanism, which we call '*Anomaly threshold*' can be briefly described as follows: given the distribution of all bids, after the bids located in the first and last deciles have been excluded, the winning bid is the one just below an anomaly threshold value given by the sum of the average bid (simple average of the not-excluded bids) and the average deviation of the bids above the average bid. In our data set, this auction mechanism is applied to 79.2% of the sample. The remaining 20.4% of the sample

We were thus left with 330 auctions (i.e. public contracts) and a total of 15,506 bidding rebates offered by 1035 firms and 2225 temporary consortia. The average reserve price of the contracts that were awarded is approximately 1.2 million euros (ranging from a 155 thousand euros to 5.2 million euros); and these contracts mainly refer to roads works (41.5%), fluvial and hydraulic works (35.0%), and buildings (9.5%)[17].

Table 1: Summary statistics

Bid-level data					
Variable	Obs.	Mean	St.Dev.	Min	Max
Rebate (%)	15506	16.98	4.92	0.001	43
Choice	15506	0.847	0.360	0	1
Reserve price (Euros)	15506	1235354	877278	155526.3	5267860
Number of participants	15506	73.013	32.071	2	155
Max rebate	15506	0.005	0.066	0	1
Anomaly threshold	15506	0.792	0.406	0	1
Anomaly threshold + lottery	15506	0.204	0.403	0	1
Road works	15506	0.415	0.493	0	1
Fluvial and hydraulic works	15506	0.350	0.477	0	1
Buildings	15506	0.095	0.293	0	1

See Appendix A for variables' abbreviation and description.

3.2 Bidders' characteristics

According to the Italian Code on public procurement[18], a bidder must be qualified to participate in a tender for a contract of value greater than 150,000 euros. The Italian pre-qualification system is run by private firms (called *SOA*) that are accredited and monitored by the *AVCP* to produce certifications after verifying that the firms meet the prescribed requirements. The aim of this system is to admit to the auction only firms that are potentially capable of efficiently executing the awarded contract. Each qualification lasts for 5

involves a similar average price mechanism augmented with a sort of lottery (i.e. '*Anomaly threshold plus lottery*'; find in the Appendix A a description of the variables). See Decarolis (2009) for a discussion on the average price auction mechanism as compared to the first price approach.

[17] See Table 1 for further summary statistics.

[18] See, Italian Law no. 163/2006.

years, is renewable, and certifies the size of contracts and the categories of work that a firm is qualified to perform. In each call for bids the CA should indicate the qualification(s) required to participate in the auction and should also distinguish the *main* category of work that is to be performed from the *other* categories[19]. Bidders should have the required qualifications based on their own resources for the *main* category of work in the auctioned contract because they cannot subcontract more than 30% of the value of the work in this category. As an alternative, firms that do not have this qualification could participate as part of temporary consortia (i.e., *ATI*, an association of firms created *ad hoc* to participate in the auction, where at least one of the associated firms is qualified). We can reasonably assume that consortia participating in auctions are qualified for all the categories of work that are included in the project.

Concerning the *other* categories of works which compose the auctioned public contract, the firm can be either fully or partially qualified. In the former case, if the firm wins the contract, it can choose either to execute all the work on its own or to subcontract parts of the work to other qualified firms (we call this subcontracting *by choice*). In the case of a firm that is partially qualified, it can still participate in the auction, but if it wins the contract it is required by law to subcontract those parts of the project for which it is not certified to other firms that are qualified (i.e. subcontracting *by law*)[20].

To empirically disentangle the effects of subcontracting *by choice* and the effects of subcontracting *by law* on bidding rebates in procurement auctions, we used several different sources of data. Information on each auctioned contract was obtained by merging the Regional Government of Valle d'Aosta dataset with the national *AVCP* database (see the detailed description in Section 3.1). On the other hand, information about each firms' qualifications for public procurement (i.e., the qualification of each bidder in relation to

[19]For example: if the construction of a road is put out for tender and its estimated value is for 1.5 million euros, the required *main* category will be III-OG3, where III refers to the size of the project and OG3 to the category "road-construction". The contract usually also requires *other* (secondary) categories of work which might be part of the project.

[20]As an alternative, the firm can lease the qualification from a qualified firm that is not participating. Our data do not allow us to distinguish between subcontracting by law and leasing a qualification ("avvalimento"). However, this is a rare event (because it involves a very expensive contract) and it can also be considered a form of vertical subcontracting because the firm is actually not qualified on its own.

each category of work which composes the auctioned contract) was extracted from another national *AVCP* dataset (which is known as the "Casellario SOA").

By way of summation, for each auctioned contract, we have information on all the qualifications required by the CA and on all the actual qualifications of each bidder. Matching the information from two sources makes it possible for us to identify which bidders would have been required to subcontract to fulfill the required qualifications.

