Analysis of mergers in first-price auctions*

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Abstract

In this paper, we analyse mergers in bidding markets. We utilize data from the Austrian construction sector where bidders may consider the strategic consequences of their backlog and price into their bids also the lost option value of winning today versus winning later. If we ignore this effect, estimated cost and thus estimated markups may yield a biased assessment of mergers. To quantify this potential bias, we build on the theoretical and empirical auction literature and estimate a static and a dynamic first-price auction model. We then compare the effects of mergers on bidding outcomes across models. Herewith, we aim to evaluate the (1) market power effect, (2) efficiency effect, and (3) effect of ignoring dynamic strategic considerations.

JEL Classifications: D44, L10, L13

Keywords: construction procurement, first-price auctions, private values, merger simulation, evaluation of mergers

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1 Introduction

Merger analysis — the study of the determinants and effects of mergers on the merging firms and on the markets they operate — has an impact on many areas of industrial organization research. It answers old questions and raises new questions of firm behavior. The most direct research agenda are questions of market power and efficiencies. Other fields of industrial organization and economics in general have derived fruitful environments from mergers and acquisitions for formulating models, deriving hypotheses and testing. Examples are financial economics, principal-agents models and the economics of research and development. Understanding of mergers, eventually, is the understanding of the competitive process, both for economic theory, empirical modelling and policy applications.

Some ground-breaking research on merger analysis has already connected theoretical models with strategies for empirical identification. As a result, merger simulations are now often standard to assess the effects of a merger.[1] Despite these major advances, there is no universal model for merger analysis. Industry characteristics remain important to decide on the appropriate model application — although, in practice, a model of Bertrand competition with differentiated goods is most often used. In addition, the intricacies of estimation lead to controversial debates of empirical results of merger simulation studies and the use of a treatment effects approach has been proposed.[2] The treatment approach has less ties to economic theory, compared to a structural simulation model, but does have advantages. Under some circumstances the treatment approach needs fewer modelling assumptions and results can be credible when the setting is suitable.

Empirical analysis of merger simulation involving bidding markets has so far received little attention. The advanced level of auction theory[3] and its empirical modelling, though, provide fertile ground for the application to merger analysis.[4] With our research we plan to address the following topics: First, we simulate mergers simulation in an auction model relying on the theoretical auction literature. Based on a model of first-price auctions, we estimate and identify the effects of a merger, i.e., market power and efficiency effects. We evaluate the mergers in

[1]Merger simulation as a tool for competition policy was introduced by Hausman et al. (1994) and Werden and Froeb (1994). For an introduction to merger simulation see Davis and Garcés (2009).

[2]See the discussion of treatment effects approach versus merger simulation in Nevo and Whinston (2010).

[3]The vast auction literature is summarized by Klemperer (2004).

[4]Among notable exceptions that combined auctions to merger analysis, in particular with respect to theoretical considerations, are Klemperer (2005) and Werden and Froeb (2005).

our data on construction procurement auctions with respect to the non-merger benchmark as implied by the merger simulation model. Second, we compare the static with the dynamic specification.

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We will model mergers within a theoretical first-price auction model. An empirical model is used for identification and recovery of the cost distribution. This paper departs from Gugler et al. (2014) where we analyze the effects of the recent economic crisis on firms' bidding behavior and markups in sealed bid auctions. Using data from Austrian construction procurement, we estimate bidders' construction costs within a private value auction model. We also implement a dyanamic auction model following Jofre-Bonet and Pesendorfer (2003). These models are our starting point to analyze mergers. We plan to extend this model in various directions taking into account endogenous entry (Athey et al., 2011, 2013; Krasnokutskaya and Seim, 2011) and

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unobserved auction specific heterogeneity (Krasnokutskaya, 2011).

The basic model for the simulation of mergers is the standard approach of analyzing first-price auctions (Athey and Haile, 2005; Guerre et al., 2000) and to derive marginal costs directly from observed bids. Based on the estimates of marginal costs, we can evaluate the effect of the merger and observe the outcome for cost efficiencies. The crucial maintained assumption of this method is — as in any merger simulation — that the theoretical model describes the agents' economic behavior well enough. Experimental evidence, especially when experienced bidders are participating in first-price auctions, shows that the equilibrium outcome is reached rapidly (Dyer et al., 1989). For practical reasons, one can impose a specific distribution on the bids, allowing to recover the distribution of bidders' costs using the first order condition for optimal bidding behavior. First order conditions are derived from standard profit maximization under the rules of first-price sealed bid auctions, i.e. that the lowest bidder wins the contract. The market model is strongly driven by the auction design rules and narrows the discretion of the researcher to some extent.

