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Entry and Subcontracting in Public Procurement Auctions

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We empirically study how the interplay between entry and subcontracting choices is affected by the use of different auction formats in public procurement. The difference-in-differences strategy used exploits a data set of auctions for public works run alternately under first price and average bid auctions. We find that the use of first price auctions causes a marked decline in both entry and subcontracting. We also find that the type of firms entering first price auctions changes with firms becoming more likely to bid jointly with other firms in ad hoc joint ventures.

Data, as supplemental material, are available at <http://dx.doi.org/10.1287/mnsc.2014.2071>.

Keywords: procurement; auctions; entry; subcontracting; difference-in-differences

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1. Introduction

When analyzing the effectiveness of different auction formats, it is often natural to focus on how bidders bid in the auction. In the context of the procurement of contracts, however, the bidding stage is merely one part of a more complex process that involves other stages taking place both before and after the bidding. In turn, since what happens in these nonbidding stages affects the auction outcomes, the evaluation of an auction mechanism in public procurement has to be undertaken within the broader context of the procurement process. The goal of this paper is to study empirically the properties of first price auctions (FPAs) and average bid auctions (ABAs) in terms of the interplay between two of the most fundamental choices firms make outside bidding: entry and subcontracting choices.

Entry and subcontracting are essential aspects of public procurement because they impact both the procurement cost for the government and the efficiency of the contract allocation. Moreover, detailed regulations about entry and subcontracting are often used by procurement agencies to pursue different goals, like fostering bidder competition and helping small and medium enterprises (SMEs). Accordingly, various studies have acknowledged the role of entry behavior in procurement auctions by either studying how the interaction of entry and bidding can affect the performance of an auction (Marmer et al. 2013) or how entry responds to certain policies like those

favoring SMEs (Krasnokutskaya and Seim 2011). Similarly, various studies have analyzed why subcontracting and, when allowed, contract resale often emerge in procurement. Indeed, since contracts often bundle together heterogeneous tasks, the winners will tend to unbundle them to exploit the different firm specializations. Moreover, subcontracts serve to deal both with changes in bidders' relative costs driven by the occurrence of cost shocks in the period between when the contract is won and when the work is performed (Haile 2001) and with the misallocation that various auction formats typically produce when bidders are asymmetric (Gupta and Lebrun 1999).

All these different motives for subcontracting suggest that allowing for subcontracting should increase the expected value of the contracts auctioned off. Therefore, subcontracting should promote entry when bidders are more likely to bid for more valuable contracts. However, the interaction between entry and subcontracting likely depends on the auction format used. For instance, in the case of simple contracts entailing a single task, we are less likely to observe subcontracting when the auction mechanism induces efficiency (i.e., in equilibrium it allocates the contract to the lowest production cost firm). In turn, participation in the auction would then appeal exclusively to those firms that have a chance of winning the contract at a price such that they will be willing to execute the job. The implication that entry and subcontracting will respond to different auction formats is important because this can change the overall assessment

of the performance of an auction format. Despite the literature devoting enormous attention to the evaluation of FPAs, very few papers consider entry and subcontracting within the same framework. Moreover, since auction formats in public procurement are rarely modified, there is essentially no empirical evidence on the causal effect induced by the introduction of FPAs.

In this paper, we observe a setting where two auction formats are used. The first one is the well-known FPA. The second one is an average bid auction (ABA) of the type often encountered in public procurement regulations in which the winner is the bid closest to (a function of) the average bid.¹ In the data set, the ABA is the status quo, but we observe the introduction of FPAs for certain contracts. Prior theoretical work suggests that this is an almost ideal experiment because in equilibrium ABAs allocate contracts like random lotteries and at high prices. Therefore, we should expect FPAs to vastly improve the allocative efficiency and to reduce winning prices. In turn, these effects are likely to influence entry and subcontracting choices. We begin our analysis by providing a simple theoretical framework to explain why both entry and subcontracting will likely decline with a switch to FPAs. This framework incorporates some relevant features of the market, in particular the fact that the FPAs that we observe in the data are characterized by an *ex post* screening of the bids, which aims to exclude low-ball bids deemed unreliable. Such screening systems are common in public procurement and, as we discuss, have a relevant impact on the functioning of the FPAs in our environment. Thus, our analysis effectively compares FPAs with screening to ABAs without screening.

We then empirically evaluate the effect of FPAs on entry and subcontracting utilizing a quasirandom switch to FPAs occurring in the procurement of public contracts in Italy. In particular, the data consist of procurement auctions for simple construction contracts, mostly roadwork repairs, awarded between 2000 and 2006. As explained in detail in the text, starting in 2003, FPAs were introduced for a share of these auctions, and this allows us to implement a difference-in-differences (DD) identification strategy. Our estimates corroborate the theoretical predictions. Specifically, we estimate that the switch to FPAs causes a reduction of the share of subcontracts that is between one-half and two-thirds of the average level of subcontracting under ABAs. Furthermore, since our data allow us to separately observe each of the subcontracts awarded within an auction, we analyze how FPAs affect the largest (within-auction) subcontract awarded. We estimate a reduction that

is between 50% and 90%, causing the largest subcontract to decline from 10% of the reserve price under ABAs to a value between 1% and 5% under FPAs. Thus, FPAs assign the contract to contractors who tend to perform the job themselves and only subcontract minor, specialized secondary tasks. With regard to entry, we find that the number of bidders substantially declines. In particular, we estimate that the adoption of FPAs reduces the number of bidders by 35–65 bidders, or at least 50% of the average number of bidders in ABAs. This sharp decline in entry is consistent with the deterrence effect of bid screening on unreliable bidders and with the different degree of competition and efficiency of ABAs and FPAs. Indeed, the competitive nature of FPAs relative to ABAs (winning discounts almost double with the switch to FPAs) and their more efficient allocation, implied by the decline in subcontracting, reduce the incentive to enter.

In this respect, an interesting additional finding is that bidders respond to the introduction of the FPA by forming “temporary joint ventures” (TJVs). Italian regulations allow firms to enter either individually or in partnerships with other firms. These joint ventures are created for the sole purpose of bidding in a specific auction and do not give rise to the creation of a new legal entity. They represent a sort of binding agreement through which a group of firms commits to a certain bid. If the TJV loses the auction, the partnership dissolves. If it wins, then its members are jointly responsible for the execution of the contract in proportion to their shares in the TJV.² In our analysis, we find that the switch to FPAs more than doubles the probability that the auction is won by a TJV. Since no restrictions are placed on the type of firms that can form TJVs, these preauction agreements are closely connected with *ex post* subcontracting. Indeed, our findings of declining subcontracting and increasing TJVs indicate that FPAs induce firms to select the set of partners with whom they will complete the contract before the auction. Part of the reason might be specific to the FPAs that we observe in the data, which are characterized by a bid screening process. Hence, forming a TJV can increase the firms’ chances of passing the bid screening process. More generally, however, since FPAs entail substantially lower winning prices than ABAs, TJVs can serve to limit holdup problems: after having won the auction at a very low price, a firm would be in a weak position in its bargaining with essential subcontractors. In any case,

¹ ABAs are commonly used in public procurement. Instances of countries that use ABAs are Colombia, Italy, China, Chile, Japan, Peru, and Taiwan.

² As explained in greater detail in the section on the regulations, at least one firm has to be declared the leader of the TJV. This firm is responsible for the execution of the entire contract, whereas the other members of the TJV are responsible exclusively in proportion to their share of the TJV.

the effect of FPAs on TJVs is particularly interesting because it implies that it is not only the number of bidders, but also the type of bidders who enter, that changes under FPAs.

There are three main policy implications that we can draw from these findings. First, using the number of bidders as a measure of competition in procurement auctions, as procurement agencies often do, is generally wrong. Although this point has been made in previous studies, we support our argument with evidence from the changing nature of the bidders that appears to be novel. Second, the degree of bidder asymmetry is endogenously determined by the broad set of rules governing entry, bidding, and subcontracting. Thus, the policies helping SMEs that are often undertaken by procurement agencies should take into account how auction formats influence the formation of partnerships before and after the auction. Third, our findings suggest that the frequent use of ABAs by procurement agencies can be reinterpreted as a way for procurement agencies to delegate the choice of who will execute the contract to the market. Although ABAs seem at odds with the conventional wisdom on how auctions should be designed, this interpretation can help to explain their enduring presence in procurement. Indeed, in the context of public procurement, where FPAs can pose a severe trade-off between winning prices and ex post performance whenever the procurement agency is unable to properly select firms, ABAs augmented with subcontracting can limit the ex post performance risk without generating severe inefficiencies.

1.1. Literature.

This paper is related to three strands of the literature. The first one concerns the analysis of entry and subcontracting (or resale) in auctions. Individually, both entry and subcontracting have received substantial attention both theoretically and empirically.³ Nevertheless, only a few studies have analyzed them jointly. Among them, Haile (2001) studies a case where subcontracting introduces an endogenous common value in the bidder valuations: whenever entry signals higher competition in the subcontracting stage, the option of subcontracting implies that the value of winning the auction is positively associated with entry.⁴ Other related studies are those

of Gil and Marion (2013) and Moretti and Valbonesi (2012) that, respectively, study how the stock of past subcontractors and the regulations mandating the use of subcontractors affect both entry and bidding behavior. The work of Moretti and Valbonesi (2012) is particularly close to our work because it uses data from the same market. Our paper differs from the previous ones in this literature because its focus is on how ABAs and FPAs induce different entry and subcontracting behavior by firms.

