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Abstract

Public agencies mainly rely on two modes to procure goods and services: auctions and direct negotiations. We study a 1994 policy change in Germany that introduced the possibility to procure rail services in auctions as well as in direct negotiations with the incumbent. We analyze the effect of the procurement mode on service frequency and procurement price. Our analysis relies on self-collected data on the frequency of rail service on about 500 rail lines. We first develop a theoretical framework to study an agency's decision on the procurement mode. We then use this framework to guide our empirical analysis on rail service, procurement price, and choice of procurement mode. Results indicate that, compared with negotiations, auctions improve service levels and reduce prices. As a result, surplus on auctioned lines increased by about 30%. Interestingly, surplus would also have increased by 16% on negotiated lines had auctions been used. We argue that the predominance of non-competitive modes reflects (actual or perceived) administrative costs of carrying out auctions.

Keywords: Auctions, negotiations, liberalization, passenger railways, public procurement

JEL Classification: D43,D44,R48

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1 Introduction

The nature of public procurement has changed dramatically over the last decades. Until the nineteen eighties, the state not only played a substantial role in the financing, but also in the provision of many goods. Most importantly, network industries such as electricity, gas, water, railways and postal services were run as state monopolies in many countries. The wave of privatization and deregulation in the nineteen eighties led to institutional change all over the world. The retreat of the state and the introduction of competition were supposed to foster efficiency and help to reduce taxes. Yet, early enthusiasm for privatization and liberalization has given way to a more critical assessment of policies introducing competition in the public domain. Reasonable arguments can be made for privatization and competition, but the efficiency-enhancing effects of these measures cannot be taken for granted.

We focus on the effects of competition in public procurement. Understanding these effects is important: First, public procurement corresponds to a huge part of economic activities, amounting to approximately 13% of GDP on average in OECD countries (OECD 2013, p.18). Second, auctions and negotiations are the main forms of public procurement of goods and services. Yet it is not clear which of the two modes is superior. There are at least two theoretical reasons why procurement auctions might lead to lower procurement prices than direct negotiations with an incumbent supplier. First, competition puts pressure on firms to submit lower bids. Second, procurement auctions tend to select the most efficient supplier.[1] However, competitive procurement is not without problems. Bidder collusion may reduce the pressure on firms to submit aggressive bids, so that competitive procurement need not always reduce prices. Moreover, it is even possible that competition leads to higher prices: In common-value environments, increased fear of the winner's curse may induce less aggressive bidding in procurement auctions, potentially leading to higher procurement prices than direct negotiations. A priori, it is thus not evident whether procurement auctions are preferable to negotiations. Moreover, as we will argue in more detail below, the empirical evidence on the relative advantage of the two means of public procurement is mixed.

This paper compares procurement auctions and direct negotiations between agency and incumbent. We analyze the effects of competition on the procurement of passenger railway services by public agencies in Germany. Many European countries gradually liberalized the sector since the nineteen nineties. As a result, negotiations and competitive procurement now coexist, sometimes even within countries. Germany is a case in point. In January 1996, the German *Regionalisierungsgesetz* came into effect. This law stipulates that state agencies are responsible for the assignment of public funds to individual lines; and that they can procure the services using direct negotiations with the dominant supplier *DB Regio* or via auctions.[2] This setting provides the unique opportunity to compare the performance of competitively procured lines and lines on which the service levels and prices resulted from negotiations.

[1] Also, it has sometimes been argued that an obligation to use competitive procurement can help to fight corruption (e.g., Chong et al. 2014).

[2] The law also specifies that a substantial part of regional passenger transport expenses is financed by the federal government.

Two specific aspects of the German railway system in the period under consideration cast additional doubts on the functioning of competition. First, because of the special role of *DB Regio* it is not clear a priori that competition lowers procurement prices. While competitive procurement usually concerns individual lines or small networks, the direct negotiations with *DB Regio* are about a large chunk of the services in the state under consideration (usually more than 50% in the period under observation). It is therefore conceivable that prices could be lower with direct negotiations because of scale economies. Second, one of the potential bidders (*DB Regio*) has close links to the main input supplier, *DB Netz*, the dominant network operator who is also a subsidiary of *Deutsche Bahn AG.*. All firms who use the network have to pay access prices to the infrastructure supplier. In the period under consideration, *DB Netz* was free to design the access price system, subject only to the control of the Federal Cartel Office. It is conceivable that it could have used this system to weaken competitors, thus allowing *DB Regio* to maintain its dominant position without bidding too aggressively in procurement auctions.