By obtaining structural estimates of marginal costs we can disentangle the efficiency effect from the market power effect due to the merger. Decreases in marginal costs from before to after the merger should be attributable to the efficiency effect, any increase in the markup should be attributable to the market power effect. Because we have two independent metrics for these effects we can disentangle them and need not rely on a measurement of the net effect.

Several interesting aspects can be addressed with our framework and data. We rely on several actual mergers completed between firms in our sample and do not only look at a single or a hypothetical merger. The data contain many bids of the companies both before and after the merger, which provides a lot of information for evaluation of the merger and evaluation of the simulation model. The merger evaluation looks at the market power and efficiency effect using the actual bids; the ex-post evaluation of the simulation model looks at ex-post bids compared to predicted bids that are solely based on ex-ante data (ex-post evaluation of the simulation model is what Nevo and Whinston (2010) call "retrospective merger study"). Some model evaluation studies have been made (see, among others, Peters (2006), Houde (2012), Weinberg and Hosken (2013)). The authors discussing strengths and deficiencies of structural and treatment approaches usually agree that more "retrospective study" is useful. None of the studies so far has considered bidding markets, despite their relevance and the rich theory that that has been developed.

Ex-post evaluation of the merger can also be possible with a treatment approach. We will take a similar approach to Hastings (2004), who identifies the treatment effect by comparing separate geographic markets. For the firms and projects in our data we also have geographic locations and distances. In addition, we will use entry information, which is given by the firms that participate as bidders, to identify geographically separate markets.

We do not attempt to set up an overall theory of why mergers occur and what their effects are but confine ourselves to the efficiency enhancing and anti-competitive effects.[7] We believe that this focus is warranted in our context.

2 Literature review

To analyze mergers, we follow the microeconomic literature and estimate bidders' cost distribution from submitted bids.[8] By imposing the structure of a game-theoretic model we are able to back out firm specific costs and run counterfactuals, in our case merger simulations. We have to assume, however, that bidders behave according to the theoretical model.[9] For the empirical implementation, our starting point is Athey et al. (2011) and a parametric version of Guerre et al. (2000) to recover the distribution of bidder costs from the observed bids. The distribution of bidders' costs uses the assumption that in equilibrium the estimates of the distribution function summarize bidders' beliefs and infererence of bidders' costs is based on the first-order conditions of optimal auctions. The estimated distribution of bids includes auction characteristics, firm characteristics as well as the level of competition to which firms are assumed to respond optimally.

Within the empirical auction literature, especially highway procurement auctions have been studied extensively. Jofre-Bonet and Pesendorfer (2003) show non-parametric identification in repeated auction games and using a parametric model for the estimations. They find evidence for capacity constraints in Californian highway procurement auctions. Krasnokutskaya (2011)

[7]For a survey on determinants of mergers, see Mueller (2012).

[8]For a survey on nonparametric identification and estimation of auction models see Athey and Haile (2005). For surveys of empirical studies of auctions see Hendricks and Paarsch (1995) or Laffont (1997).

[9]Bajari and Hortaçsu (2005) provide evidence from experimental data that assesses the reasonableness of structural estimates.

proposes a nonparametric estimation method to recover the distribution of bidders' private information when unobserved auction heterogeneity is present and finds that private information is estimated to account for 24 percent of the variation in bidders' costs in Michigan highway procurement auctions. Balat (2012) looks at road construction in California and investigates the effect of the American Recovery and Reinvestment Act on equilibrium prices paid by the U.S. government. He extends the models by Jofre-Bonet and Pesendorfer (2003) and Krasnokutskaya (2011) and allows for unobserved project heterogeneity and endogenous participation. His results show that prices rather than quantities increase as a consequence of the implemented stimulus. Further studies accounting for endogenous participation are Krasnokutskaya and Seim (2011), Athey et al. (2011), and Athey et al. (2013).

With the results for the cost estimates we run counterfactuals to mimic the situation after a merger. Here, we follow the large standard literature on merger simulation in models with Bertrand competition. Merger simulation as a tool for competition policy was introduced by Hausman et al. (1994) and Werden and Froeb (1994). Subsequent research has looked at a variety of issues, such as alternative demand models, e.g. Nevo (2000), Epstein and Rubinfeld (2001) or Ivaldi and Verboven (2005). Some of this work has explicitly compared different demand models and showed how different functional forms may result in rather different price predictions, see Froeb et al. (2003), Huang et al. (2008) and Slade (2009).