A noteworthy point about the public procurement setting examined in this study is that the requirement for some bidders to subcontract *by law* resulted in *de facto* vertical outsourcing because they had to subcontract with firms that had different capabilities (i.e., different qualification(s)) than their own; on the other hand, bidders who were potentially able to subcontract *by choice* could engage in horizontal outsource from external firms (i.e., rivals having qualifications that are similar to their own).

As shown in Table 2, our sample contains bidders who participated in some auctions where they fulfilled all the required qualifications, and in other auctions where they were missing some of the required qualifications (approximately 76% of bids and 13% of the participating firms). It also includes some bidders who always had all the required qualifications and others who never had all the required qualifications. Bidders who could always subcontract *by choice* (i.e., consortia and firms that always held all the required qualifications) represent approximately 81% of the participants (13% if consortia are excluded), they offered approximately 22% of the total number of bids (8% if we exclude consortia), and they won approximately 26% of the auctions (7% if consortia are excluded). Bidders who always faced a requirement to subcontract *by law* were approximately 5% of the candidates, they offered 2% of the bids, and they won almost 1% of the auctions[21].

[21] In some of our model specifications we also used fixed-effects at the firm level, i.e., we focused on those firms that had the status of fully-qualified candidates in some auctions and that had the status of partially-qualified candidates in other auctions.

Table 2: Sample composition

	% of the sample	% of firms (including consortia)
Subcontracting option:		
always by law	1.819	5.339
by choice and by law	75.925	13.580
always by choice (excluding consortia)	7.907	13.025
Firm size:		
Small	11.453	5.490
Medium	52.237	19.202
Large and co-operatives	22.004	7.116
Consortia	14.349	68.055
Local firms	32.439	35.870

See Appendix A for variables' abbreviation and description.

4 Empirical evidence

4.1 Bidding rebates

Our testable hypothesis is that there might be a significant difference in the value of the bidding rebates between firms that subcontract *by law* and firms that are potentially in a position to subcontract *by choice*. In the setting of this study, firms that are potentially in a position to subcontract *by choice* are the ones that could contribute to a rise in horizontal subcontracting because if they win the contract and choose to subcontract they will outsource to their potential rivals. In a theoretical investigation of horizontal subcontracting, Spiegel (1993) shows under mild assumptions that this practice contributes to productive efficiency because it allows work to be shifted from the high-marginal-cost firm to the low-marginal-cost firm. In the context of our study, this theoretical principle can be tested by observing the bids of firms that are allowed to subcontract *by choice*. If these firms expect to achieve improvements in productive efficiency by outsourcing horizontally, they will offer more competitive bids. By contrast, firms that are required to subcontract *by law*, and that will therefore be required to outsource part of the work, might bid less aggressively.

Table 3: Correlation: subcontracting by choice or by law and bidding rebates

	Average rebate	Average rebate (excluding consortia)
Choice	17.24	17.31
Law	15.53	15.53
Difference	1.71***	1.77***

See Appendix A for variables' abbreviation and description. Significance at the 10% (*), at the 5% (**), and at the 1% (***).

A simple two-group mean-comparison test (Table 3) shows that the average rebates offered by firms that are required to subcontract *by law* are significantly lower (i.e., prices are higher) than the rebates offered by firms that can subcontract *by choice*. This result is observed even when consortia are excluded. This descriptive evidence, however, might be the result of different factors that are associated with the bidding strategy of the participating firms, such as the characteristics of the firm itself (i.e., its production capability, financial position, productivity, location and logistical problems, etc.), the type of auction, the dimensions of the project, and the category of work. Indeed, one could argue that some firms are qualified for more categories of works and are, therefore, more likely to be fully qualified simply because they are larger and/or more efficient.

To control for all these factors and to capture the differences between firms that are subcontracting *by choice* and firms that are subcontracting *by law* in terms of the size of the rebates they offer, we estimate the following model specification for bidding rebates:

$$Rebate_i j = \alpha + \beta_1 Choice_i j + \beta_2 Q_j + \beta_3 X_i + \epsilon_i j. \quad (1)$$

where $Choice_i j$ is a dummy variable that takes the value 1 when the firm i can subcontract *by choice* (i.e., when it has all the required qualifications to execute the project j) and that takes the value 0 otherwise. Q_j is a set of variables that control for the project and auction characteristics (i.e., proxies for project characteristics such as dimension/complexity and type of work, and proxies for auction characteristics such as type of auction and level of competitive pressure). X_i represents a set of characteristics of firms (such as a proxy for

the size of the firm)[22], and $\epsilon_i j$ is the error component. To reduce the problem of omitted variables, we include year dummies to control for temporal shocks that might have affected both the temporal tendencies of firms in their bidding behavior and the contractual choices of the CA. We also include firm fixed effects to control for firm-specific characteristics (e.g. size, productivity, financial position). These characteristics can also vary over time, in fact, in different specifications of the model, we also control for firm-year fixed-effects.