Our empirical approach includes two parts. First, we separately estimate the determinants of prices and quantities for negotiated and auctioned lines. We model quantities by simple regression models. The same is true for prices on negotiated lines, whereas we implement a structural model for prices on auctioned lines. Our econometric auction model follows the approach developed by Guerre et al. (2000) who suggest to estimate the bid distribution 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. Second, we predict prices and quantities for negotiated and auctioned lines in sample and out of sample. Herewith, we obtain predicted and counterfactual outcomes for all lines. With the obtained predictions, we are able to compare the surplus under negotiations and auctions controlling for line characteristics. We are also able to calculate marginal cost and markups using the structural auction model. Knowing the marginal cost of incumbents and bidders, we can then identify the respective contributions of competitive pressure and selection of more efficient suppliers to price reductions.

Our focus is on how competition affects the frequency of service provided on regional passenger lines and the transfers paid by the agencies for the provision of the railway services. The fact that regional train services were procured both via direct negotiations and competitive auctions provides for an empirical design that allows studying the relative performance of these two procurement modes. However, the choice of procurement mode is not random. We address endogeneity of procurement mode in two ways. On the theoretical level, we construct an explicit structural model of procurement choice and outcomes. On the empirical level, we collect a rich data set that contains information on the frequency of service on the line before and after the introduction of the reform to characterize choice of procurement mode. Our data show that regional passenger service agencies used auctions predominantly on remote lines that were not very frequently served before the reform. Yet once we condition on observed characteristics, we find no difference in the pre-reform frequency of service between lines to be auctioned and lines that were negotiated with the incumbent. Thus, the railway reform in Germany created a quasi-experimental design that allows assessing the relative importance of auctions and negotiations.

In addition, the empirical analysis uncovers several main findings. First, the frequency of service on lines that were procured by auctions is 12% higher than the frequency of service on lines where the agency negotiates directly with the incumbent supplier. This remains true even if one controls for the endogeneity of procurement.

Moreover, when we allow for selection of lines based on unobserved cost or surplus components, we find such selection not to be empirically important. Results show that the procurement price is 20 percent lower on auctioned lines than on those procured in direct negotiations. This suggests that auctions indeed improve the efficiency of procurement of regional passenger railway lines. Auctions reduce the prices that the agencies have to pay for any given service level on a particular line. Since agencies have a fixed overall budget, they ask for higher service levels on the comparatively cheap lines that are procured using auctions.

Second, structural auction estimation allows us to back out costs and mark-ups. Our results show that there is a selection effect – more efficient bidders win the procurement – and there is a competitive pressure effect – more firms participate in the procurement. Costs fall by around 20% due to selection of efficient bidders. Markups decrease from about 9% in negotiations to about 5% in auctions on negotiated lines, a reduction of about 50%. Both effects contribute to improving the efficiency of regional passenger rail service.

Third, we find substantial increases in agency surplus on auctioned lines. Surplus increases by about 30% as a result of the auction on lines that agencies procured via auctions. Our counterfactual estimates also provide us with an estimate of the effect of competitive procurement for lines that were procured in direct negotiations. Interestingly, auctions would also have increased the surplus on negotiated lines by 16%, which is lower than for auctioned lines, but still sizeable.

Fourth, based on our theoretical model, we obtain estimates of two parameters that can potentially rationalize why some lines are procured competitively and some are not, namely the administrative costs of procuring the auction and the bargaining power of the incumbent. Our preferred estimates indicate that the regional agency has all bargaining power, but is constrained by administrative costs amounting to 45% of the total surplus on the line. These costs can explain why agencies often use negotiations rather than auctions.