Ex-post merger analysis moved in parallel with merger simulation, and mainly aimed to evaluate the relevance or effectiveness of competition policy towards mergers. Early work focused on mergers in major industries, such as airline markets (Borenstein, 1990; Kim and Singal, 1993), banking (Focarelli and Panetta, 2003) and gasoline (Hastings, 2004; Hastings and Gilbert, 2005; Hosken et al., 2011). Ashenfelter and Hosken (2008) take advantage of scanner data to assess mergers in five different branded goods industries. They find moderate but significant price effects in the range of 3 to 7 percent. Using different methodological approaches, all these studies find some evidence for price increases after mergers in the industry. This points to a preponderance of market power effects over efficiency effects.

The discussion about the analysis of the effects of mergers takes a prominent role in the discussion of structural versus treatment approaches in Nevo and Whinston (2010). While Nevo and Whinston (2010) acknowledge that a quasi-experimental analysis of treatment effects of mergers can have advantages in certain circumstances, they also see the need for estimation based on simulation. The main challenge for direct causal analysis of mergers in the treatment approach is to use data to describe a counterfactual world in which the merger did not occur.[10] In particular, it is not obvious to find firms that are good comparisons yet at the same time not affected by the merger. Nevo and Whinston (2010) see the additional problems that mergers may be endogenous and — in an anti-trust context — that it is hard to find past similar mergers to guide anti-trust decision making on a given current merger. The difficulty for analysis based on simulations is the requirement to estimate several aspects of the market: first, a demand system has to be specified and appropriate instrumental variables have to be found; second, a model of market conduct (e.g. Bertrand-Nash price-based competition with product differentiation) has to be postulated. The substitution matrix that results from the estimated demand system together with the assumptions on market conduct identifies marginal costs from first order conditions; finally, industry outcome is simulated with and without the merger.

The question of why firms merge is a perennial one not only in economics but also in business administration and finance. In a recent survey, Mueller (2012) lists the following reasons of mergers: (1) mergers may be just another form of investment (Jovanovic and Rousseau, 2002); (2) mergers occur in the context of Coase's theory of the firm and are efficiency-enhancing solutions to market failures (Weston, 1970; Williamson, 1970), (3) mergers are attempts to eliminate competition and increase market power (Stigler, 1950). These three sets of theories can all be characterized as neoclassical in that they assume that managers are maximizing profits and thus that mergers increase profits. Further reasons for mergers are: (4) behavioral theories posit other goals for managers, like empire building (Mueller, 1969), or hypothesize that managers are gripped by irrational impulses out of hubris (Roll, 1986). These theories do not imply that mergers increase profits, but that they are likely to destroy shareholder wealth. (5) Hostile takeovers might be solutions to managerial failures. Poorly managed companies get taken over and their managers replaced (Manne, 1965; Marris, 1964).

[10] Nevo and Whinston (2010) in particular mention Hastings (2004) as being very careful in that respect.

3 Merger simulation in auctions

In the widely applied model of Bertrand competition with product differentiation the effect of a merger is measured by decreasing the number of competitors by one and assuming that the same products earlier offered by two firms are now produced by one firm. Product repositioning or entry of new firms is usually not considered. In a bidding market the reduction of one bidder may not completely capture the effect of merger. Firms may alternately participate in auctions or always participate in the same auctions. Depending on their past behavior the effect of the merger will differ — even if there is no repositioning or no entry. By estimating bidder specific cost we can also take efficiencies into account.

Our empirical setting focuses on procurement auctions, where demand comes from the government. We are aware of the possibility to model the government as an additional player to represent decision making on the demand side. For the basic model, we will neglect this and treat the government's demand decisions as unaffected by potential changes in price setting after the merger. We are also aware that we treat firms' decision to merge exogenously. This choice, however, might be influenced by past, current or anticipated future market conditions unobserved to the researcher (Nevo and Whinston, 2010). To model the choice of firms to merge explicitly, a dynamic model and enough observed mergers are warranted.

This section describes the theoretical model, the econometric model of the distribution of bidders' construction costs and the hypotheses for our empirical analysis.[11] We also describe our data and give summary statistics. To estimate the distribution of bidders' costs, we implement a static and dynamic first-price auction. In the latter model, we account for the strategic effect of capacity constraints following Jofre-Bonet and Pesendorfer (2003). In an extension, we also model endogenous entry following Athey et al. (2011). In Jofre-Bonet and Pesendorfer (2003), firms price into their bids also the lost option value of winning today versus winning later. The static model does not account for this additional effect: we attribute some of the lost option value to the (technical) cost of the project and therefore expect to underestimate markups. In Athey et al. (2011), firms incur entry costs to gather information before participating in the auctions. Ignoring these costs may yield biased estimates for the markups.