The second branch of the literature to which we contribute is on the difference between pre- and post-award subcontracting choices. This is an instance of the more general problem of the boundary of the firm on which an extensive literature initiated by Oliver Williamson exists. Although along the ideal line ranging from full integration to full separation, the TJV is closer to the latter, a TJV is nonetheless a contractual agreement by which firms precommit to collaborate. A valuable insight from the organizational literature is that, in addition to the obvious cost motives pushing firms to integrate, the strategic desire to deprive rival bidders of a valuable contractor can be an important motive driving preaward subcontracting choices (Arya et al. 2008). Moreover, since forming a TJV can increase expected payoffs through the increased probability of winning in FPAs, but has no such effect in ABAs, the results of Legros and Newman (2013) would suggest greater usage of TJVs in FPAs. Despite a vast literature on firm integration, its penetration into the auction literature is limited. Albano et al. (2009) survey the literature on joint bidding in auctions, relating it to that on collusion, mergers, and joint ventures to clarify the motivations and the likely effects of allowing joint bidding. Their main conclusion is that very little is known about the effects of joint bidding, despite its being a common practice in procurement. Hence, our findings are important because they indicate an effect of the auction format on the timing with which firms form joint production agreements.⁵ Moreover, they imply that forming a TJV makes bidders' asymmetry endogenous and, hence, suggest a more nuanced look at the problem of SMEs bidding under alternative auction formats.⁶

models without subcontracting. Without subcontracting, higher entry implies a lower procurement cost for the auctioneer and no change in values for bidders in a private value environment, but higher procurement cost and lower values for bidders in a common value environment.

⁵ In this respect, it is also related to the work of Marechal and Morand (2003) who study whether an auctioneer should require bidders to select their subcontractors before or after auctions.

⁶ The issue of SMEs has recently received attention (Marion 2007, Krasnokutskaya and Seim 2011, Athey et al. 2013). However, only Albano et al. (2009) mention the possibility of addressing this issue via joint bidding regulations.

³ Among the theoretical studies on entry see McAfee and McMillan (1987) and Levin and Smith (1994). Among the empirical studies see Marmer et al. (2013) and Coviello and Mariniello (2014). Among the theoretical studies on subcontracting see Gupta and Lebrun (1999), Haile (2003), and Hafalir and Krishna (2008). Among the empirical studies see Haile (2001), Marion (2009), Gil and Marion (2013), Moretti and Valbonesi (2012), and Jesiorski and Krasnokutskaya (2013).

⁴ Haile (2001) shows that this feature differentiates models of auctions with subcontracting from standard private and common value

Finally we also contribute to the literature on ABAs. The frequent use of ABAs in real-world procurement, along with their intuitively unappealing theoretical properties, has induced this literature to focus on which features of procurement can better rationalize ABAs. Spagnolo et al. (2006) and Decarolis (2013), among others, argue that ABAs induce all bidders to offer the same (high) price in equilibrium. This can help an auctioneer concerned about the correct execution of the contract to avoid awarding it to unreliable firms offering excessively low prices in the auction. Decarolis (2014) uses the same data set analyzed in this paper to document that the switch from ABAs to FPAs indeed lowers the winning price but also worsens cost overruns and completion delays. Despite this valuable effect of the ABA, the typically very high awarding price, as well as the major inefficiencies it produces, suggest limits to the usefulness of this format. A different interpretation, however, has been offered by Chang et al. (2015), who find that ABAs perform remarkably well relative to FPAs in a laboratory experiment where bidders have purely common costs. In this environment, the ABA seems able to avoid the worse effects caused by the behavioral biases of the experimental subjects that induce them to overbid. Relative to these studies, our analysis shows that, without the need to rely on the presence of behavioral biases, ABAs perform better than what was previously thought because bidder subcontracting choices limit efficiency losses; hence, ABAs allow government agencies unable to effectively select among bidders to delegate the choice of the final contractor.

2. Public Procurement System and Policy Changes

2.1. Main Regulations

Individual public administrations (PAs), mostly local governments of municipalities and counties, award contracts for public works under a body of national regulations. For this study, the most salient elements of these regulations are those concerning auction formats, bidder entry, and subcontracting.

In the period that we analyze, the regulations entail two different types of auction formats: FPAs and ABAs. They are identical in everything except for the way the winner is determined. For both ABAs and FPAs, the process starts with a PA releasing a call for tenders that illustrates the contract features, including the maximum price the PA is willing to pay (i.e., the reserve price) and the procedure used (FPA or ABA). Each bidder submits a sealed bid, consisting of a discount over the reserve price. If the FPA is used, then the highest “responsible discount” wins. This means that the highest discount wins, but only if it clears an

ex post screening aimed at assessing the seriousness of the offer. Essentially, bid screening is a formalized process through which the PA’s engineers try to assess whether firm costs are compatible with fulfilling the contract at the conditions promised.

If the ABA is used, the contract is awarded to the highest discount strictly below an “anomaly threshold” that is calculated as a trim mean of the bids.⁷ There is no ex post bid screening under ABAs: the intended objective of the regulator is to automatize the selection of a reliable contractor by selecting the firm offering a discount close to the average discount.⁸ Indeed, whereas in an FPA the highest discount will typically win, in an ABA it will certainly lose. In both ABAs and FPAs, the winner is paid its own price to execute the contract.

As regards entry, firms qualify to bid if they are certified for the economic value and the typology (i.e., roads, buildings, etc.) of the contract being auctioned. Certifications are based on various criteria in terms of capital, portfolio of completed public contracts, and lack of Mafia connections for managers and owners. Once a firm obtains a qualification, it retains it for the following five years, provided that at the end of the third year it successfully completes a review process. In addition to entering individually, a firm can bid jointly with other firms in a “temporary joint venture” (TJV). These two options are mutually exclusive and, moreover, for every auction a firm can join at most one TJV. For a firm that holds the right qualification, entering individually or as a TJV is a free choice. However, by allowing firms to pool their certifications, TJVs allow entry by firms that would not be individually qualified.⁹ A TJV must designate a leading firm, and the only restrictions that the regulation places on a TJV are that (i) at the entry stage, either its leader individually or its members jointly

⁷ This “anomaly threshold” is calculated as follows: First, discounts are ordered from the lowest to the highest, and a trim mean (A1) is calculated by excluding 10% of the highest and lowest bids. A new threshold (A2) is then calculated as the average between all the discounts greater than A1, but lower than the lowest discount in the top 10% of bids. A2 is the “anomaly threshold.” In cases of ABAs with fewer than 5 bids submitted, A2 is not calculated and the winner is the highest responsible discount. This latter case happens in less than 5% of the auctions in our sample.

⁸ The emphasis of the regulation on the risk posed by high discounts is, in part, driven by the lack of an effective system of financial guarantees. A major difference between the U.S. and the Italian systems is that the former requires a 100% performance bond on almost all contracts, whereas the latter requires letters of credit, typically covering approximately 20% of the contract value.

⁹ A July 2006 reform of the law introduced a third method of entry known as “avvalimento,” that, under certain conditions, allows entry by individual firms even if they do not have the right qualifications. Given that our analysis focuses on the period before this reform, we ignore this option.

have the appropriate certifications; and (ii) in case the TJV wins, in the execution stage each TJV member performs exclusively work for which it has the adequate certification. The TJV is formed to bid in a single auction where it is allowed to place just one bid. If it loses, it dissolves. If it wins, its members must complete the contract at the promised price. The benefits of entering as a TJV are also associated with the screening process described above for FPAs: it will be more credible for a firm to commit to a certain low price if all the subcontractors are already locked in by a preaward agreement.

For subcontracting, contracts specify how the job is divided into tasks and indicate which task is the main one. For instance, repairing a road might entail paving it (main task) as well as fixing the electric and water pipes passing beneath it (secondary tasks). Each secondary task can be fully subcontracted out, but for the main task there is a maximum of 30% of the task value that can be subcontracted out. The main task and any secondary tasks can be executed only by those firms holding the right qualifications. Thus, although a firm (or a TJV) is necessarily entitled to execute the main task (otherwise it would not be allowed to bid), it must subcontract out any secondary tasks for which it is not qualified.¹⁰ As regards the timing of subcontracts, each bidder is required to specify in its bid whether it will use subcontractors or not, but not the identity of subcontractors. In practice, all bids always indicate the use of subcontractors.

2.2. The Policy Change: The Switch from ABAs to FPAs

In the period that we consider in this study, between January 2000 and June 2006, national regulations required the use of ABAs for all contracts with a reserve price below (approximately) €5 million, while European Union regulations required the use of FPAs for contracts at or above this value.¹¹ The policy change that we exploit for our analysis consists of the switch to FPAs for all the contracts below €5 million auctioned off by two PAs. This policy change was implemented at the beginning of 2003 by the municipality and the county of Turin after a case

of collusion in ABAs became public. Since part of the blame for the episode of collusion was attributed to the functioning of the ABA, these PAs ruled to replace ABAs with FPAs for all contracts. The central government, however, challenged their reform in court on the grounds that only state laws can determine the auction formats allowed. This response from the central government prevented similar reforms in other PAs. Thus, it was only after a national reform in July 2006 allowed PAs to choose freely between ABAs and FPAs that other PAs replaced ABAs with FPAs. Although this switch to FPAs in Turin is clearly not random, the difference in the timing with which it happened in Turin, relative to the other similar PAs that switched to FPAs after the 2006 reform, is what generates the quasiexogenous variation that we exploit. In §5 we discuss the identification strategy in more detail, arguing that the quasirandom assignment of the policy change is likely to hold within a subset of PAs comparable to Turin.¹²

3. Theory Overview

The goal of this section is to provide a theoretical guide for our empirical analysis. Theoretical models of entry, bidding, and subcontracting are not common in the literature, possibly because modeling firms' behavior in these three phases requires making a large number of assumptions about each phase individually and their linkages. Our approach is to present below the key elements of a basic framework that links these three phases and incorporates some of the main institutional features of the market. The framework combines existing results in the literature to rationalize why a switch from ABAs to FPAs will reduce both entry and subcontracting. We conclude this section with a discussion of some alternative modeling assumptions. The online appendix (available as supplemental material at <http://dx.doi.org/10.1287/mnsc.2014.2071>) presents a formalized version of our framework.