Our primary coefficient of interest is β_1, which indicates whether the firm's option on subcontracting is discounted in its bidding rebate. This coefficient reflects the difference in rebates offered by firms that have the potential to subcontract *by choice* compared to the rebates offered by firms that are required to subcontract *by law*. The estimation results reported in Table 4, columns 1-4, show that the coefficients of the variable *Choice* always have a positive sign and are statistically significant. This result shows that when everything else is held equal the average rebates that are offered by firms that are fully qualified to execute the project and have the choice to subcontract part of the work are significantly higher than the rebates offered by other firms. In particular, these firms offer rebates that are approximately 0.25 percentage points higher than the rebates offered by firms that are required to subcontract *by law*. This is quite a substantial difference. Fully qualified firms offer bids with rebates that are on average approximately 1.5% higher (i.e., bids that yield lower prices in the awards). To deal with the presence of outliers and heteroscedasticity problems, we employ OLS estimations with robust standard errors clustered at the firm level (i.e., allowing for the correlation of observations within the firm) as shown in columns 1, 3, and 4 of Table 4, and we use a robust regression method (i.e., iteratively re-weighted least squares) which iteratively assigns a lower weight to deviant observations, as shown in column 2 of Table 4.

As previously noted, in the particular context of Italian public procurement, the two

[22] As we do not have data on the size of the firms, we use the juridical form of the firm as a proxy. See Appendix A for more details about the definitions of the variables.

Table 4: Regression results: Qualification requirements and bidding rebates

	(1)	(2)	(3)	(4)
Dependent variable	Rebate			
Mean outcome	16.98	16.98	16.94	17.07
Choice	0.172**	0.094**	0.273***	0.254***
	(0.080)	(0.040)	(0.080)	(0.090)
(log of) Reserve price	0.099*	0.197***	0.223***	0.177***
	(0.052)	(0.022)	(0.058)	(0.053)
Participants	0.013***	0.004***	0.014***	0.014***
	(0.002)	(0.001)	(0.002)	(0.002)
Category of work dummies	YES	YES	YES	YES
Type of auction dummies	YES	YES	YES	YES
Firm's size dummies	YES	YES	NO	NO
Firm fixed-effects	NO	NO	YES	NO
Firm-year fixed-effects	NO	NO	NO	YES
Year dummies	YES	YES	YES	YES
Observations	15,506	15,506	11,773	11,233
R-squared	0.518	0.866	0.567	0.647

The dependent variable in columns 1-4 is the rebate offered by the bidders. The first row reports the mean outcome of the dependent variable. See Appendix A for abbreviations and definitions of the variables. The OLS estimates are reported in columns 1, 3, and 4. Iteratively reweighted least square estimates are reported in column 2. The number of observations varies between model specifications as follows: In column 3, firm fixed-effects are included so firms that have participated in only one auction are dropped. In column 4, firm-year fixed-effects are included so firms that have participated in only one auction in a given year are dropped. Because columns 3 and 4 include firm fixed effects, they do not include the rebates of consortia or the rebates of firms that have always had all the required qualifications or that have never had all the required qualifications. Standard errors are reported in parentheses. Robust standard errors were clustered at firm-level for OLS estimates.

types of subcontracting (*by choice* and *by law*) can actually be classified as horizontal and vertical subcontracting. In fact, the pre-qualification system indicates that a partially qualified firm is required to subcontract with qualified firms for the parts of the work for which it is not qualified. This means each firm must subcontract with other firms that have a different specialization (i.e. vertical subcontracting). Conversely, a fully qualified firm can choose to subcontract parts of the work to qualified firms. This means subcontracting with firms with whom it shares a similar specialization in the aim to increase its capacity (i.e., horizontal subcontracting). Thus, in terms of the difference between horizontal and vertical subcontracting in a public procurement context, our results show that firms can use subcontracting as a form of flexibility to improve their production efficiency in the absence of a binding requirement to subcontract. In fact, they anticipate this effect by offering bidding rebates that are higher than the rebates that are offered by firms that

are required to outsource part of the works and that are therefore in a worse bargaining position with respect to subcontractors.

The estimation results for other variables included in the model specifications are consistent with the results obtained in previous empirical studies on the awarding of public procurement contracts. In particular, the estimated coefficients for the reserve price in auctions and for the number of participants are positively and significantly associated with the rebate. It is not surprising that in a small market, such as the market that is covered by our data, firms can easily predict approximately how many competitors they will face in each auction and their rebates are influenced by competitive pressure. It is also not surprising that the rebates are influenced by the size of the project[23].