The remainder of the paper is organized as follows. Section 2 provides a review of related literature, and Section 3 discusses the institutional background. In Section 4, we develop a simple theoretical framework to describe procurement choice; we then provide an empirical specification in Section 5. Section 6 describes the data set. In Section 7, we present our results. Section 8 concludes.

2 Related Literature

Our paper not only contributes to the discussion on the relative efficiency of auctions and negotiations in public procurement. In addition, it provides insights on the success of reforms in the railway sector, an important example of a network industry. We thus provide a short summary of the literature on both issues.

Auctions vs. Negotiations: The literature has focused on the advantages and disadvantages of auction mechanisms, and it has identified circumstances under which procurement auctions are preferable to negotiations. Bulow and Klemperer (1996) give general conditions under which adding a competitor to an optimal sales mechanism with n buyers improves the outcome for the seller, and, in particular, auctions ($n > 1$) are preferable to negotiations ($n = 1$). Applied to a procurement context, the result identifies the circumstances under which, from the perspective of the agency, competitive procurement is favorable to negotiations with a single supplier, no matter how cleverly these negotiations are designed.

With common or affiliated values, it is well-known that, because of fear of the winner's curse, rational bidders will bid less aggressively when the number of bidders increases. As a result, bids are not necessarily decreasing in the number of firms, and not even necessarily lower with competitive bidding than with direct negotiations.[3] Empirical evidence supports this idea. For instance, using data from highway procurement in New Jersey, Hong and Shum (2002) argue that procurement costs are lowest with three bidders, so that unlimited competition is not necessarily advantageous for the agency.

Collusion is another reason why potential price advantages from competitive procurement do not materialize.[4] While collusion between bidders does not necessarily prevent the efficient allocation of the task, it reduces competitive pressure. Moreover, Manelli and Vincent (1995) have highlighted the potential disadvantages of auctions when the buyer has preferences for both high quality and low procurement costs; such disadvantages are also a common concern of procurement agencies. Finally, extending the work of Goldberg (1977), Bajari and Tadelis (2001) have emphasized that the necessity of ex-post adaptations of a project may limit the usefulness of competitive procurement mechanisms; see Bajari et al. (2009) for a related empirical analysis.

Some authors have taken a positive rather than a normative approach, trying to identify the circumstances under which auctions are more likely to be chosen. For instance, Bajari et al. (2009) show that buyers tend to use negotiations when the number of potential bidders is low, when projects are complex and when sellers are reputable and experienced. Chong et al. (2010) identify a similar role of complexity with Frech procurement data.

The observation that procurement decisions depend on project characteristics suggests that a comparison of auctions and negotiations needs to take the potential endogeneity of the decision into account. We take this issue seriously and provide a simple model of procurement choice and resulting quantity outcomes. We are not aware of any papers that do so for the comparison between procurement auctions and negotiations. However, Gagnepain and Ivaldi (2010) have considered the related decision between cost-plus and fixed price contracts, using data from the French public transportation sector.[5] Like us, they consider situations where the decision may reflect lobbying of the firms.

Railway Reforms: The paper also contributes to a literature on the evaluation of the railway reforms introduced in Europe in the nineteen nineties. Several papers deal with the efficiency effects of various reforms in an international context on an aggregate level (Cantos et al. 1999, Friebel et al. 2010), emphasizing the role of cross-country institutional differences. Friebel et al. identify positive efficiency effects of deregulation. Other authors resort to before-and-after comparisons in individual countries. For instance, Cowie (2002) and Pollitt and Smith (2001) analyze the outcomes of the U.K. reform, coming to more positive conclusions than the political debate in the U.K. would suggest.

Contrary to these contributions, our paper allows the comparison of different institutions within one country, without relying on a before-and-after comparison. Also, it focuses on a specific aspect of the reform (competitive

[3]See, for instance, the examples of Wilson (1992) for the first-price sealed-bid sales auctions, and the analysis of Bulow and Klemperer (2002) for ascending bid auctions.

[4]See Mc Afee and Mac Millan (1992) for a theoretical analysis of bidding rings in auctions.