3.1. Baseline Framework

Consider the usual private value environment of Levin and Smith (1994): firms first decide whether to pay an entry fee or not, then they learn their cost (privately drawn from the same distribution), and, finally,

¹⁰ Moretti and Valbonesi (2012) study how mandatory subcontracting affects entry and bidding. In our analysis, we control for the difference between auctions with and without mandatory subcontracts.

¹¹ In this period, two other procurement formats existed but were considered an exception: they were negotiated procedures and scoring rule auctions, in which multiple criteria determined the winner. We will disregard these latter procurement methods, and hence our results do not necessarily extend to contracts of small economic value (below €300,000), for which negotiations are allowed, or to contracts involving projects of high technical complexity, for which scoring rule auctions are used.

¹² Indeed, the presence of collusion in ABAs was systematic for the type of auctions that we study and involved not only Turin but, most likely, all five regions where the auctions in our data were held. This is suggested by two facts. First, many of the firms convicted in the Turin case were based in other cities and won auctions all over the country. Second, various other court cases nearly identical to that in Turin occurred in other cities. For instance, in 2009, cases similar to that in Turin in terms of the type of collusion episodes and number of firms involved went to court in two northern cities, Treviso and Vicenza.

bid.¹³ To extend the analysis to subcontracting, suppose that after the auction all firms (both those entering and those not) privately know their cost and can bid (without entry fees) in a second price-sealed bid auction where the winner of the main auction offers to resell the contract. If the reserve price in the resell auction equals the winner's cost, then it is easy to show that this auction game is isomorphic to that in Levin and Smith (1994) with the only difference being that the entry fee is redefined as the sum of the entry fee in the main auction and the expected profit from winning the resell auction. Hence, like in Levin and Smith (1994), under appropriate parameter restrictions, the game allows for a unique mixed strategy entry equilibrium in which all firms enter with the same probability. Thus, relative to Levin and Smith (1994), reselling reduces entry in the main auction: the option value of winning the resell auction makes staying out more appealing.

The presence of subcontracting in equilibrium derives from the possibility that the lowest-cost firm does not win the main auction. The source of this inefficiency is closely connected to the auction format used in the main auction. To begin, suppose that the main auction is an FPA: under the appropriate assumptions, the symmetric independent private value formulation ensures that the winner is the firm with the lowest cost among the entrants. Therefore, a resell can only involve one of the firms that did not bid in the main auction.

Suppose now that the main auction is an ABA. As explained in greater detail in the online appendix, previous theoretical work shows that in equilibrium the ABA is equivalent to a lottery: all entering bidders offer the same price. In particular, under the features of the ABA rule described earlier, all firms bid the maximum price (i.e., reserve price) set by the auctioneer, and the winner is chosen by a random draw among the bidders.¹⁴ Results about bidding in ABAs are less well known than those concerning FPAs and deserve a few clarifications. First, Conley

and Decarolis (2012) show that the equilibrium previously described is susceptible to collusion, but that even with collusion the allocation resembles an unfair lottery, and the awarding price is typically higher in ABAs than in FPAs.¹⁵ Second, the bidding behavior has an intuitive explanation: in order to win, every bidder (or coalition of bidders) tries to guess where the other bidders are guessing the relevant trim mean will lie, which creates a concentration of bids in a narrow range. The public disclosure of past winning discounts implies that these discounts can work as a simple coordination device to determine the range within which discounts will lie.

An example from the data will clarify this discussion. Most of the ABAs awarded by the municipality of Turin before the switch to FPAs had a winning discount in a narrow range between 17% and 18%. Moreover, within each auction the vast majority of discounts was typically concentrated at approximately 18%. Bidders were aware of this "focal bid," and from auction to auction a large number of them were bidding between 17% and 18% because this was their best guess of what the other bidders were doing. Although groups of bidders coordinating their bids often tried to pilot the trim mean determining the winner, the large number of noncolluded firms participating implied that across auctions the bid distribution remained fairly concentrated at 18%. A similar behavior, with the only difference one of different "focal bid" values, is observed in all other PAs in the data.

For entry and subcontracting, the implications of using an ABA as the main auction are thus clear: the random selection of the winner makes subcontracting highly likely. Moreover, the fact that all firms ask a high price bolsters the expected payoff from winning the main auction and, accordingly, increases entry. Therefore, a switch from ABAs to FPAs is expected to produce a decline in both entry and subcontracting.

A richer version of this baseline framework would allow for cost uncertainty at the time of bidding and the possibility of a winning firm's defaulting on its bid. Cost uncertainty is a fundamental aspect of the procurement of contracts (Spulber 1990), whereas the risk of ex post default is an important element in explaining the use of ABAs (Decarolis 2013). In the online appendix, we formulate a model with these features. Assuming that the default risk is linked to a dichotomous bidder type (i.e., "serious" versus "risky" bidders), the bid screening in FPAs is integrated into the model as a technology that allows the

¹³ To avoid ambiguities driven by differences in the terminology in the literature, we use the term *entry* to indicate firms that participate in the auction by submitting a bid. We indicate as *main auction* the auction held by the PA and as *resell auction* the auction held by the winner of the main auction. We consider an environment where contracts consist of a single task and we use *resell* and *subcontract* indifferently.

¹⁴ Specifically, Decarolis (2013) shows that, in an ABA specifying that the winner is the bidder closest to the average, a continuum of equilibria of this type exists. In an ABA like the one used in Italy, which is described in §2, there is a unique equilibrium where all bidders offer a discount equal to zero. Although the model used is one of independent private values, absent behavioral biases (like those associated with winner's curse phenomena), these results would hold unaltered in a model with purely common value.

¹⁵ Indeed, although the presence of collusion in ABAs complicates the description of the expected effects of a switch to FPAs, the basic implications of the model in the online appendix hold under the types of cartel behavior that Conley and Decarolis (2012) describe for the Italian ABAs.

PA to learn the type of the bidder. Thus, a switch from ABAs to FPAs is expected to reduce participation for two reasons: first, since proving to be a serious type is costly, the entry cost is higher in FPAs than in ABAs; second, only serious bidders enter FPAs if bid screening entails excluding risky bidders. As regards subcontracting, the reduction in subcontracting associated with a switch from ABAs to FPAs follows the same intuition described above.

Since bid screening is likely costly for the PA as well, this type of model is able to rationalize ABAs as a way to limit the default risk of FPAs without having to pay the cost of bid screening.¹⁶ In terms of welfare, however, the presence of a cost of doing the screening for the PA implies that, even if ABAs and FPAs ultimately result in the same firm executing the contract, their equivalence in terms of welfare is ambiguous. Moreover, their ranking in terms of welfare is linked to the frictions that might exist in the subcontracting and TJV decisions.

3.2. Discussion and Extensions

The above discussion suggests that ABAs are an almost ideal starting point from which to study the effects of FPAs on entry and subcontracting: since both entry and subcontracting are expected to be particularly high in ABAs, the switch to FPAs in the data is a powerful experiment to detect whether FPAs lower entry and subcontracting.¹⁷ However, since these effects have been shown under specific modeling assumptions, it is interesting to discuss the likely effects of some alternative assumptions about entry and subcontracting.

3.2.1. Alternative Models of Entry. *Informed entry.* The Samuelson (1985) entry model assumes that firms know their cost before deciding to enter. In equilibrium, a cutoff strategy leads to entry by the most efficient firms only. In our context, the inefficient allocation of the ABA, coupled with the efficient resell mechanism, suggests that there will be values of the entry cost such that the most efficient firms stay out of the main auction. This makes entry in ABAs even more appealing for inefficient firms and subcontracting even more likely relative to a case where entry is free. In this environment, a switch to FPAs would lower subcontracts but not necessarily lower

entry. Apart from this case, a model of informed entry would lead to similar conclusions to those of our baseline framework in terms of the effects of the two auction formats.

Joint bidding. An interesting aspect of the data is that firms have the option to bid either individually or as members of a TJV. Although the random allocation in ABAs should push firms to enter individually and postpone the choice of subcontractors to later stages, a switch to FPAs might bolster entry via TJVs. The first motive for entry via TJVs is linked to bid screening: a TJV might allow its members to share the cost related to collecting and also credibly disclosing cost information to the PA. Since the highest discount is eliminated during the screening in approximately 10% of the FPAs in the data, it is clear that improving the probability of passing might be valuable.¹⁸ Although so far we assumed that contracts consist of one task, most of the contracts in the data are bundles of multiple tasks. Thus, a second motive for TJVs can be to lock in a key supplier to prevent competitors from partnering with it. Third, since FPAs entail substantially lower winning prices than ABAs, winners of FPAs face greater holdup problems: after having won the auction at a very low price, a firm would be in a weak position in its bargaining with potential subcontractors because few subcontractors could afford a low price. The same holdup problem would be less of a concern in ABAs in which many potential subcontractors could compete. Finally, a fourth motive for TJVs is that FPAs are an effective way to collude, unlike ABAs, where submitting multiple bids serves to pilot the trim mean. Thus, although formalizing a model of TJV formation and bidding would substantially complicate our simple model, there are clear theoretical reasons that TJVs should become more common with the switch to FPAs.