Concerning other characteristics of the firms, the model specifications in columns 1 and 2 of Table 4 include dummy variables for the size of firms. The model in column 3 includes firm fixed-effects dummy variables that allow us to control for those characteristics of the firm that do not vary over time (such as the location). Finally, the model in column 4 includes firm-year fixed effects dummy variables that are meant to capture characteristics of the firms for any given year (such as dimension, financial position and productivity). The firm's fixed-effects dummy variables in the model also allow us to exclude from the sample consortia and firms that always or never have all the required qualifications. In this way, we are able to concentrate only on those firms that have participated in some auctions where they fulfilled all the required qualifications and in other auctions where they did not fulfill all the required qualifications. This represents an important test that enables us to guard against concerns about biased estimates that might have resulted from the presence of consortia in the sample (and the related assumptions about whether the consortia fulfill all the qualifications). The results of this analysis support the inference that overall results are not driven by those firms that always have, or do not ever have,

[23]These results are consistent with the empirical evidence reported in previous studies that estimate firms' bidding behavior in public procurement auctions. For instance, in the US, Bajari et al. (2006) show that a higher number of competitors in an auction reduces the bidding price. Similarly, in a sample of Italian public procurement auctions, Decarolis (2009) finds that the number of bidders increases the size of the winning rebate. In regard to the effect of the reserve price, our results confirm a positive effect on rebates similar to the findings of Coviello and Gagliarducci (2010), and Decarolis (2009).

all the required qualifications.

4.2 Winning rebates

In this section we test whether the difference in bidding strategies that we previously observed between firms that can *potentially* subcontract *by choice* and firms that are required to subcontract *by law* holds in relation to the winning rebates (i.e., the rebates that were offered in the winning bids) after controlling for the firms' *actual* decision to subcontract. One could argue that firms that are free to choose to subcontract decide ex-ante not to do so, or that they are less likely to subcontract. From this perspective, the finding that higher bidding rebates are associated with firms that can subcontract *by choice* might simply reflect the costs of entering into a subcontracting relationship that is required *by law* for firms with partial qualifications. Because we are not interested in the cost of subcontracting *per se*, but rather in the difference between the two types of subcontracting, we control for each bidder's actual decision to engage in a subcontract. One necessary assumption for this test is that all firms know their production plans at the bidding stage to discount the cost of subcontracting in their rebate.[24] Similarly, to account for the possibility of collusive behavior during the auction stage between the firm that wins the bid and the subcontractor, we control for whether the subcontractors participated in the same auction as bidders. This is necessary because subcontracting could be used as way of providing compensation for an agreement between the firms[25].

[24]This assumption is coherent with the rule that each bidder in open tender for an Italian public contract is required to declare at the bidding stage whether he will adopt subcontracting in the execution of the work or not. The amount of work to subcontract and the number of subcontractors to use - which are not required to be declared - might also be decided ex-ante by bidding firms: indeed, firms which are required to subcontract *by law* know at least the minimum dimension of their *forced* subcontracting at the bidding stage.

[25]The contractors who choose subcontractors among firms that participated in the same auction tend to make agreements with the firms that are performing relatively well. In fact, 74% of the bidders-subcontractors during the auction had offered rebates that were higher than the average rebate for the auction, and 54% had offered a rebates higher than the winner. Assuming that the bidding rebates actually reflect the firm's production efficiency (and are not artifacts of a collusive strategy), this evidence indicates that when winners choose subcontractors for any reason, they tend to be well informed and to choose efficient firms.

Table 5: Summary statistics: project-level data

Procurement projects issued by Valle d'Aosta Regional Government					
Variable	Obs.	Mean	St.Dev.	Min	Max
Winning rebate (%)	282	16.998	4.639	3	34.87
Sub	282	0.794	0.405	0	1
Choice	282	0.883	0.322	0	1
No. Subcontractors	282	1.563	1.543	0	9
Value of subcontracts	282	232678.9	328378.9	0	2960000
Bidder-Subcontractor	282	0.355	0.480	0	1
Reserve price (Euros)	282	1150453	927076.3	155526	5267860
Number of participants	282	53.081	3.001	1	155
Max rebate	282	0.032	0.176	0	1
Anomaly threshold	282	0.798	0.402	0	1
Anomaly threshold + lottery	282	0.168	0.375	0	1
Road works	282	0.319	0.467	0	1
Fluvial and hydraulic works	282	0.280	0.450	0	1
Special structural works	282	0.195	0.397	0	1
Procurement projects issued within the borders of Valle d'Aosta by several CAs					
Variable	Obs.	Mean	St.Dev.	Min	Max
Winning rebate (%)	743	15.353	5.245	0.1	36.639
Subcontracting	743	0.746	0.436	0	1
Choice	743	0.701	0.458	0	1
No. subcontractors	743	1.680	1.997	0	17
Value of subcontracts	743	195840.8	353342	0	4726000
Reserve price (Euros)	743	959840.3	1197187	150000	23315951
Number of participants	743	41.377	35.879	0	182
Max rebate	743	0.110	0.314	0	1
Anomaly threshold	743	0.890	0.314	0	1
Road works	743	0.322	0.467	0	1
General structural works	743	0.244	0.430	0	1
Fluvial and hydraulic works	743	0.140	0.347	0	1

See Appendix A for variables' abbreviation and description.