[11] In this preliminary version, we here heavily draw on Gugler et al. (2014).

3.1 Bidding behavior

We adopt a standard first-price sealed bid auction model to describe the bidding process.[12] We consider an auction for a single contract. The set of bidders is denoted with $\mathcal{N} = 1, ..., N$. Bidders are assumed to be risk-neutral and their identity to be known.[13] Bidder i learns her private cost for the project, c_i, and bids in the auction. Bidder i's cost, c_i, is an independent draw from a distribution F_i with continuous density f_i and support $[\underline{c}, \overline{c}] \subset R_+$. Bidders independently submit bids and all bids are collected simultaneously. The contract is sold to the bidder with the lowest bid, provided that her bid is not higher than the seller's secret reserve price r, and the winner receives her bid for the contract.[14] A bidding strategy $b_i = b_i(c_i; \mathcal{N})$ specifies i's bid as a function of her cost, the number of bidders and their identity.

Bidder i has cost c_i and maximizes her expected profits

$$\pi_i(c_i; \mathcal{N}) = max_{b \leq r}(b_i - c_i) \prod_{j \in \mathcal{N} \setminus i} (1 - G_j(b; \mathcal{N})), \tag{1}$$

where the lowest bidder wins the contract and makes a profit equal to $b_i - c_i$ and all other bidders make zero profits. For the estimations, it is helpful to follow Guerre et al. (2000) and write bidder i's expected profit as a function of G_j instead of F_j, where $G_j(b; \mathcal{N}) = F_j(b_j^{-1}(b; \mathcal{N}))$ is the probability that j will bid less than b and $b_j^{-1}(b; \mathcal{N}) = c_j$.[15] As is standard in the literature, we focus on Bayesian Nash equilibria in pure bidding strategies. The first order condition for i's bidding problem is then

$$\frac{1}{b_i - c_i} = \sum_{j \in \mathcal{N} \setminus i} \frac{g_j(b_i; \mathcal{N})}{(1 - G_j(b_i; \mathcal{N}))}, \tag{2}$$

[12] For an introduction to auction models in general and first-price sealed bid auction models in particular, see Krishna (2009).

[13] This is a commonly made assumption in the empirical auction literature. From personal conversations with firms we inferred that it is also suitable for our environment. Before submitting their bids, bidders in these auctions usually know who is potentially capable to complete the construction and is likely to bid.

[14] In Austrian procurement auctions, the seller has the right to withdraw the auction only when the winning bid is "contra bonos mores" (offending against good morals). In court, the seller would have to proof this by providing a cost estimate that is based on standard commercial and professional principles and be able to show that the winning bid is far higher than this estimate. We interpret this as a secret reserve price that is hardly ever binding. In principle, we could model a secret (random) reserve price and estimate the distribution of sellers' valuation as in Li and Perrigne (2003). In our sample, we however do not observe any rejected bids to obtain an estimate for that distribution.

[15] Note that – anticipating our empirical specification – the asymmetry across bidders in our paper comes from variation in observable firm characteristics such as distance to the construction site or number of employees.

which provides the basis for estimating bidders' cost distributions. There is no explicit solution to (2), but the first order conditions, together with the boundary conditions that $b_i(\overline{c};\mathcal{N}) = \overline{c}$ for all i uniquely characterize optimal bidding strategies. In equilibrium, the bidders use a markup strategy and bid their values minus a shading factor that depends on the equilibrium behavior of opponents (Maskin and Riley, 2000).[16,17]

3.2 Estimation of Bidders' Costs

To illustrate the econometric model and the structural estimation of the distribution of bidders' construction costs, we use sealed-bid data to estimate the parameters of the theoretical model as a function of auction and bidder characteristics making use of the approach developed by Guerre et al. (2000). They suggest to estimate the distribution of bids in a first step and to recover the distribution of bidders' costs in a second step by using the first order-condition for optimal bidding behavior. With the estimates of the distribution of bidders' costs at hand, we then calculate markups.

Let $\mathcal{X}$ denote the set of auction characteristics and $\mathcal{Z}$ denote the set of bidder characteristics. We assume that both sets of characteristics are known to the econometrician and the bidders. Such an assumption precludes the existence of characteristics unknown to the econometrician, but known to bidders. We believe that due to the detailed data set including backlog, distance and firm size, this assumption is plausible. We model $\mathcal{N}$, the set of bidder identities, with number of bidders N and cumulative characteristics of the other bidders that participate in the auction.[18] The list of variables denoting $\mathcal{X}$, $\mathcal{Z}$ and $\mathcal{N}$ is given in Table 1.