3.2.2. Alternative Models of Subcontracting. In our framework, subcontracting emerges because the allocation of the main auction is inefficient. There are at least three additional reasons for subcontracting discussed in the literature. First, as shown in Haile (2001), if private idiosyncratic costs evolve over time, the winner of the main auction might seek to resell the contract if its cost relative to the other firms worsens after having won the main auction. Second, if the contract is composed of multiple tasks, subcontracting

¹⁶ Decarolis (2013) compares the auctioneer's revenues under four auction formats: an ABA and an FPA, each of which can be augmented by a bid screening stage where the auctioneer (at a cost) learns bidders' types. He shows that, conditional on paying the screening cost, FPAs dominate ABAs. However, each of the three remaining mechanisms can lead to the highest revenues depending on screening and default costs.

¹⁷ Clearly, this switch also appears to be an ideal way to study the trade-off between low winning price and likely ex post defaults caused by FPAs. This is the focus of Decarolis (2014), who finds evidence in favor of this trade-off.

¹⁸ In ABAs, instead, the lack of bid screening implies that a firm could bid the focal bid even without knowing its cost and then learn it only to play the resell auction. Indeed, this aspect of ABAs might be a major advantage of this format in environments where information acquisition is very costly and firms might make bidding mistakes. Relatedly, in multiunit settings, the favor toward uniform price auction is sometimes explained as a way to contain problems caused by bidding mistakes.

can occur because the winner decides to unbundle it and resell its components. Third, subcontracting can be part of a scheme aimed at sustaining a collusive agreement. These alternative motives for subcontracting have potentially important consequences for our analysis. For instance, if we were to compare ABAs involving contracts with bundled tasks to FPAs with single-task contracts, then finding less subcontracting in FPAs would be driven not by a behavioral response to the auction format but by the different composition of the contracts procured. In §5, we will explain how we control for these forces.

4. Data

The analysis uses the database of the Italian Authority for Public Contracts (Authority sample). The Italian Authority for Public Contracts gathers data on all contracts for public works with a reserve price above €150,000 procured by all Italian PAs. Our data set includes contracts awarded between January 2000 and June 2006 and reports information about subcontracting (the value of subcontracts, identity of subcontractors, and so on) until the date of completion or August 2011, whichever comes first. We restrict our analysis to the simplest types of public works (consisting mostly of roadwork construction and repair jobs), awarded through either ABAs or FPAs, with a reserve price between €300,000 and €5 million, auctioned by either counties or municipalities located in five regions in the North (Piedmont, Lombardy, Veneto, Emilia-Romagna, and Liguria). Simple roadwork contracts are among the most frequent types of contracts in the data set and represent one-quarter of all public works. They are the most appropriate for our analysis because their reserve prices are comparable across PAs and, since bids are rebates over the reserve price, the comparability of auctions depends on the comparability of reserve prices.

A key feature of the contracts that we study is the process leading to determination of the reserve price. The types and quantities of inputs needed to complete a project are determined by the PA engineers, who then set the reserve price by multiplying these inputs by their prices and summing up these products. Importantly, input prices are list prices set every year for the respective regions and used exclusively by PAs to calculate reserve prices. We use auctions held in only five Italian regions because we found that this improves the comparability of reserve prices. Moreover, by focusing on simple roadwork jobs, we enhance the possibility that differences in the type and quantity of inputs is driven by the technology of the work and not by the engineers' discretion.¹⁹

¹⁹ PAs are not allowed to change the process determining the reserve price depending on the auction format used. To find empirical

Table 1 reports summary statistics separating the auctions into six subsamples according to whether the PA is the county of Turin, the municipality of Turin, or one of the control PAs and whether the time at which the auction was held is before or after the switch to FPAs in Turin. These statistics confirm that the reserve price is quite similar across the subsamples and show that winning discounts are markedly higher under FPAs.

The main independent variable in our analysis is a dummy equal to one when the auction is an FPA and zero otherwise. As regards the dependent variables, we focus on the following.

Entry. There are two variables regarding entry that we analyze. The first one, *N. bidders*, is the number of bids submitted in the auction. The second one, *TJV wins*, is a dummy equal to one when the winner is a TJV and zero when it is an individual firm. The comparison of the means reported in Table 1 suggests that, although participation experiences a large drop under FPAs, the frequency of winners that are TJVs increases.²⁰ Although in our main data set we observe exclusively whether the winner is a TJV, in §5 we present additional results using a smaller data set for which the identities of all bidders are observed. We use this data set to analyze how FPAs affect the probability that any bidder is a TJV, as well as the share of bids in the auction coming from TJVs.

Subcontracting. We focus on two variables related to the value of subcontracts. The first one is the total value of all subcontracts, and the second one is the value of the single largest subcontract. Since the winning price is endogenous relative to the auction format, whereas the reserve price is not, we express both subcontracting variables as a percentage of the reserve price. The usefulness of the second of these two variables is to capture whether the change in subcontracting behavior involves the reselling of one major task of the contract and not just many ancillary small tasks. A plain inspection of Table 1 shows a significant drop in the mean share of subcontracting (total and of the largest subcontract) under FPAs.

5. Empirical Analysis

5.1. Empirical Strategy and Identification

The empirical strategy that we use to identify the effect of the auction format on entry and subcontracting is the same used in Decarolis (2014) and is

support for this fact, we estimated a linear model for the reserve price including an FPA dummy, finding it never statistically significant.

²⁰ The summary statistics also indicate an increase in the number of bidders in the control group (the value increases from 38 bidders in the period 2000–2002 to 47 in the period 2003–2006). However, a formal test for the equality of means in the two subsamples indicates that the difference is not statistically significant.

Table 1 Descriptive Statistics: Authority Sample

Variables	Municipality of Turin			County of Turin			Other PAs		
	Mean	SD	N	Mean	SD	N	Mean	SD	N
January 2000 to December 2002									
Reserve price (in €1,000)	919.1	776.8	121	914.1	805.4	63	868.8	710.5	1,009
Winning discount	17.07	5.049	121	17.32	5.897	63	12.83	6.167	1,009
N. bidders	59.91	26.85	121	40.25	40.49	63	37.54	34.53	1,009
TJV wins	0.073	0.261	96	0.079	0.272	63	0.052	0.222	634
Perc. subct.	10.81	12.01	100	7.974	11.91	62	8.563	12.56	918
Perc. largest subct.	8.613	7.154	67	8.083	11.70	48	10.55	10.42	519
N. subcontracts	2.222	1.993	99	1.371	2.113	62	1.492	1.807	915
Population	900	0	121	2,243	0	63	1,024	1,083	1,009
Experience	521	0	121	416	0	63	186.4	90.98	1,009
Fiscal efficiency	0.750	0.035	121	0.884	0.015	63	0.813	0.140	1,009
January 2003 to June 2006									
Reserve price (in €1,000)	1,371	892.7	156	988.5	760.5	137	922.1	791.0	930
Winning discount	30.97	9.837	156	27.66	7.244	137	12.38	5.445	930
N. bidders	7.615	9.339	156	12.72	15.32	137	46.99	35.19	930
TJV wins	0.181	0.386	149	0.234	0.425	137	0.051	0.220	924
Perc. subct.	4.239	6.529	140	3.928	6.018	129	10.18	12.22	897
Perc. largest subct.	4.090	4.996	94	4.649	5.153	73	13.44	9.941	492
N. subcontracts	1.614	2.006	140	1.750	4.228	128	1.646	6.911	898
Population	900.6	0	156	2,243	0	137	388.4	245.9	930
Experience	521	0	156	416	0	137	171.4	75.24	930
Fiscal efficiency	0.806	0.040	156	0.866	0.032	137	0.866	0.092	930

Notes. Variables: *Reserve price* is the reserve price in thousands of euros. *Winning discount* is the rebate offered by the winning bidder and is expressed as a percentage discount over the reserve price. *N. bidders* is the number of bidders participating in the auction. *TJV wins* is a dummy equal to one when the winner is a TJV and zero when it is an individual firm. *Perc. subct.* is the total value of subcontracts divided by the reserve price. *Perc. largest subct.* is the value of the largest subcontract divided by the reserve price. *N. subcontracts* is the total number of subcontracts. *Population* is the resident population in thousands of persons. *Experience* is the number of auctions run by the PA in the sample period. *Fiscal efficiency* measures for each PA and each year the total actual revenues from taxation over the total expected revenues from taxation.

based on two pillars. The first one is a difference-in-differences (DD) regression model that exploits the different timing of adoption of the FPA between Turin and other PAs. Indicating by Y one of the four dependent variables described above, we estimate the following model:

$$Y_{i,s,t} = a_s + b_t + cX_{i,s,t} + \beta FPA_{s,t} + \varepsilon_{i,s,t}, \quad (1)$$

where i indicates the auction, s the PA, and t the year. We seek to identify β , the effect on the dependent variable of a dummy equal to one for FPAs and zero for ABAs, conditional on PA and time fixed effects (a_s and b_t , respectively) and other covariates (X).