[5]In a related paper on this industry, Gagnepain et al. (2013) analyze a model where the type of the contract (cost-plus or fixed-price) can be renegotiated. They find substantial welfare costs of renegotiation.

procurement) which has been important in several other countries as well.[6] It shares this feature with Lalive and Schmutzler (2008). Using a difference-in-difference approach, we established a positive relation between competition and the frequency of service for a small subsample of the one we use in this paper. We considered only Baden-Württemberg, one of the 16 German states. Moreover, the present paper differs substantially from its precursor in at least three important dimensions. First, thanks to our structural model of the procurement mode decision, we can discuss the problem of endogeneity of procurement choice. Second, because we now have procurement price data, we can identify that the previously found positive relation between competition and frequency of service reflects a negative relation between competition and procurement prices. Third, with our structural model, we can now obtain estimates of the effects of competition on cost and mark-ups, on administrative costs, incumbent power and net surplus.[7]

3 Regional Passenger Railways in Germany

In most European countries, integrated state monopolies controlled the railways until the early nineteen nineties.[8] In West Germany, *Deutsche Bundesbahn* owned most of the infrastructure and was the dominant operator for passenger and freight services. In addition, there were several minor railroad companies (*NE-Bahnen*) that were typically also vertically integrated and carried out freight and/or passenger transportation on small networks. In East Germany, *Deutsche Reichsbahn* was the integrated operator of the railway system.

In response to the EU-directive 91/440, a major railway reform became effective in Germany on January 1, 1994. *Deutsche Bahn AG* became the successor of *Deutsche Bundesbahn* and *Deutsche Reichsbahn.* In addition, the reform had several elements that are important in the context of our analysis.

3.1 Financing

Before the reform, the railway system created large deficits. Local passenger transportation clearly was responsible for a large part of this deficit, but as the central government took over the total deficit ex post, it was impossible to attribute the costs to specific lines. The reform changed the approach to financing passenger services radically. Whereas long-distance transportation is expected to be profitable, it is still taken for granted that the revenues from passenger service do not suffice to cover costs on the local passenger lines. Our analysis will deal exclusively with these non-profitable local passenger railway services. Procurement of these services now relies on contracts specifying the expected service level and the payments from the state to the railway companies ex ante. Starting in 1996, the federal state distributed a total of about 5-7 billion Euros per year to the 16 states, mainly to finance the services. The responsibility for the use of these funds (the so-called *Regionalisierungsmittel*) lies with the states.

[6] The most prominent examples are the United Kingdom and Sweden, but several other European countries have followed suit.

[7] Beyond the railway sector, there is a substantial amount of (descriptive) evidence on competitive tendering in the bus industry, as surveyed by Hensher and Wallis (2005). The results are mixed, with reports of substantial efficiency gains in the early phase of the deregulation in London (White 2000), but essentially no effects in Italy (Boitani and Cambini 2006).

[8] This purely descriptive section has considerable overlap with Lalive and Schmutzler (2008); see this reference for additional details.

3.2 Vertical Industry Structure

As a prerequisite for the introduction of competition, Deutsche Bahn AG was divided into two upstream subsidiaries (DB Netz for the network and DB Station & Service for the stations) and three downstream subsidiaries (DB Regio for regional passenger transportation, DB Reise und Touristik for long-distance passenger services and DB Cargo for freight). Thus, a move into the direction of vertical separation took place. Railway companies (including *DB Regio*) that want to use the network of *DB Netz* pay access charges determined by DB Netz. These access charges, which vary across lines, are an important cost component for the railway operators, which also influence the prices that agencies pay. In our analysis, we will therefore use them to construct procurement prices on negotiated lines.

3.3 Auctions vs. Negotiations

The 16 states have created agencies organizing the procurement process. These agencies receive a fixed budget for the procurement of railway services, but they have considerable freedom in the way that they procure services. The crucial distinction for our analysis is between auctions and negotiated lines.

Throughout the period under consideration, direct negotiation with the incumbent supplier remained the dominant mode of procurement. Long-term contracts between the agencies and DB Regio usually covered at least half of the regional passenger services. These contracts specified the expected service level over a period of 10-15 years and the payments to DB Regio. Also, the contracts typically contained clauses regulating the speed with which competitive procurement was to be introduced.