Bidders also know their private cost c_i. We denote the distribution of bidders' costs as $F_i(\cdot|\mathcal{X}, \mathcal{Z})$, and assume that bidders' costs are independent conditional on $(\mathcal{X}, \mathcal{Z})$. Given these assumptions, one can write the distribution of bids as $G_i(\cdot|\mathcal{X}, \mathcal{Z}, \mathcal{N})$.

Distribution of Bids. The first step of Guerre et al. (2000)'s approach to obtain an estimate for the distribution of bidders' cost is to estimate the distribution of bids. Their approach is

[16] The conditions for a unique equilibrium are provided in (Lebrun, 2006; Maskin and Riley, 2003).

[17] If there were only one bidder, which we do not observe in our data, the equilibrium strategy had to be adjusted.

[18] In the empirical analysis, our $\mathcal{N}$ also includes the count of active construction firms described earlier as a measure of potential bidders. Herewith, we account for differences between potential and participating bidders, although bidders' entry decisions are for simplicity not formalized in the theoretical model that describes our main specification.

Table 1: Variable descriptions

Variable	Description
Log(number of bidders)	Log of number of bidders in the auction.
Backlog	Backlog variable, standardized by firm mean and standard deviation.
Backlog sum	Sum of backlog of the other bidders in the auction.
New orders	Gross inflow of new contracts, countrywide, per month (mill. 2006 euros).
Engineer estimate	Engineer cost estimate for the construction project.
Log(employees)	Log of the number of employees of a bidder.
KM	Travel distance in kilometers from a bidder's location to the project site.
KM average	Average of all other, competing bidders' distances between their location and the project site.
KM sum	Sum of all other, competing bidders' distances between their location and the project site.
Same postal	Bidder location has the same postal code as project site.
Same district	Bidder resides in the district of the project site.
Same state	Bidder resides in the state of the project site.
Heavy construction	Dummy for auctions in heavy construction sector.
General contractor	Dummy for bidders serving as "general contractors".
Open format	Dummy for auctions following the "open procedure".
No. of potent. bidders	Number of potential bidders.

very general and allows the non-parametric identification and estimation of the distribution of bidders' cost. Here, we adopt a parametric approach. Conditional on the observable auction and firm characteristics $(\mathcal{X}, \mathcal{Z})$, and the set of bidders identities $\mathcal{N}$, the joint distribution of bids in a given auction is the distribution $G_i(\cdot|\mathcal{X}, \mathcal{Z}, \mathcal{N})$. We specify the Weibull distribution as the distribution of bids:

$$G_i(b_i|\mathcal{X}, \mathcal{Z}, \mathcal{N}) = 1 - \exp\left\{ - \left(\frac{b_i}{\lambda_i(\mathcal{X}, \mathcal{Z}, \mathcal{N})} \right)^{\rho_i(\mathcal{X}, \mathcal{Z}, \mathcal{N})} \right\}, \tag{3}$$

where $\lambda_i(\mathcal{X}, \mathcal{Z}, \mathcal{N})$ is the scale and $\rho_i(\mathcal{X}, \mathcal{Z}, \mathcal{N})$ is the shape of the Weibull distribution. We parameterize the scale as $\lambda_i(\mathcal{X}, \mathcal{Z}, \mathcal{N}) = \lambda_0 + \lambda_{\mathcal{X}}\mathcal{X} + \lambda_{\mathcal{Z}}\mathcal{Z} + \lambda_{\mathcal{N}}\mathcal{N}$ and the shape as $\rho_i(\mathcal{X}, \mathcal{Z}, \mathcal{N}) = \rho_0 + \rho_{\mathcal{X}}\mathcal{X} + \rho_{\mathcal{Z}}\mathcal{Z} + \rho_{\mathcal{N}}\mathcal{N}$. We estimate the parameters of the model, (λ, ρ), by maximum likelihood estimation.

Distribution of Costs. Assuming bidders behave as predicted by the model, the distribution $F_i(\cdot|\mathcal{X}, \mathcal{Z})$ is identified from the distribution of observed bids. The advantage of this approach is that no differential equation has to be solved and no numerical integration has to be applied.