The second pillar of the identification strategy is the definition of the control group for the DD analysis. This relies on two assumptions: first, the fact that the switch to FPAs that occurred in Turin, and not in another PA similar to Turin, is essentially random. This assumption is motivated by the observation that the switch in Turin was the first one to occur because its collusion case was the first to emerge publicly (see Conley and Decarolis 2012). As mentioned in §2, during the same period other PAs were also blaming ABAs for fostering collusion; however, they

had not collected enough information to build a criminal case against allegedly colluding firms by the time at which Turin switched. For instance, a few months before the Turin case became public, a similar case was brought to court in Milan, but the judge refused to proceed against the firms involved on the basis of lack of sufficient evidence. Thus, several other PAs were facing a situation similar to that of Turin and, indeed, transited to FPAs as soon as allowed to by the central government (July 2006).

The second assumption of the identification strategy is that we can infer which PAs would have switched together with Turin in 2003 if so allowed. This assumption can be justified on the basis of what happened after July 2006 when all PAs became free to switch to FPAs. Using data for the period after 2006, Decarolis (2014) estimates the probability that a PA voluntarily transitions from ABAs to FPAs. His findings show that large PAs that most frequently run auctions are the most likely to switch. Therefore, the control group of the DD includes exclusively PAs that are similar along this dimension to Turin. The exact measure of similarity used, called *Experience*, is reported in the note to Table 2 and was subject to extensive robustness checks (reported in the online appendix).

Table 2 Baseline Regressions

Variables	<i>N. bidders</i>		<i>TJV wins</i>		<i>Perc. subct.</i>		<i>Perc. largest subct.</i>	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Municipality of Turin								
<i>FPA</i>	−69.11*** (8.200)	−60.59*** (6.111)	0.100*** (0.038)	0.098** (0.0411)	−9.566*** (1.901)	−8.238*** (1.968)	−9.040*** (1.597)	−5.694*** (1.576)
Obs.	1,469	1,469	1,461	1,461	1,468	1,468	838	838
<i>R</i> ²	0.295	0.431	0.064	0.123	0.087	0.128	0.177	0.272
Panel B: County of Turin								
<i>FPA</i>	−48.05*** (8.708)	−45.15*** (8.177)	0.151*** (0.049)	0.159*** (0.048)	−6.676*** (1.168)	−6.055*** (1.325)	−7.115*** (1.530)	−6.846*** (1.455)
Obs.	1,616	1,616	1,614	1,614	1,615	1,615	930	930
<i>R</i> ²	0.274	0.397	0.084	0.146	0.093	0.130	0.159	0.250

Notes. For each dependent variable shown in the top margin, two numbered columns report the results of DD estimated with different control variables. Odd numbered columns include year and PA dummies. Even numbered columns include year, PA, municipality, and work type dummies and reserve price. The control group is composed of all PAs with a value of experience that is within 75% of that in the treated group (either the municipality or the county of Turin). Standard errors are clustered for PA and year.

** $p < 0.05$; *** $p < 0.01$.

Together these two assumptions imply that random assignment of the FPA treatment occurs at the PA level within the union of the treatment and control groups. Although the identification of β should follow from this randomization, an additional obstacle to conducting inference on β is that we would need the number of PAs to go to infinity. Clearly, since only Turin constitutes the treated group, we are not satisfying this asymptotic condition. The concern is that anything that happened in Turin at the same time as the switch to FPAs that could potentially affect all the contracts will bias the results. This effect would be averaged out with a large number of treated groups. A solution to this problem, which often plagues DD studies, has been proposed by two closely related papers, Abadie et al. (2010) and Conley and Taber (2011). These studies show that, under random assignment at the PA level, the PAs in the control group can be used to construct a distribution of PA-level shocks, which is then used for inference on β . In more detail, we estimate the distribution of unobservable shocks ε in Equation (1) using the large number of PAs in the control group. Under the maintained assumption of random assignment to treatment and control groups, this distribution is a valid estimate of the distribution of unobservable shocks in Turin. The standard error of the DD estimator is then corrected to account for the small sample bias in the treatment group. In essence, under this methodology, the asymptotic requirement regards only the PAs in the control group and is likely satisfied in the current setting, in which a large number of PAs is included in the control group.

The rest of this section presents first a set of baseline DD estimates of the effect of the switch to FPAs on entry and subcontracting. We then report robustness checks addressing the problems of identification, by analyzing time trends, and of inference, by

using the Conley and Taber (2011) method. We also report robustness checks dealing both with collusion in ABAs and subcontracting determinants, which are further explored in the online appendix.

5.2. Effects of the FPA on Entry and Subcontracting: Baseline Estimates

Table 2 presents the baseline DD estimates of the switch to FPAs on the four outcome variables. For each dependent variable, we run two specifications, which differ in the covariates included in X (see Equation (1)): odd numbered columns include dummy variables for the year and the identity of the PA; even numbered columns additionally include the reserve price, dummies for whether the PA is a municipality, and dummies for the type of work. Panel A reports the estimates for the municipality of Turin, and panel B reports those for the county of Turin. For each of the treated PAs, the control group is selected as the set of counties and municipalities located in five northern regions that hold a number of auctions in the sample close to that of the treated PA.

Panel A shows that for the municipality of Turin the switch to FPAs has a large and statistically significant effect on all the dependent variables considered. The number of bidders falls on average by 61–69 bidders, depending on the model specification; the awarding of the contract to a TJV becomes more likely, increasing by 10%; and the percentage of both total subcontracts and of the largest subcontract declines, between 8% and 10% in the former and between 6% and 9% in the latter. Qualitatively similar results are reported in Panel B of Table 2 for the county of Turin: the sign and significance of the estimates is the same, but, with the exception of the TJV dummy, the effects on the other three dependent variables are smaller in magnitude than those in panel A.

At first glance, the estimated effects appear to be quantitatively large. Therefore, before moving to the robustness check analysis that is standard in DD studies, we discuss in more detail the sources of these findings. Proceeding in the same order in which the dependent variables are presented, we begin by looking at the case of entry. The large estimates are consistent with the descriptive evidence in §4, which revealed a marked drop in entry in FPAs relative to ABAs. Moreover, the framework described in §3 rationalizes this large drop as driven by both the exit of risky bidders and the decreased participation of serious bidders due to the costly bid screening process. However, a natural concern is whether part of this drop might be caused by colluding firms' reducing their participation after the cartel has been exposed. Relatedly, this effect might be amplified by the presence among the colluding firms in ABAs of "shills" (i.e., firms that had been set up for the sole purpose of helping another firm to manipulate the bid distribution in ABAs). Shills are useful in ABAs for increasing the number of bids submitted to manipulate the average but are worthless in FPAs. To assess to what extent collusion in ABAs can explain the lower entry in FPAs, we exploit the findings in Conley and Decarolis (2012). They report that the typical ABA in Turin had 51 firms bidding, with 17 of them being members of the cartels. Moreover, half of these 17 firms were likely to be shills. Therefore, we propose to use a range between two-thirds and five-sixths of the DD estimates in Table 2 as a more conservative benchmark of the effect of the change in the auction format that accounts for the exit of either all colluding firms, or just the shills. Even after this adjustment, our estimates indicate an economically large drop in entry due to the switch to FPAs. Indeed, even if all 17 colluding firms present on average in ABAs stop entering FPAs, the exit of noncolluding firms is required to explain the drop in average participation from 51 to 8 firms.

The other measure related to entry, the dummy *TJV wins*, increases significantly with the switch to FPAs. The estimated effect is similar across specifications and indicates an increase of approximately 10% in the probability that the winner is a TJV. A comparison of this number with the sample mean of the ABAs of the municipality of Turin (7%) implies that the fraction of winning TJVs more than doubles under FPAs. A limitation of our data set, however, is that we can only assess the TJV or individual firm status for the winner. To have a more complete description of how bidders respond to the introduction of FPAs in the preauction stage, we collect an additional data set in which we can observe whether, for each bid, the bidder is an individual firm or a TJV. This is a small sample containing 135 FPAs and 762 ABAs held after

Table 3 Presence of TJVs Across All Bidders

Variables	N. TJV			Share of TJV	
	(1)	(2)	(3)	(4)	(5)
FPA	0.651*** (0.184)	0.628*** (0.184)	0.458** (0.216)	0.084*** (0.030)	0.068** (0.032)
Firm controls	NO	YES	YES	NO	NO
N. bidders	NO	NO	YES	NO	YES
Obs.	34,690	34,690	34,690	891	891

Notes. Standard errors are clustered by PA and year. The data set used is a panel containing information for each bidder in each auction (762 ABAs and 135 FPAs). Columns (1)–(3) report the results of a probit model using as a dependent variable the number of TJVs participating in an auction. Columns (4) and (5) use as a dependent variable the share of TJVs participating in an auction (number of bids submitted by TJVs divided by total number of bids submitted). Columns (1)–(3) are estimated via maximum likelihood, columns (4) and (5) via OLS. All regressions control for year fixed effect, the reserve price, a measure of work complexity (the number of categories of the tasks involved in the work), and the contractual time to complete the job. A YES in the row "Firm controls" indicates that the regression model includes three firm-specific controls: the distance between the firm and the location of the work (at zip code level), a dummy for whether the firm has unlimited liability, and the amount of firm-subscribed capital. A YES in the row "N. bidders" indicates that the regression model also includes the number of bidders in the auction.