Competitive procurement usually involved a bidding procedure in which firms asked for transfer payments to carry out railway services. The successful bidder received his required transfer and obtained the franchise for a period of about 10 years. In the simplest case, the agency specified the frequency of service and detailed requirements about the expected service quality. The specifications included the rolling stock, the prices charged to customers, etc.[9] The contracts were awarded in a first-price sealed-bid auction, where the bids corresponded to the procurement prices.[10] In other cases, the agencies used multi-dimensional auctions where the bidders obtained scores for high quality as well as for low prices.[11]

The extent to which competitive procurement was used varied considerably across agencies, and so did the details of the procedure. In the period under consideration, agencies were essentially free to determine the procurement mode for any of the lines they served.[12] However, it became a common practice that the agency and the incumbent negotiated on which lines should be opened to competition during the lifetime of the

[9]Regional public transport organisations (Verkehrsverbünde) decide on timetables, prices etc. on a large part of the network. This limits the freedom of railway operators to set prices. Similar restrictions apply to rolling stock which is usually tightly specified (Brenck and Peter 2007).

[10]This differs from textbook models of competition for the market (Viscusi et al. 2000). In those models, instead of the subsidy, contractors bid the price they want to charge to consumers and the lowest bid wins (Demsetz 1968).

[11]See Che (1993) for a formal analysis of such auctions. However, the role of the quality dimension is often not made absolutely clear ex ante, so that the mechanism corresponds to a beauty contest.

[12]This right has been challenged both by national courts and the EU. This is leading to a clearer move into the direction of more competition (Brenck and Peter 2007).

contract.[13] The institutional structure and the history of regional passenger service provision suggest reasons why government agencies might be responsive to suggestions of the incumbent. *DB Regio* belongs to *Deutsche Bahn AG* whose other subsidiaries take decisions on such issues as infrastructure and long-distance travel which are of vital interests for many local states. Also, the incumbent can exert some pressure on the agency because it is a large public employer.[14]

3.4 Types of Contracts

Our empirical analysis will account for the fact that the contracts in our sample are heterogeneous in several ways. First, contracts differ according to the treatment of fare revenues. In *net contracts*, the train operator receives the revenues, and the agency only pays the difference between costs and revenues. In *gross contracts*, the agency receives the revenues, whereas the operator receives a cost compensation. In addition, our sample contains various hybrid forms which are essentially gross contracts with additional demand incentives. In our data set, 67 % of competitive lines were procured in net contracts. The grand contracts with *DB Regio* were usually net contracts.[15] We take this asymmetry between competition and direct negotiations into account in our estimation.

Second, there is the standard distinction between fixed price contracts and cost plus contracts. According to Brenck and Peter (2007), in a sample of contracts analyzed by Borrmann (2003) which contains many of our contracts, 40% of the contracts were fixed-price, whereas the rest contained cost-pass-through clauses for costs on which the operator has little influence, such as energy costs and infrastructure charges. On a related note, the contracts typically contained dynamic adjustment formulas, at least for access charges. Such provisions reduce the need for renegotiation. Further, the contracts typically described detailed provisions for negotiations (Brenck and Peter 2007).

Finally, the contracts contained various incentive elements to deal with quality issues, including sanctions and bonus payments (Brenck and Peter 2007).

3.5 Evolution of the Market

As a result of the introduction of competition for the market, the market share of *DB Regio*'s competitors has grown substantially. In 1994, the NE-operators had a market share of 3% (based on train-km); in 2004, the share was 12% (Brenck and Peter 2007). However, these figures understate the dynamics of the competition. On lines with competitive procurement, the NE-operators won more often than DB Regio.

There are several distinct types of competitors. First, there are the above-mentioned pre-reform NE-operators. Starting from their old infrastructure, they often have expanded their operations onto the network

[13]The most competition-friendly authority (LVS in Schleswig-Holstein) signed a long-term contract in 2003, according to which the last part of the network will be opened to competition in 2014, 20 years after the railway reform. (See *http://www.premiumpresse.de/bahn-und-land-schleswig-holstein-unterzeichnen-verkehrsvertrag-PR156817.html*, visited July 4, 2011.