The estimation of bidders' costs is directly derived from identification and can be expressed as follows:

$$\hat{c}_i = \phi_i(b_i; \mathcal{X}, \mathcal{Z}, \mathcal{N}) = b_i - \frac{1}{\sum_{j \in \mathcal{N} \setminus i} \frac{\hat{g}_j(b_i|\mathcal{X},\mathcal{Z},\mathcal{N})}{1-\hat{G}_j(b_i|\mathcal{X},\mathcal{Z},\mathcal{N})}}, \tag{4}$$

where $\hat{G}_j$ and $\hat{g}_j$ are estimates of the distribution and the density of bidder j's costs. Bidder i's estimated cost are a function of her equilibrium bid and the joint distribution of her rivals' equilibrium bids. If we observe all bids and bidder identities, then the asymmetric independent private values model is identified (Campo et al., 2003; Laffont and Vuong, 1996; Li and Zhang, 2013) and it is then straightforward to construct an estimate of ϕ_i given the estimates of G_i and g_i, i.e. $\hat{G}_i$ and $\hat{g}_i$.[19,20,21] With the pseudo sample of bidders' costs, $\hat{c}_i$, we are able to calculate the distribution of bidders' costs as

$$\hat{F}_i(\hat{c}|\mathcal{X}, \mathcal{Z}) = \hat{G}_i(\phi_i^{-1}(\hat{c}_i; \mathcal{X}, \mathcal{Z}, \mathcal{N})|\mathcal{X}, \mathcal{Z}, \mathcal{N}). \tag{5}$$

Finally, we assume a unique equilibrium or that the selected equilibrium is the same across observations. If this is not case, we would not match the distribution characterizing a bidder's beliefs in a given auction, as the observed distribution of opponent bids would be a mixture of those in each equilibrium.

3.3 Dynamic model

Our main specification does not consider that firms may price into their bids also the lost option value of winning today versus winning later. Thus, we may underestimate markups in both periods and only obtain a lower bound for the estimated drop in markups in the crisis. We illustrate the econometric model of bidders' dynamic decision based on the estimated distribution of their

[19] Actually, Li and Zhang (2013) show identification in the affiliated value model with endogenous entry. For a general discussion on identification in first-price auctions, see Athey and Haile (2005).

[20] Note that in our case G_i also depends on firm characteristics, $\mathcal{Z}$. Thus, we have to calculate G_j for all bidders j in equation (4). This is different to other applications such as Athey et al. (2011) and Krasnokutskaya (2011). In these applications there are at most two groups of bidders and G_j is equal among these groups.

[21] As the reserve price in Austrian procurement auctions is secret, we do not need to account for it in the estimations. Note that we observe all bids, thus there is also no selection in the data.

construction cost following Jofre-Bonet and Pesendorfer (2003).[22] They estimate a dynamic game in which bidders play sequential equilibria and use symmetric Markovian strategies, i.e., given the state variables bidders are symmetric and follow the same bidding strategy once they are in the same state.

Let $\mathcal{Q} = (\mathcal{X}, \mathcal{Z}', \mathcal{N})$ with $\mathcal{Z}' = \mathcal{Z} \setminus (s_i, s_{-i})$, where s_i is the backlog of bidder i and s_{-i} the backlog of all other firms.[23] We define the hazard function of bids submitted by bidder i as

$$\hat{h}(.|\mathcal{Q}, s_i, s_{-i}) = \frac{\hat{g}(.|\mathcal{Q}, s_i, s_{-i})}{1 - \hat{G}(.|\mathcal{Q}, s_i, s_{-i})}, \tag{6}$$

where $\hat{G}$ and $\hat{g}$ are the estimated distribution function and the estimated density function of our main specification. Using (6), the first order condition of optimal bids yields the following equations for privately known cost:

$$\hat{c}_i = \phi(b|\mathcal{Q}, s_i, s_{-i}, h, V) = b - \frac{1}{\sum_{j \in \mathcal{N} \setminus i} \hat{h}(b|\mathcal{Q}, s_j, s_{-j})}$$
$$-\beta \sum_{j \in \mathcal{N} \setminus i} \frac{\hat{h}(b|\mathcal{Q}, s_j, s_{-j})}{\sum_{l \in \mathcal{N} \setminus i} \hat{h}(b|\mathcal{Q}, s_l, s_{-l})} [V_i(\omega(\mathcal{Q}, s, i)) - V_i(\omega(\mathcal{Q}, s, j))], \tag{7}$$

where V is the value function and ω the transition function. Equation (7) provides an explicit expression of the privately known cost that involves the bid, the hazard function of bids and the value function. Once we know the value function and the transition function, we are able to back out cost from bids.