** $p < 0.05$; *** $p < 0.01$.

November 2005 by PAs in the North of Italy to procure roadwork contracts.²¹ These data include FPAs run not only by Turin, but also by other PAs that switched to FPAs starting in 2006. Without attempting to identify causal effects in this small data set and with the sole purpose of conducting a descriptive analysis, we present in Table 3 estimates from a probit model for the probability that a bidder is a TJV (first three columns) and OLS regressions for the share of bidders in the auction that are TJV. The signs of the conditional correlations that we estimate are consistent with our previous findings and suggest an increase of TJV entry under FPAs.²²

The last four columns of Table 2 present the evidence regarding subcontracting. Both the total share of subcontracts and the share of the largest subcontract fall significantly with the adoption of FPAs. The effect on the total share of subcontracts is similar across specifications and indicates a fall of approximately 10% of the total value of the contract outsourced by the winner. This is not only significant but also a large value when compared to the mean share

²¹ This is a subset of auctions for which the TJV variable is available within the set of auctions in the "Telemat data set" described in Conley and Decarolis (2012).

²² In ABAs, 3% of bidders are TJVs, whereas in FPAs 9% of all bidders are TJVs. Moreover, 2.5% of ABAs are won by TJVs, whereas 7% of FPAs are won by TJVs. So TJVs are three times more likely to participate in FPAs and win a share of auctions three times larger. Thus, their higher participation is likely to be the reason that TJVs win more frequently.

Table 4 Adding Winner Fixed Effects

Variables	<i>N. bidders</i>		<i>TJV wins</i>		<i>Perc. subct.</i>		<i>Perc. largest subct.</i>	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Municipality of Turin								
<i>FPA</i>	−65.01*** (6.587)	−67.98*** (6.707)	0.216*** (0.0533)	0.192*** (0.0550)	−9.428*** (2.636)	−8.975*** (2.752)	−2.521 (2.460)	−0.526 (2.647)
Obs.	1,464	1,464	1,457	1,457	1,463	1,463	834	834
<i>R</i> ²	0.857	0.873	0.714	0.737	0.686	0.707	0.832	0.857
Panel B: County of Turin								
<i>FPA</i>	−40.39*** (7.805)	−38.73*** (8.055)	0.136** (0.0612)	0.155** (0.0627)	−6.934** (3.091)	−6.350** (3.200)	−6.964** (3.161)	−8.069** (3.459)
Obs.	1,611	1,611	1,609	1,609	1,610	1,610	925	925
<i>R</i> ²	0.842	0.854	0.750	0.773	0.676	0.699	0.805	0.825

Notes. The estimates reported in this table are analogous to those reported in Table 2 with the only difference being that fixed effects for the identity of the winner are included in all regression models. Refer to Table 2 for the description of the other regression covariates.

** $p < 0.05$; *** $p < 0.01$.

of subcontracts in the period before 2003, which is approximately 14% for both the municipality of Turin and the other PAs in the control group. The similarly large effect on the share of the largest subcontract corroborates the idea that under FPAs the winner tends to execute the core job by itself.²³

As we discussed in §3, the decline in the level of subcontracting can have different explanations. On one hand, there is a composition effect due to the allocative efficiency of FPAs. On the other hand, there is a within-firm effect associated with a holdup problem in the subcontracting stage and the locking in of strategic suppliers. To disentangle these two effects, we also estimate the model above including winner fixed effects (see Table 4).

The coefficient on the total level of subcontracting remains negative and statistically significant, suggesting that the change in the overall amount of subcontracting occurs within firm. The coefficient on the level of the largest subcontract is, however, not significant in this specification, indicating that the decline in the share of the largest subcontract is mainly driven by a change in the composition of the winners.²⁴

²³ Table 3 reports an effect on the percentage going to the largest subcontractor, which is larger than the percentage going to subcontractors overall. The reason is that for some auctions we do not have information on the largest subcontract; therefore, the two samples are not exactly the same. If we restrict the sample only to observations for which we have both variables, the effect of auction format on the percentage going to the largest subcontractor is smaller than the percentage going to subcontractors overall, as it should be.

²⁴ An additional argument in favor of both effects being at play comes from looking at winner identities. We looked at the share of winning firms in FPAs who also win in ABAs (and vice versa). In a total of 139 unique winners in the FPA sample, 33 win 11% of the auctions in the ABA sample in the pretreatment period. Therefore, winners in FPAs won a nonnegligible fraction of the ABAs. This evidence suggests that the fall in subcontracting may not be entirely due to a composition effect.

These results are consistent with the conclusion that both a composition effect and a within-firm effect contribute to the observed fall in the level of subcontracting. Finally, additional results showing that the effect on subcontracting is not driven by confounding effects due to regulation requirements are reported in the online appendix. There we show that nearly identical estimates are found if we restrict the analysis to the cases where there are no mandatory subcontracts.²⁵

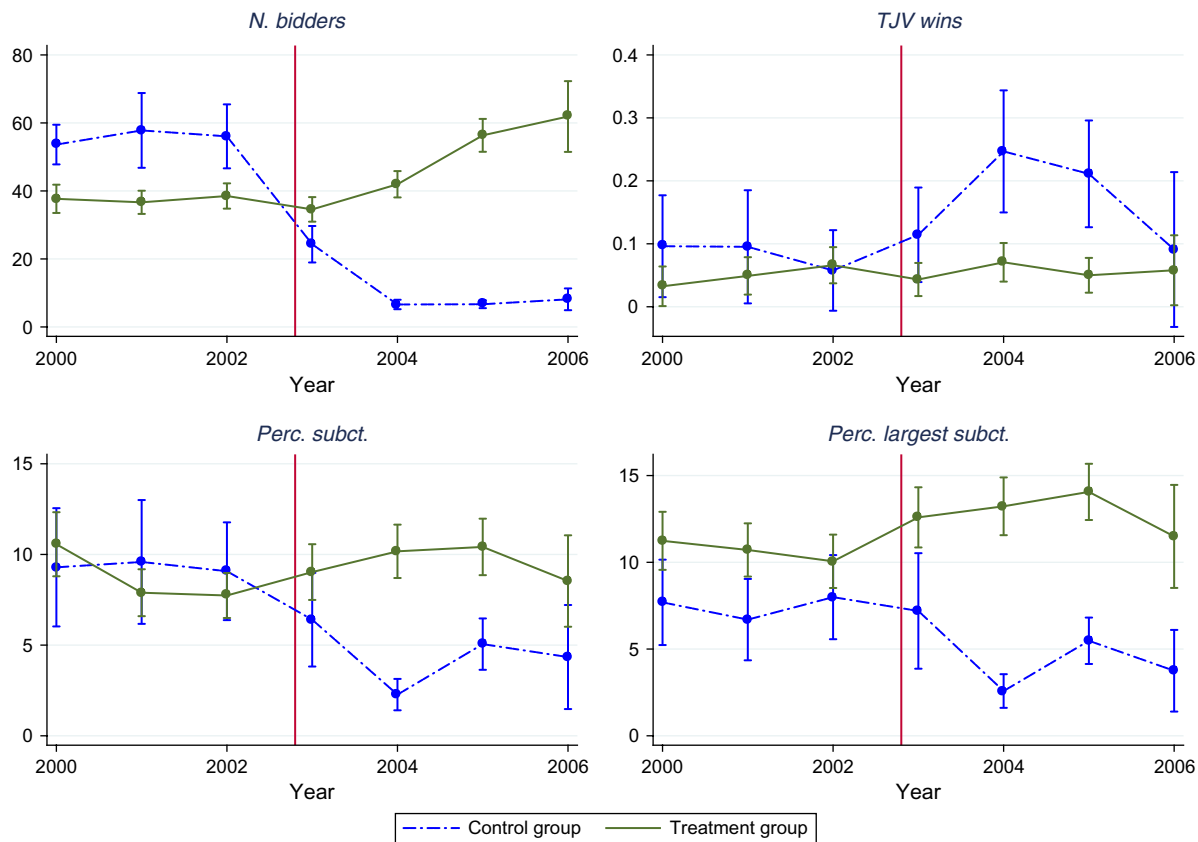
These results depict a clear change in participation and subcontracting under the two auction formats. Consistent with the theoretical arguments in §3, we observe under FPAs (i) a large fall in participation, (ii) an increase in the fraction of auctions awarded to TJVs, and (iii) a significant fall in subcontracting activity. In the next subsection we analyze the robustness of these results with respect to several issues associated with DD estimation.

5.3. Robustness Checks

The first set of robustness checks deals with the presence of common trends among PAs. A common trend between treatment and control groups before the treatment is a key assumption of the DD strategy. To understand whether our results are driven by heterogeneity in the time trends across PAs rather than the auction format, we present in Figure 1 the behavior over time of the four dependent

²⁵ As explained in §2, the possible presence of mandatory subcontracts when the winner is not qualified to perform the secondary tasks can affect bidder behavior. The results in the online appendix, however, show that estimates nearly identical to the estimates in the text are obtained if the sample is restricted to contracts with a single task where, necessarily, subcontracting is always voluntary. A similar finding was also obtained by modifying the dependent variable to account for subcontracts given exclusively in the main job category (which, necessarily, are also always voluntary subcontracts).

Figure 1 (Color online) Time Trends



Note. Dots indicate yearly means, vertical lines show the standard deviation of ± 1.96 .

variables. The four plots indicate a parallel behavior between treatment and control groups before the policy change.²⁶ They also visually confirm the strength of the effects discussed earlier and reveal how the differences between treatment and control groups gradually increase between the first and the second year after the policy change.

Table 5 complements this graphical evidence by presenting the estimates of β when we augment the set of covariates with PA-specific time-varying variables. Estimates in the odd numbered columns include in the specification a measure of fiscal efficiency often used in public finance—the ratio of the actual to the expected tax revenues—measured at the PA-year level. Even numbered columns include PA-specific time trends.