To test whether there is a direct effect of subcontracting (independently of whether the subcontracting was *by choice* or *by law*) on firms' bidding strategy, we have to focus on the winning rebates because only the winning firms can actually subcontract part of the work when they are executing the projects. In particular, we use two samples of winning rebates. The first sample consists of the winning rebates from our sample of auctions

issued by Regional Government of Valle d'Aosta[26]. The second sample, which serves as a robustness check, includes a larger number of winning rebates for 743 auctions issued by several CAs within the border of Valle d'Aosta in the 2000-2009 period[27]. For each project we take information from the (*AVCP*) dataset on the dimension of subcontracting and the number (and ID) of the subcontractors that the winning firm decides to employ during the execution of work (see the summary statistics in Table 5).

To begin this analysis, we examine whether the effect of *Choice* on the bidding strategy holds even after controlling for whether the winning firm actually engages in subcontract(s). In particular, we add to our benchmark model specification (i.e., equation 1) a dummy variable *Sub* which takes the value of 1 if the winner actually engages in a subcontract and otherwise takes the value of 0. The estimation results presented in Table 6 (columns 1-2 and 4-5) for the winning rebates in the two samples of auctions show that the estimated coefficient of *Choice* is always positive and statistically significant, but the effect of subcontracting (*Sub*) is not statistically different than zero[28]. Two different forces may be responsible for the non-significant effect of subcontracting. In accordance with the finding of Spiegel (1993), horizontal subcontracting allows firms that choose to outsource to achieve production efficiency. In our study, production efficiency would be reflected in higher rebates. On the other hand, in the particular situation examined in our study, some firms are required to subcontract *by law*. This puts the firms in a disadvantageous bargaining position because they are required to engage in a "forced" relationship with qualified

[26]The sample that is analyzed consists of 282 winning rebates (not the winning rebates of all the 330 auctions issued by the Regional Government of Valle d'Aosta) because we do not have full information regarding the number of subcontractors and the value of work that was subcontracted. See the upper panel of Table 5 for summary statistics on this sample.

[27]For this larger sample of rebates we can only observe the characteristics of the winning firms and the winning rebates. We do not have information on the single bids and the bidders' characteristics. See the lower panel of Table 5 for summary statistics on this sample. These data were obtained from *AVCP*, which collects auction and project information on public works issued by several CAs. In this sample, 47% of the projects were issued by the Regional Government, 40% were issued by municipalities, and the rest were issued by other public authorities such as health commissions and territorial associations of mountainous areas. Note that the smaller set of winning rebates for contracts issued by the Regional Government is a sub-sample of this larger one.

[28]The coefficient of *Sub* is not statistically significant and has a negative sign also when we include the interaction term *Sub*Choice*, which is instead positive and statistically significant.

subcontractors. The form of vertical subcontracting that is imposed by law might result in higher prices[29]. This hypothesis is confirmed by the estimation results in columns 3 and 6 of Table 6, where the two samples of auctions are restricted to projects where at least some work has been subcontracted (i.e., the focus in these columns is limited to projects that involved subcontracting). The estimated coefficient of *Choice* is again positive and statistically significant.[30]

As previously discussed, one other concern we have relates to the possibility that certain characteristics of subcontracting (such as the number of subcontractors and the amount of subcontracting) might be discounted in the bidding strategy and could influence the validity of the estimated effect of *Choice*. To address this possibility, we add two variables to the benchmark model specification for each project: one that reflects the number of subcontractors (*No. of subcontractors*) and, another, the value of the subcontracts (*Value subcontracts*).

The estimation results for the two restricted samples of winning rebates (columns 3 and 6 of Table 6) show that the estimated coefficients of *No. Subcontractors* and *Value subcontracts* are not significantly different from zero[31]. This result reaffirms the evidence indicating that the number of relationships that a winning bidder might establish with other firms is not necessarily a cost per se. Instead, the effects of these relationships are probably related to form of subcontracting (*by choice*-horizontal or *by law*-vertical), and

[29]Even though the public procurement market in Valle d'Aosta is quite small, we do not observe frequent repeated interactions between contractors and subcontractors. On average, they meet each other only 1.2 times in the span of 10 years. Therefore, our results are probably not affected by the advantages that might be associated with repeated interactions (i.e. efficient reduction of transaction costs, implicit incentives, etc.