The transition function ω describes how the backlog evolves over time and is exactly defined as in Jofre-Bonet and Pesendorfer (2003). The key idea to obtain an estimate for the value function V is to draw a random sample of states and numerically solve the explicit expression for the value function derived in Jofre-Bonet and Pesendorfer (2003) for every bidder on this grid and approximate it by a polynomial outside the grid. We draw 200 contracts randomly. For the quadratic polynomial, we run a robust regression including firm fixed effects. Our simulation sample includes 398 bidders. As a robustness check, we also run the static specification with this (reduced) sample and obtain markups that are very close to the original ones.

[22] For an implementation of a dynamic first-price auction model with endogenous entry and unobserved heterogeneity, see Balat (2012).

[23] Note, in the econometric specification of the static model, the backlog is an element of $\mathcal{Q}$.

3.4 Additional aspects

Two extensions we intend to include in our model, are: First, unobserved heterogeneity; second, endogenous entry. When we modelled bidders' costs, we have assumed that the set of auction characteristics is known to the econometrician and to the bidders. Such an assumption precludes the existence of characteristics unknown to the econometrician, but known to bidders. To relax this assumption, we follow Krasnokutskaya (2011) and allow for unobserved heterogeneity. Assuming a multiplicative structure for the common shock and idiosyncratic private information, she derives sufficient conditions under which such a model is identified. She also proposes a nonparametric estimation procedure which results in uniformly consistent estimators of the distributions of the common shock and bidders' idiosyncratic costs. We thus plan to estimate a model that accounts for auctions specific unobserved heterogeneity in a parametric specification.

Endogenous entry will be modelled similarly to Athey et al. (2011). For the empirical entry model we follow Gugler et al. (2014) and plan to estimate a logit model for different time periods. Each of the firms in our sample can be considered a potential bidder in the estimation of entry probabilities for each auction. To evaluate the entry model, we simulate combinations of bidders for each auction, where each bidder enters with the probability predicted in the entry model.

3.5 Expected effects of a merger

After a merger, the incentive to shade bids above one's cost increases. A bid is equal to the expected cost of the competitors conditional on the competitors' costs being less than the bid. If there is less competition in the sense that there are fewer actual bidders in an auction, the markup goes up, because the expected conditional cost of competitors decreases after the absorption of one of the competitors. This implies that bidders' expected rents go up in equilibrium and gives the first hypothesis:

Hypothesis 1: The Lerner index of merging firms goes up post merger, i.e. there is a market power effect due to the merger.

Costs of the combined entity can decrease after the merger. This efficiency effect drives the bids down after the merger. In general, both effects can be present at the same merger, thus our our second hypotheses is:

Hypothesis 2: The marginal costs of merging firms go down post merger, i.e. there is an efficiency effect due to the merger.

The net externality on the market depends on the relative strength of these two effects, but standard oligopoly models suggest a positive net effect: under quantity competition or price competition with differentiated goods, the merged entity finds it — absent substantial efficiency gains — optimal to reduce its production (Deneckere and Davidson, 1985; Farrell and Shapiro, 1990). In reaction, the competitors expand their output, but by a lesser amount than the insiders decrease their output. In the new equilibrium the competing firms sell a higher quantity at a higher price, which clearly is profitable. Farrell and Shapiro (1990) consider the possibility that the merged entity experiences efficiency gains through economies of scale or learning. Using simple Cournot examples, they show that these efficiency gains would have to be relatively large to make the merger unprofitable for outsiders. In Bertrand oligopolies with differentiated products (Deneckere and Davidson, 1985) mergers are profitable for both insiders and outsiders, but again the free-riding outsiders benefit more than the merging firms. Thus from both kinds of standard IO oligopoly models (quantity competition and price competition with differentiated products), we would infer a positive externality on the profits of the rivals in the relevant market concerned by the merger, as long as no substantial efficiency gains are achieved.

Prices rise (here: bids) when the market power effect outweighs the efficiency effect. Ex-ante, we do not know which effect dominates, and this is what is tested via hypotheses one and two.[24]

4 Data

For the empirical analysis, we combine several sources of data to complement the main data on procurement auctions in the construction sector.[25] An Austrian industrial construction company provided data containing bids, competitors and auction characteristics. These data

[24]The main underlying assumption for hypothesis one is that a decrease in the number of bidders yields higher procurement prices and higher bidder revenues. This is a standard competition argument, but need not always be true. In a model with common values, informational asymmetries such as the "winners' curse" may offset the above argument. For example, Somaini (2011) and Hong and Shum (2002) provide evidence of interdependent valuations in the construction industry. However, even in an independent private values model as we apply here, bidder asymmetries or costly bidding may also lead to the effect that more bidders could lead to reduced price competition. Cantillon (2008) show that the composition of strong versus weak bidders is the relevant factor. Li and Zheng (2009) show that it is possible that as the number of competitors increases bidding may become less aggressive.