The estimates of β are significant and consistent with the results previously analyzed. For the

municipality of Turin, the switch to FPAs has a negative effect on the number of bidders, although the absolute magnitude is partially attenuated. Nonetheless the magnitude of the switch is still large, with approximately 34 bidders in the model with time trends, compared to the sample mean in the ABA period of 60. Moreover, the probability of a winning TJV remains the same with the inclusion of *Fiscal efficiency* and increases with the inclusions of PA-specific time trends. For the municipality of Turin, the estimated value of β becomes insignificant for the measures of subcontracting with PA-specific time trends. However, note that, for the county of Turin, both effects remain significant independently of the covariates included. The rest of the results for the county of Turin confirm what has just been discussed for the municipality of Turin.

The inclusion of PA-specific time trends should, however, be interpreted with caution. As first noted by Wolfers (2006), a policy reform such as the one we analyze may affect the outcome variable gradually over time. Therefore, the inclusion of PA-specific time trends may capture part of the effect of the policy change. To support this argument, we plot in the online appendix the time trends of the four variables of interest for the treatment and the control group.

²⁶ Furthermore, the plots do not display any change around 2003 for the control group. The only exception is the number of bidders, for which there is a slight increase after 2003, which is not statistically significant but could result from some weak “bidders” turning from auctions in Turin to other PAs. The robustness checks described in the online appendix address precisely this concern. From those results, we conclude that our results are not affected by contamination.

Table 5 Robustness Check: PA-Specific Time Trend and Fiscal Efficiency

Variables	<i>N. bidders</i>		<i>TJV wins</i>		<i>Perc. subct.</i>		<i>Perc. largest subct.</i>	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Municipality of Turin								
<i>FPA</i>	−65.00*** (6.799)	−34.59*** (8.493)	0.096** (0.043)	0.200*** (0.068)	−8.018*** (2.071)	−1.993 (2.758)	−6.692*** (1.753)	−0.743 (2.819)
Fiscal efficiency	YES	NO	YES	NO	YES	NO	YES	NO
Linear trend	NO	YES	NO	YES	NO	YES	NO	YES
Obs.	1,469	1,469	1,461	1,461	1,468	1,468	838	838
<i>R</i> ²	0.434	0.487	0.123	0.130	0.128	0.159	0.274	0.311
Panel B: County of Turin								
<i>FPA</i>	−44.04*** (8.146)	−13.38 (8.926)	0.158*** (0.049)	0.188*** (0.069)	−6.201*** (1.259)	−6.275** (2.620)	−6.632*** (1.529)	−9.687*** (2.072)
Fiscal efficiency	YES	NO	YES	NO	YES	NO	YES	NO
Linear trend	NO	YES	NO	YES	NO	YES	NO	YES
Obs.	1,616	1,616	1,614	1,614	1,615	1,615	930	930
<i>R</i> ²	0.399	0.454	0.146	0.155	0.130	0.162	0.251	0.290

Notes. Standard errors are clustered by PA and year. The dependent variables are reported above the columns. All regressions control for year, PA, municipality type, and work type dummies and the reserve price. A YES in the row “Fiscal efficiency” indicates that the regression model includes the variable *Fiscal efficiency* among the controls. A YES in the row “Linear trend” indicates that the regression model also includes both a linear time trend and PA-specific time trends among the controls. Results were obtained by using a control group based on experience.

** $p < 0.05$; *** $p < 0.01$.

These graphs support the validity of the DD strategy because for all four variables the trends before 2003 are similar between treatment and control and start to diverge in 2003. Furthermore, the effect is gradual in the first year after the reform. In light of this evidence, the inclusion of PA-specific time trends does not substantially alter the main evidence found in the previous section.

In the second set of robustness checks we focus on the methodology used to compute standard errors. The analysis performed so far uses standard errors clustered at the PA-year level. This level of clustering is conventionally used in DD studies and seems particularly appropriate here because of the presence of PA-specific factors that might change across years. Nevertheless, the well-known criticism of Bertrand et al. (2004) regarding the autocorrelation of standard errors, which causes the PA-year level clustering to produce statistical significance when significance is in fact absent, requires an assessment of whether the estimate of β remains significant once standard errors are clustered at the PA level. Table 6 reports the 95% confidence intervals (CIs) obtained when replicating the regressions presented in Table 5 using different sets of standard errors.

The first row shows the CI when the standard errors are clustered at the PA-year level (as in our baseline estimates), whereas the second row reports the CI when clustering is performed at the PA level. The results confirm the evidence presented in Table 5. The county of Turin confirms all our main results and the municipality of Turin confirms them except

for one set of regressors where the endogenous variable is the level of subcontracting. The third row of Table 5 addresses the problem, described earlier, that standard errors (clustered at the PA-year or PA level) are inadequate for inference on β since only one PA is treated. Therefore, this row reports the CI obtained with valid standard errors calculated by following Conley and Taber (2011) who, loosely speaking, calculate an empirical distribution of the shocks affecting the PAs in the control group and evaluate whether the estimate of β is large enough not to be considered as the realization of a shock from this distribution. Our findings indicate that the set of CIs obtained with this method closely resembles those generated by clustering at the PA-year level and, overall, confirms all our findings.

The last issue that we address is related to collusion in ABAs. In 2008, the Turin Court of Justice ruled that 267 auctions had been rigged by 8 groups of 95 total firms. These groups were identified as cartels and their members were fined, with some of them even being sentenced to jail. For our purposes, the presence of these cartels in ABAs might affect the level of subcontracting. If subcontracting is used as side payment within the cartel, the significant decrease in subcontracting in FPAs would be due to the absence of cartels in these auctions rather than the introduction of FPAs. To assess this issue, we focus on the sample of ABAs held before 2003, and we construct a dummy equal to one if the auction is won by a cartel member and zero otherwise. We then estimate via OLS the effect of this dummy on the subcontracting variables (total share of subcontracts and the share of

Table 6 Robustness Check: Standard Errors

Variables	N. bidders			TJV wins			Perc. subcontract		Perc. largest subcontract	
	(1)	(2)		(3)	(4)		(5)	(6)	(7)	(8)
Panel A: Municipality of Turin										
PA-Year	(-78.49--51.51)	(-51.44--17.74)		(0.010-0.181)	(0.066-0.335)		(-12.13-3.909)	(-7.465--3.479)	(-10.17--3.210)	(-6.342--4.857)
PA	(-79.96--50.04)	(-45.78--23.40)		(0.042-0.149)	(0.139-0.261)		(-11.29--4.742)	(-4.743-0.757)	(-10.12--3.263)	(-4.128--2.643)
Conley-Taber	(-119.5--34.59)	(-43.01--21.35)		(0.034-0.133)	(0.115-0.269)		(-11.47--4.177)	(-5.923-1.336)	(-11.11--3.002)	(-3.568--2.170)
Obs.	1,470	1,470		1,462	1,462		1,465	1,465	1,070	1,070
R ²	0.434	0.487		0.123	0.130		0.111	0.153	0.923	0.926
Panel B: County of Turin										
PA-Year	(-60.17--27.91)	(-31.05-4.296)		(0.062-0.254)	(0.051-0.325)		(-8.693--3.708)	(-11.46--1.089)	(-9.662--3.603)	(-13.79--5.581)
PA	(-52.50--35.58)	(-21.38--5.380)		(0.116-0.199)	(0.116-0.259)		(-8.010--4.392)	(-8.546--4.005)	(-9.259--4.006)	(-12.30--7.076)
Conley-Taber	(-101.1--16.70)	(-20.67--6.595)		(0.109-0.204)	(0.111-0.255)		(-8.368--4.063)	(-9.610--2.758)	(-9.016--4.088)	(-12.55--7.173)
Obs.	1,617	1,617		1,615	1,615		1,610	1,610	1,159	1,159
R ²	0.399	0.454		0.146	0.154		0.104	0.145	0.426	0.437

Notes. This table reports the 95% confidence interval (CI) estimates of the effect of the FPA dummy. For each panel, A and B, the first row reports the CI obtained when standard errors are clustered by PA and year, the second when they are clustered by PA, and the third when they are calculated as in Conley and Taber (2011). The table structure follows that of Table 4: all regressions control for year, PA, municipality type of PA, and work type dummies, as well as for the reserve price. For odd numbered columns, the regression model also includes the variable fiscal efficiency among the controls. For even numbered columns, the regression model also includes both a time trend and PA-specific time trends among the controls. Results were obtained by using control group based on experience. Results for the other two control groups are in the online appendix.

the largest subcontract). If these estimates reveal that awarding the contract to a cartel member does not systematically affect subcontracting, then we would be more confident that our baseline estimates are not confounded by the presence of collusion.²⁷ Table 7 reports the results.

Panels A and B of Table 7 refer to the municipality and county of Turin, respectively; and odd and even numbered columns include the same controls as Table 2. Since none of the estimated values is significant at the 5% level for either PA, we conclude that there is no empirical support for the idea that the drop in subcontracting is explained by the termination of the cartels in Turin.²⁸ Similarly, the additional checks presented in the online appendix indicate that the effect of FPAs on subcontracting is not driven by a different composition of contracts in terms of the tasks they bundle.²⁹

Finally, a different approach to assessing the role of the termination of Turin's cartels on our estimates is to include in the control group only auctions less affected by their activity. Table 8 replicates the baseline estimates of Table 2 but excludes from the control group all PAs located in the same region as Turin. For all specifications the magnitude of the estimates is close to that in Table 2, indicating that our findings are not driven by a contamination of the control group associated with the exit of colluded firms. Additional checks related to this issue and using alternative definitions of the control group are presented in the online appendix.