[30]To deal with the presence of outliers and heteroscedasticity problems, we used OLS estimations with robust standard errors clustered at firm level for columns 1 and 4 of Table 6, and for columns 2-3 and 5-6 we used robust regressions (i.e., iteratively re-weighted least squares) which iteratively assigns a lower weight to deviant observations. In regard to the distributions of winning rebates, the average winning rebates are not substantially different in the two samples but when the winning rebate distributions are compared with the distribution of all bidding rebates for contracts of the Regional Government of Valle d'Aosta (as discussed in Section 4.1), it appears that the presence of outlying observations could have a heavier weight in the wining rebate distribution.

[31]Note also that in column 3 of Table 6 the coefficient of the variable *Bidder-subcontractor* (which controls for the presence of at least one subcontractor who has participated as bidder in the same auction) is not statistically significant.

the resulting bargaining positions of the firms.

Table 6: Robustness checks: Subcontracting by choice and winning rebates

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable	Winning rebate					
Mean outcome	17.00	17.00	16.85	15.35	15.35	15.30
Choice	0.720	0.786**	0.532*	0.749*	0.653***	0.727***
	(0.617)	(0.351)	(0.276)	(0.394)	(0.247)	(0.231)
(log of) Reserve price	0.351	0.186	0.175	0.489**	0.207	0.344**
	(0.325)	(0.158)	(0.171)	(0.234)	(0.135)	(0.164)
Participants	0.032**	0.004	0.006	0.018**	0.009**	0.004
	(0.013)	(0.005)	(0.004)	(0.009)	(0.004)	(0.004)
Sub	-0.321	0.377		0.016	0.300	
	(0.710)	(0.268)		(0.491)	(0.238)	
No. Subcontractors			-0.033			0.026
			(0.070)			(0.056)
Value of subcontracts			0.000			-0.000
			(0.000)			(0.000)
Bidder-subcontractor			-0.136			
			(0.186)			
Category of work dummies	YES	YES	YES	YES	YES	YES
Type of auction dummies	YES	YES	YES	YES	YES	YES
Type of CA dummies	NO	NO	NO	YES	YES	YES
Firm's size dummies	YES	YES	YES	YES	YES	yES
Year dummies	YES	YES	YES	YES	YES	YES
Observations	282	281	221	743	743	543
R-squared	0.501	0.871	0.942	0.478	0.760	0.778

The dependent variable in columns 1-4 is the rebate offered by the bidders. The first row reports the mean outcome of the dependent variable. See Appendix A for the abbreviations and definitions of the variables. In columns 1 and 4, the OLS estimations are reported. Columns 2-3 and 5-6 report the iteratively re-weighted least squares estimations. Note that the number of observations varies across columns. In columns 1-3, the sample is restricted to winning rebates for auctions issued by the Regional Government of Valle d'Aosta. In columns 4-6 the sample includes winning rebates for auctions issued by several CAs within the border of Valle d'Aosta (including the Regional Government of Valle d'Aosta). In columns 3 and 6 the sample is restricted to projects that actually involved subtracting. In columns 4-6 it is not possible to disentangle consortia from single firms. Robust standard errors are presented in parentheses (robust standard errors clustered at the firm-level for OLS estimations). Significance at the 10% (*), at the 5% (**), and at the 1% (***).

As an indication of the economic magnitude of our main result, please note that the winning rebates are reduced by approximately 0.6 percentage points in cases where subcontracting is required *by law*. In other words, the rebates in these cases are approximately 4% lower than the average winning rebates. This amounts to an average price per contract

that is 5-6 thousand euros higher (given the contracts' average reserve price of approximately 960 thousand euros) and a total cost of approximately 1.2 million euros per year for the Region of Valle d'Aosta (given that an average of 200 contracts having a value of at least 150,000 euros have been awarded every year in this region over the past ten years).

5 Conclusion

In this study we conducted an empirical investigation on the differences between subcontracting *by choice* and *by law* as they relate to bidding rebates in Italian public procurement auctions. We used data relating to the pre-qualifications system adopted in the Italian market for public contracts to disentangle these two forms of subcontracts.