[25]The construction sector accounts for 7 percent of GDP on average between 2006 and 2009 (in Germany this share is 4.2 percent, in the USA 4.4 percent; OECD STAN data set).

cover all auctions in both building and heavy construction during the period 2006 to 2009, where this company took part either as the parent company itself or through a subsidiary. According to the company, the database covers more than 80 percent of all auctions which must be conducted according to the Austrian Public Procurement Law.[26] Thus our sample covers nearly the population of all public procurement auctions in Austria during the four years 2006 to 2009. Within this period, these data reflect on average 14 percent of Austria's total construction sector. Additional data is obtained from matching the bidding firms to Bureau van Dycks Amadeus database, which contains nearly the population of companies in Austria. Matches are possible by company names and postal codes. Almost all bids were made by firms that are well known in Austria and matching is not a major concern. The population of Austrian construction firms, as reported by the Austrian Central Bureau of Statistics, consists of 4,796 firms on average for 2006 to 2009 (building: 3,958, heavy: 838). Therefore, about one third of all construction firms submitted bids in the procurement auctions.

For our sample of firms we have bidder characteristics such as number of employees, sales and assets. In addition, we measure transportation costs by the distance of a firm to a construction site. Based on the construction sites' and bidders' postal codes, we used Microsoft's Bing Maps to calculate the driving distances for all bidders to the project sites corresponding to the auctions.[27] Backlog used by a firm at a point in time is calculated as in Jofre-Bonet and Pesendorfer (2003). Every project is added to the backlog when a firm wins it. Projects are linearly worked off over their construction period, which releases capacity. Every firm's backlog obtained is standardized by subtracting its mean and dividing by its standard deviation.

Auction characteristics are the technical estimate, the subsector (building, heavy construction) and variables describing the auction procedure. We further know the actually participating bidders and cumulative characteristics of other participating firms such as the sum of distances or the sum of backlogs. We also derive measures for potential bidders, applying restrictions like counting only firms that submit a bid for any heavy construction auction in the sample as potential bidders for any other heavy construction auction, and constraints relating auction size

[26] Austria's public authorities (federal and regional government, social security institutions, and the like) are subject to the Federal Public Procurement Law ("Bundesvergabegesetz"). In principle, there are no lower limits for the applicability of the Public Procurement Law. Upper limits are in effect, but only to enforce EU-wide announcement rules for larger projects (in construction, currently 4.845 million euros).

[27] If a firm has multiple plants we still can only calculate the distance between the headquarter and the construction site as we do not have any information on plants. Only for larger firms we know their subsidiaries and can calculate the distances accordingly.

and distance to historical bidding behavior of each firm.

Over the sample period, our data contain ten transactions where both the acquirer and the target have records as bidders in the procurement auctions. To identify the transactions, we have used three sources: Thomson Reuters' SDC Platinum Database, the case list of the DG Competition (ec.europa.eu/competition) and the case list of the Austrian Competition Authority (www.bwb.gv.at). The acquirers are major players in the construction sector. They submit about a third of the 30,000 bids in our sample. The targets submit 250 bids. Six of the ten transactions are full acquisitions, three acquisitions of majority interest and one is an acquisition of partial interest. We will further enrich the sample of mergers by complementary search in Austrian trade and economics periodicals to also identify smaller transactions that might be overlooked by our main sources.

On average 7.5 firms take part in Austrian procurement auctions in the construction sector. The population of Austrian construction firms, as reported by the Austrian Central Bureau of Statistics, consists of 4,796 firms on average for 2006 to 2009 (building: 3,958, heavy: 838). This suggests a highly competitive market environment. But there are a few large construction companies, too,[28] and there is differentiation both in the product and the spatial dimension. Our sample contains bids from 1,655 different companies — so one third of all construction firms submitted bids in the procurement auctions. The firms in our sample, with a few exceptions, are mostly medium sized companies with around 50 employees. The mergers we observe in the sample period — the data contain ten mergers where both acquirer and target submit bids — similarly involve small to medium sized firms. In such an environment behavioral hypotheses on mergers do not appear to be the main driving forces, as e.g. empire building or hubris, nor are there hostile takeovers in our sample. Thus, we are left with the neoclassical hypotheses, of which the efficiency versus market power motives play the central role. Firms are likely to merge in the Austrian construction sector because they expect to increase their efficiency via economies of scale and scope and/or because they expect to be able to reduce competition.

[28]The largest four firms have approximately 40 percent market share within our sample of procurement auctions.

5 Estimation results and counterfactual analysis

6 Conclusions

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