[14]Moreover, in some cases, former *DB Regio* employees making a career in the state and vice versa. For instance, Otto Wiesheu, one of the leading Bavarian politicians, became a member of the managing board of Deutsche Bahn in 2005.

[15]According to private communication with Felix Berschin (Nahverkehrsberatung Heidelberg), the state of Hessen is an exception.

of Deutsche Bahn where they only provide the downstream services. Second, some companies have expanded their activities from other modes of public transportation into the railroad sector. Third, some new companies emerged. Fourth, some railway operators are joint ventures between several companies, in some cases including *DB Regio*. Finally, foreign firms such as *Connex*, *Arriva* and *Abellio* have entered the market.

4 Theoretical Model

This section discusses a simple theoretical framework explaining procurement choice and price and quantity decisions. This framework is essential to understand endogeneity of procurement choice. The model also explains the quantity of railway services procured and the prices paid by agencies.

For simplicity, we suppose that costs on any given railway line are independent of the quantity supplied on other (in particular, neigboring) lines. Moreover, we assume that costs are linear on any line; thereby ruling out a decisive rule of capacity constraints. We suppose that firms (incumbents and potential entrants) are symmetric with respect to costs. All costs are drawn independently from a symmetric distribution with support $[c-y, c+y]$, where $c>0$ and $y \in (0, c)$. Hence c is the expected cost of any firm; in particular, it is the expected cost of the incumbent, c_I.[16] We suppose the agency has an objective function $\left(s\sqrt{q}-pq\right)$, which we refer to as (agency) surplus. The term $s\sqrt{q}$ in this function is supposed to capture two effects. First, the improvements in public transportation will generate direct benefits for the users (consumer surplus). Second, substitution from road to rail goes along with reductions in pollution and accidents. The term pq captures total payments to the operator; p is the price paid by the agency. On lines supplied by the incumbent, he cares about profits, which are given as $(p-c_I)\,q$.

In this setting, we first predict prices and quantities (and thus payoffs) for negotiations and auctions. We then use two alternative mechanisms for selection of the procurement mode.

4.1 Negotiations

We consider a very simple "negotiation mechanism". Even though the negotiations often concern "grand contracts", we treat each line individually here. We assume that the agency is constrained by the requirement that the line under consideration has to be supplied "at any price" (or, less dramatically, at any price below $c+y$). It makes a take-it-or leave-it offer to the incumbent, taking into account the constraint that the line has to be served with probability 1. Clearly, the lowest price it can set under this restriction is $c+y$. The agency then selects the quantity optimally given this price; thus it maximizes

$$W_N \equiv \left(s\sqrt{q}-(c+y)\,q\right). \tag{1}$$

The following simple result summarizes the outcome of the negotiations.

[16] While there are reasons why the incumbent may have lower costs (for instance, experience or scale advantages), there are also reasons why entrants might have lower costs (for instance, less rigid employment contracts). We thus opted for a symmetric treatment.

Proposition 1 *(i) The prices and quantities under negotiations are given as*

$$p = c + y \tag{2}$$

$$q = \frac{s^2}{4\left(c+y\right)^2} \tag{3}$$

(ii) The resulting agency payoff is $W_N^* = \frac{1}{4}\frac{s^2}{c+y}$, *the incumbent payoffs are* $\Pi_N^* = \frac{ys^2}{4(c+y)^2}$.

Proof. See Appendix A.1. ■

Proposition 1 has some obvious comparative statics implications. Any increase in the maximal possible cost level $c + y$ increases prices and reduces quantities. An increase in the surplus parameter s has no price effect, but increases quantity. Moreover, the values of $c + y$ and s are identified by the model from price and quantity observations.