We assembled an original dataset on procurement auctions in the Italian region of Valle d'Aosta. By considering the qualification requirements for participating in these auctions, we were able to distinguish firms that are fully qualified (who can potentially subcontract *by choice*) from firms that are partially qualified (who are required to subcontract *by law*) for each contract that was awarded. We investigated the bidding behavior of these two types of firms to determine whether firms discount their subcontracting options at the tender stage when they submit their bidding rebates. In the context of public procurement, the *de facto* result of firms that subcontract *by choice* is the promotion of the phenomenon known in economic and management literature as "horizontal subcontracts" (Kamien et al. 1989; Spiegel, 1993) because these firms outsource to potential rivals (i.e. in our case, similarly qualified firms). By contrast, those firms that subcontract *by law* engage in "vertical subcontracts" because they outsource to firms that have complementary in abilities (i.e., firms that have different qualifications).

After controlling for several auction/project characteristics and firm fixed effects, we found that firms that potentially engage in horizontal subcontracting offer higher bidding rebates in procurement auctions (i.e., lower prices) than firms that are required to vertically subcontract. This result reaffirms the theoretical contribution by Spiegel (1993) which em-

phasized the increase in production efficiency that results from horizontal subcontracting. In particular, we argued that firms that can freely choose to subcontract use this strategy as a tool to improve their production flexibility and efficiency. Conversely, firms that are required to subcontract suffer a cost which they anticipate in their bidding rebate. The cost of "forced outsourcing" could result from the cost of searching for a subcontractor (Grossman and Helpmann, 2002), or it could result from the firm's weaker bargaining position vis-a-vis the potential subcontractors.

Subcontracting practices in public procurement are particularly relevant in times of economic slowdown because they can serve as a driver for local economic growth (EU Green Book on Procurement, 2011). Our paper offers the first empirical analysis on the anticipated effects of horizontal and vertical subcontracting on firms' bidding behavior in open tenders for the awarding of public contracts; it also suggests that the design of firms' "entry rules" in public procurement sector - such as the pre-qualification system in Italy - deserve more attention.

References

Atamtrk, A., D.S. Hochbaum. 2001. Capacity acquisition, subcontracting, and lot sizing. *Management Science* **47**(8) 1081-1100.

Bresnahan T.F., J. D. Levin. 2012. Vertical integration and market structure. NBER working paper no. 17889.

Bajari, P., G. Lewis. 2011. Procurement contracting with time incentives: theory and evidence. *The Quarterly Journal of Economics* **126** (3) 1173-1211.

Bajari, P., R. McMillan, S. Tadelis. 2008. Auctions versus negotiations in procurement: an empirical analysis. *Journal of Law, Economics and Organization* **25**(2) 372-399.

Bajari, P., S. Tadelis. 2006. Incentives and award procedures: competitive tendering versus negotiations in procurement, in *Handbook of Procurement*, N. Dimitri, G. Piga, G. Spagnolo (eds.), Cambridge University Press.

Bajari, P., S. Tadelis. 2001. Incentives versus transaction costs: a theory of procurement contracts. *The Rand Journal of Economics* **32**(3) 287-307.

Cachon, G.P., M.A. Lariviere. 2001. Contracting to assure supply: how share demand forecast in supply chain. *Management Science* **47**(5) 629-646.

Coase, R.H. 1937. The nature of the firm. *Economica* **4**(16) 386-405.

Coviello, D., S. Gagliarducci. 2010. Building Political Collusion: Evidence from Procurement Auctions. IZA Discussion Papers 4939, Institute for the Study of Labor (IZA).

Decarolis, F. 2009. When the highest bidder loses the auction: theory and evidence from public procurement. Economic working papers, 717, Bank of Italy, Economic Research Department.

Lewis, T. R., D.E.M. Sappington. 1991. Technological change and the boundaries of the firm. *American Economic Review* **81**(4) 887-900.

Gil, R., J. Marion. 2011. Self enforcing agreements and relational contracting: evidence from California Highway Procurement. *Journal of Law, Economics, and Organization* forthcoming.

Grossman, S.J., O.D. Hart. 1986. The costs and benefits of ownership: a theory of vertical and lateral integration. *Journal of Political Economy* **94**(4) 691-719.

Grossman, G.M., E. Helpman. 2002. Integration versus outsourcing in industry equilibrium. *Quarterly Journal of Economics* **117**(1) 85-120.

Lewis, T.R., D.E.M. Sappington. 1991. Technological change and the boundaries of the firm. *American Economic Review* **81**(4) 887-900.

Kamien, M., L. Li. 1990. Subcontracting, coordination, flexibility and production smoothing in aggregate planning. *Management Science* **36**(11) 1352-1363.

Kamien, M., L. Li, D. Samet. 1989. Bertrand competition with subcontracting. *RAND Journal of Economics* **20**(4) 553-567.

Kellogg, R. 2011. Learning by drilling: inter-firm learning and relationship persistence in the Texas Oilpatch. *Quarterly Journal of Economics* **126** 1961-2004.

Lember, V., T. Kalvet, R. Kattel. 2011. Urban competitiveness and public procurement for innovation. *Urban studies*, in press. (Published online 21 September 2010. DOI: 10.1177/004209801037/4512).