6. Discussion and Policy Implications

The findings in the previous section illustrate clearly that different auction formats induce bidders to change their behavior outside the bidding stage. A first implication of these findings is that they offer a novel and striking illustration of why using the number of bidders in the auction as a proxy for the degree of competition is unwise. Indeed, in our case the higher entry observed in ABAs, relative to FPAs, appears to be indicative of the high level of rents produced by the subcontracting of jobs inefficiently allocated by ABAs. Moreover, a second finding that should discourage the use of the number of bidders in

²⁷ We use only auctions in the ABA sample because the cartels operated in the period before the reform.

²⁸ Moreover, we repeated the baseline estimates of Table 5 using only auctions in which the winner is not among the 95 firms convicted for collusion, confirming our results.

²⁹ As stated in a previous footnote, estimates similar to our baseline estimates are obtained within the subset of contracts with no secondary tasks. Furthermore, the inclusion of controls for the number or the type of secondary tasks in the model specifications does not alter the findings.

Table 7 Robustness Check: Cartels

Variables	Perc. subct.		Perc. largest subct.	
	(1)	(2)	(3)	(4)
Panel A: Municipality of Turin				
<i>Dummy cartel winner</i>	2.824 (1.770)	2.756 (1.648)	3.441* (1.977)	2.533 (1.827)
Obs.	598	598	343	343
R^2	0.088	0.137	0.082	0.159
Panel B: County of Turin				
<i>Dummy cartel winner</i>	2.052 (2.122)	2.102 (2.148)	2.947 (2.545)	3.025 (2.697)
Obs.	649	649	384	384
R^2	0.099	0.139	0.102	0.182

Notes. Standard errors are clustered for PA and year. The variable *Dummy cartel winner* is equal to one when the auction is won by a member of a cartel. Odd numbered columns include year and PA dummies. Even numbered columns include year, PA, municipality, and work type dummies and reserve price. We use only auctions in the ABA sample (the investigation started before the reform), and the control group is composed of all PAs with a value of experience that is within 75% of that in the PA analyzed (either the municipality or the county of Turin).

* $p < 0.1$.

Table 8 Robustness Checks: PAs Outside Piedmont

Variables	<i>N. bidders</i>		<i>TJV wins</i>		<i>Perc. subct.</i>		<i>Perc. largest subct.</i>	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Municipality of Turin								
<i>FPA</i>	−70.37*** (8.623)	−63.02*** (6.298)	0.101** (0.0386)	0.102** (0.0410)	−10.17*** (1.847)	−8.707*** (1.916)	−8.978*** (1.584)	−5.638*** (1.575)
Obs.	1,314	1,314	1,306	1,306	1,314	1,314	767	767
R^2	0.309	0.447	0.064	0.127	0.091	0.137	0.186	0.286
Panel B: County of Turin								
<i>FPA</i>	−49.02*** (9.311)	−46.77*** (8.586)	0.153*** (0.0494)	0.163*** (0.0482)	−7.309*** (1.206)	−6.650*** (1.392)	−7.231*** (1.636)	−6.910*** (1.583)
Obs.	1,461	1,461	1,459	1,459	1,461	1,461	859	859
R^2	0.286	0.411	0.084	0.148	0.098	0.139	0.165	0.260

Notes. Baseline estimates including within the control group only auctions held by PA located outside the Piedmont region (the region where Turin is located). Odd numbered columns include year and PA dummies. Even numbered columns include year, PA, municipality, and work type dummies and reserve price. See Table 2 for additional details.

** $p < 0.05$; *** $p < 0.01$.

the analysis of FPAs is related to the increase of TJVs under this format. The change in the nature of the bidders showcased by the increase of TJVs suggests that a lower number of bidders might be associated with more competition: if two firms join their forces as a TJV, the number of bidders will decline, but it is highly plausible that the degree of competition will increase. This would be true if, for instance, those two firms were able to exploit relevant synergies.

The above point about TJVs also implies that the degree of bidder asymmetry is endogenous. In particular, it is determined by the broad set of rules governing entry, bidding, and subcontracting. Thus, to evaluate an auction format in terms of its revenues, allocative efficiency, and distributional effects across bidders, we must analyze the broader set of

institutions within which the auction format operates. A particularly striking example regards the hotly debated issue of SMEs. The recent literature on this topic has focused on the question of whether bid preferences (i.e., bid subsidies) or contract set-asides is the most effective system to ensure that SMEs are awarded contracts. These two systems are inspired by their usage in procurement in the United States. Our analysis describes an alternative to both methods.³⁰ Fostering the formation of TJVs is a viable alternative that provides a way for SMEs to compete on common ground with larger contractors. Although the issue of SMEs is widely considered a first-order concern

³⁰ Indeed, contrary to the U.S. system, Italian regulations do not contemplate auctions with bidding preferences (or quotas) for SMEs.

in procurement, there is no clear theoretical indication regarding which system might be better, bidding preferences (or quotas) or TJVs. More generally, it is surprising that, despite the vast literature on the boundaries of firms and on integration, so little of this literature has penetrated the auction literature.

A third set of considerations regards ABAs. Although most of our discussion has focused on the FPA, our analysis also helps to clarify the benefits associated with the ABA. Focusing exclusively on bidding, we note that the use of ABAs has been justified by Decarolis (2013) as a superior alternative to FPAs in the presence of a severe default risk due to adverse selection. A recent contribution by Chang et al. (2015) proposes a different rationalization based on laboratory experimental evidence. Chang et al. (2015) show that, given the behavioral biases characterizing bidders, this format performs well by allocating the contract to a firm that is likely to complete it and earn a “nonexcessive” profit.³¹ Nevertheless, neither rationalization is fully satisfactory: the former suggests that, despite the fact that ABAs outperform FPAs in terms of default risk, ABAs open the door to too many other problems in terms of high and unpredictable awarding prices, inefficient allocation, collusion, and lack of full elimination of the default risk; the latter is founded upon laboratory experimental results that may not apply in the field. In particular, although a behavioral bias might characterize environments with inexperienced bidders and complex contracts, the real-world environment of ABAs is characterized by frequently held auctions for relatively simple contracts.³²

However, once seen within the broader context of entry and subcontracting behavior, the interpretation of the ABA changes. There are circumstances under which ABAs are an effective method for procurement agencies to delegate to the market the choice of who will execute the contract. In the context of public procurement, where FPAs can pose

a severe trade-off between winning prices and ex post performance whenever the procurement agency is unable to properly select firms, ABAs augmented with subcontracting can limit the performance risk without causing severe inefficiencies.³³ This is a particularly realistic situation in public procurement where firms might be better informed than the public officials about the cost conditions and the reliability of the other firms in the market. Moreover, as argued by Moszoro and Spiller (2012), the presence of third-party opportunism induces public officials to select auction formats that minimize the risk that their political opponents could attack them for poor management choices. Given the high visibility of an incomplete or simply delayed public project, it is evident that public officials might be willing to outsource the choice of who is the best contractor to the market, even if this causes the payment of large rents to the winner of the auction.

7. Conclusions

Using a change in Italian public procurement regulations, this paper analyzes how FPAs affect the interplay between pre- and postauction stages, i.e., entry and subcontracting decisions. Our main findings indicate that FPAs substantially reduce subcontracting and entry and induce a shift in the type of bidders from individual firms toward TJVs created for the sole purpose of bidding and executing the contract. In particular, we find that the introduction of FPAs more than doubles the fraction of contracts won by TJVs. These results indicate the need to evaluate auction formats in light of their interactions with the other institutions governing the procurement process, in particular those regulating entry and subcontracting. We have shown that in the case of ABAs this can lead to the reevaluation of the role of this format. Furthermore, this paper identifies the need to better understand how auction formats interact with firm boundaries. A more in-depth theoretical analysis is needed to evaluate the performance of auctions when firms have the freedom to substitute between subcontracting ex post and forming partnerships ex ante.

³¹ Their experiment tests how bidders with pure common value behave in ABAs and FPAs. In FPAs the experimental subjects fail to correct for the winner’s curse and offer prices that are too low. In ABAs, surprisingly, they bid almost exactly as in FPAs. This behavioral bias is well described by a model where bidders ignore, or believe that others ignore, informational content of the most extreme cost signals and best respond to other bidders behaving in the same way. The implication is that under this type of behavior the winner’s curse is no longer a problem because the ABA selects as winner a bidder who has not systematically underestimated the cost of the project.

³² Furthermore, a pure common value environment like that assumed in Chang et al. (2015) is incompatible with the extensive usage of subcontracting that we observe in our data. Nevertheless, it is important to remark that the substantial difference between the two approaches is not in terms of how they model the valuation structure, but in terms of the equilibrium strategies considered.

³³ Although a complete welfare analysis is beyond the scope of this paper, we looked at the identities of winners and subcontractors in FPAs and ABAs for the subset of auctions for which we have this information. There are 106 winners in FPAs, 20% of which are subcontractors in ABAs. On the contrary only 2% of the 782 winners in ABA are subcontractors in FPAs. In 78% of the ABAs, either the winner or at least one subcontractor is also a winner or subcontractor in FPAs. Thus, since under either mechanism nearly the same set of firms ends up performing the job, the difference in allocative efficiency could be limited.

Supplemental Material

Supplemental material to this paper is available at <http://dx.doi.org/10.1287/mnsc.2014.2071>.

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