4.2 Auctions

To capture competitive procurement, suppose the agency uses a first-prize procurement auction. The rules of this auction specify a fixed quantity q. After having observed this quantity, the successful firm has to supply a quantity q announced by the agency at the submitted price. Suppose there are N firms participating in the auction, where N is common knowledge. Denote the expectation of the lowest cost as $c_{(1)}$ and the expectation of the second-lowest cost as $c_{(2)}$. In the Nash equilibrium of the auction, the expected absolute markup is $m = c_{(2)} - c_{(1)}$ and the expected costs are $c_{(1)}$. Therefore, the expected price paid by the agency is $p^A = c_{(2)}$. A risk-neutral agency therefore chooses q so as to maximize the expectation of

$$W_A \equiv s\sqrt{q} - c_{(2)}q. \tag{4}$$

Proposition 2 *(i) The outcome of the auction is*

$$p = c_{(2)} \tag{5}$$

$$q = \frac{s^2}{4\left(c_{(2)}\right)^2} \tag{6}$$

(ii) The resulting agency payoff is $W_A^* = \frac{s^2}{4c_{(2)}}$, *the incumbent payoffs are* $\Pi_A^* = \frac{s^2\left(c_{(2)}-c_{(1)}\right)}{4N\left(c_{(2)}\right)^2}$.

Proof. See Appendix A.2. ■

Proposition 1 implies that an increase in the second-order statistic $c_{(2)}$ increases prices and reduces quantities. An increase in the surplus parameter s has no price effect, but increases quantity. Moreover, the values of $c_{(2)}$ and s are identified by the model from price and quantity observations.

4.3 Selection of Procurement Mode

It is straightforward to show that the agency always has higher payoffs under auctions than under negotiations, whereas this is not the case for the incumbent. As we will see below, the majority of the the lines was not procured competitively. Thus, the observed procurement decision cannot be the result of the decision of an agency with the payoff functions described in the previous section. We therefore now provide two different suggestions to reconcile the model with the evidence.

Our first approach continues to rely on the assumption that agencies take the procurement decisions. However, in line with anecdotal evidence, we assume that the agency faces additional administrative costs when it carries out an auction rather than relying on negotiations with the incumbent. We assume that these administrative costs are increasing in the complexity of the procurement task, which we capture by the size of the line under consideration (as given by the agency surplus W^A). For simplicity, we assume a proportional relation. Thus, the agency surplus net of administrative costs becomes $w^A = \varphi W^A$, where $\varphi \in [0,1]$; thus $\left((1-\varphi) W^A\right)$ corresponds to losses from administrative costs. Therefore, the agency selects the auction if and only if $\varphi W_A^* > W_N^*$ or equivalently

$$\varphi > \frac{c_{(2)}}{c+y}. \tag{7}$$

The agency thus uses competitive procurement if and only if the benefits from lower transfers outweigh the increased administrative costs. We will use this approach to identify the administrative costs (under the assumption that they are the main driver for the prevalence of negotiations). We interpret these costs in an "as-if" way: Agencies decide as if there was a cost corresponding to a fraction $(1-\varphi)$ of the surplus in an auction. This could reflect true administrative costs. Alternatively, it could capture perceived costs resulting from a lack of familiarity with auction mechanisms. Finally, the unwilingness to choose competitive procurement may also stem from the fact that a substantial part of the burden resulting from auctions accrues to the decision makers in the agencies, whereas the benefits accrue to consumers in the jurisdiction etc.

Our second approach disregards administrative costs. Instead it relies on the idea that the incumbent has an influence on the procurement decision. We use this alternative approach to capture the incumbent's bargaining power in procurement negotiations with the agency (under the assumption that this bargaining power is actually the driver behind the prevalence of negotiations). Specifically, we capture bargaining on the procurement mode by assuming that its outcome reflects Generalized Nash bargaining. Thus, there exists a $\tau \in [0,1]$ such that competitive procurement is used if and only if $(W_A^*)^\tau (\Pi_A^*)^{1-\tau} > (W_N^*)^\tau (\Pi_N^*)^{1-\tau}$.