Levin, L., S. Tadelis. 2010. Contracting for government services: theory and evidence from U.S. cities. *Journal of Industrial Economics* **58**(3) 507-541.

McMillan, J. 1995. Reorganizing vertical supply relationships, in Horst, S. (ed.), *Trends in business organization*, Institut fr Weltwirtschaft: Kiel.

Miller, D. 2011. Subcontracting and competitive bidding on incomplete procurement contracts. Mimeo.

Monteverde, K., D. Teece. 1982. Supplier Switching Costs and Vertical Integration in the Automobile Industry. *Bell Journal of Economics*, **13** 206213.

Quinn, J.B., F.G. Hilmer. 1994. Strategic outsourcing. *Sloan Management Review* Summer 43-55.

Sabel, C.F. 1989. Flexible Specialization and the Re-emergence of Regional Economies, in Hirst, P., J. Zeitlin (eds.) *Reversing Industrial Decline?* St. Martin's Press, New York.

Shy, O., R. Stenbacka. 2003. Strategic outsourcing. *Journal of Economic Behavior and Organization* **50**(2) 203-224.

Shy, O., R. Stenbacka. 2005. Partial outsourcing, monitoring costs and market structure. *Canadian Journal of Economics* **18**(4) 1173-1190.

Spiegel, Y. 1990. Horizontal subcontracting. *RAND Journal of Economics* **24**(4) 570-590.

van Mieghem, J.A. 1999. Coordinating investment, production and subcontracting. *Management Science* **45**(7) 954-971.

Webster, M., C. Alder, A.P. Muhlemann. 1997. Subcontracting within the supply chain for electronics assembly manufacture. *International Journal of Operations and Production Management*, **17** (9) 827 - 841.

Williamson, O. 1985. *The economic institutions of capitalism*. Free Press: New York.

Appendix A: Variables' abbreviation and description

Rebate It is the rebate offered by auction's participant and it is expressed as a percentage of the auction's reserve price.

Choice It is a dummy variable that takes value 1 if the firm has the choice to subcontract part of the works in the project (as it is fully qualified to execute the works). It takes value 0 if the firm is required by law to subcontract part of works (as it is partially qualified).

Law It is a dummy variable that takes value 1 if the firm is required by law to subcontract part of the works in the project (as it is partially qualified to execute the works). It takes value 0 if the firm has the choice to subcontract part of the works (as it is fully qualified).

Reserve price It is the auction's starting value (in Euros) and it is decided by the contracting authority (all observed projects have a reserve price greater than 150,000 euros).

No. of participants It is the number of bidders participating to the auction.

Firm size It a set of dummy variables which represent proxies for the size of participant firms. Since we do not have data for firms' number of employees or total asset, we construct proxies based on the juridical form of the firm. In fact, there is a positive correlation between Italian firms' juridical form and their size. In particular, our proxies' definition is as follows: *Small*: individual, SAS and SNC firms. *Medium*: SRL firms. *Large+cooperatives*: SPA and cooperatives firms.

Consortium It is a dummy variable which takes value 1 when it refers to a temporary association of firms, 0 otherwise. Firms can join together, pool together their qualifications and form a consortium to participate to an auction. For this reason we assume that Choice takes value 1 for consortia.

Type of auction It is a set of dummy variables that indicates the auction mechanism. *Maximum rebate* is when the firm with the higher offered rebate (lower price) win the auction. *Anomaly threshold* is an average price auction defined as follows: given the distribution of all the bids for any auction, after excluding the bids located in first and last deciles, the winning bid is the one just below an anomaly threshold value given by the sum of the average bid (simple average of the not excluded bids) and the average deviation of the bids above the average bid. *Anomaly threshold+lottery* it is an average price auction defined as follows: given the anomaly threshold value computed as before, the winning bid is the one closest to the average value between the anomaly threshold and a value drawn by the awarding committee among nine equidistant numbers ranging from the lowest admitted bid and the bid just below the anomaly threshold (both bids not considered).

Category of work It is a set of dummy variables that represent the main category of work in the project (i.e, road works, buildings, hydraulic works, etc.).

Sub It is a dummy variable that takes value 1 if the winning firm subcontracts part of the works in a project. It takes value 0 otherwise.

No. of subcontractors It indicates the number of subcontracting firms in a project.

Value of subcontract It indicates the value (in euros) of the subcontracts in a project.

Bidder-Subcontractor It is a dummy variable that takes value 1 if, in a project, at least a subcontractor has participated as bidder in the auction for the same project. It takes value 0 otherwise.

Type of CA It is a set of dummy variables that represent the type of contracting authority that has issued the auction (i.e., regional government, municipalities, health authorities, etc.).