Inserting the values of W_N^* and Π_N^* from Proposition 1 and the values of W_A^* and Π_A^* from Proposition 2 and rearranging, we find that Nash bargaining leads to competitive procurement if and only if[17]

$$\left(\frac{c_{(2)} - c_{(1)}}{Ny}\right)^{1-\frac{1}{2-\tau}} > \frac{c_{(2)}}{c+y}. \tag{8}$$

As in condition (7), the right-hand side of the condition is small when the auction is expected to reduce the transfers to the incumbent by a large amount. This reflects the expected benefits from auctions for the agency. The left-hand side captures countervailing forces, reflecting the incumbent's interest. First, the incumbent's influence matters more (the condition is more likely to be violated) when the agency weight τ is low.[18] Moreover, the incumbent's influence tends to work more strongly against auctions when the incumbent expects to win with a small probability in the auction because N is high. The incumbent will also more strongly oppose competitive

[17] For details of the calculations, see Appendix A.3.

[18] Note that $c^{(2)} - c^{(1)} < y$, so that the ratio on the left-hand side is smaller than 1.

procurement when the expected markup under negotiations (y) is high relative to the markup under auctions ($c_{(2)} - c_{(1)}$). Note that one reason why $c_{(2)} - c_{(1)}$ can be low is that the number of firms is high: As N increases, first- and second-order statistics tend to move closer together. Note also that $c_{(2)}$ depends, inter alia, on N. Thus, Condition (8) does not give us a simple comparative statics with respect to N: $\frac{c_{(2)} - c_{(1)}}{N}$ and $c_{(2)}$ are both decreasing functions of N. As N increases, the agency wants the auction more, because it expects a stronger effect on the price it pays. Similarly, the incumbent wants the auction less, because its chances of winning and the expected markup both fall.

5 Econometric Framework

Our econometric approach has four parts. We start by investigating quantities. We run OLS regressions and explain observed quantities by line characteristics. We distinguish between lines with auctions and negotiations, and we use predicted values for counterfactual outcomes. We then analyze the prices from the negotiations. Again, we use OLS regressions and regress prices on line characteristics. The regression equation is then the basis for out-of-sample predictions. In this way, we obtain predicted prices that would have been the outcome of negotiations for the sub-sample where we actually observe auctions. The next part of our analysis describes the determinants of winning bids from the auctions. We use a structural auction model to obtain an estimate for firms' bid distribution and to back out firms' cost. Again, we form out-of-sample predictions. In this case, we obtain predicted prices (winning bids) that would have been the outcome of auctions for the sample where we actually observe negotiations. Finally, based on the optimality condition for procurement choice, we use a linear probability model to estimate the parameter τ measuring the bargaining power of the agency and the administrative cost of an auction captured inversely by φ.

5.1 Prediction of Quantities and Negotiated Prices

For each set of observations (auctions and negotiations), we fit a linear regression model to log quantities, i.e.,

$$\log q_i = \alpha_0 + \alpha_X X, \tag{9}$$

where X denotes the set of line characteristics, α_0 and α_X are the parameters to be estimated. We denote the predictions with $\log \hat{q}_{negs}$ and $\log \hat{q}_{bids}$. Based on these estimates, we are able to calculate the surplus parameters $\hat{s}_{negs}$ and $\hat{s}_{bids}$ using equations (1) and (4).

According to our model on negotiations, the incumbent sets a price equal to highest cost $c + y$. In the empirical model, we fit a linear regression model, i.e.,

$$\log p_i = \beta_0 + \beta_X X, \tag{10}$$

where X denotes the set of line characteristics, β_0 and β_X are the parameters to be estimated. We denote the predictions with $\log \hat{p}_{negs} \equiv \widehat{c + y}$.

5.2 Estimation of Bid Distribution and Bidders' Costs

We use data on winning bids to estimate the distribution of firms' bids and costs in the sealed-bid auctions. Our econometric auction model follows the approach developed by Guerre, Perrigne and Vuong (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' bids and costs at hand, we can then make out-of-sample predictions.

We assume that the set of line characteristics X is known to the econometrician and the bidders. Bidders know their private cost c_i. We denote the distribution of bidders' costs as $F(\cdot|X)$, and assume that bidders' costs are independent conditional on X. Given these assumptions, one can write the distribution of bids as $G(\cdot|X, N)$. Following Guerre, Perrigne and Vuong (2000), the first order condition for i's bidding problem is

$$c_i \equiv b_i - \frac{1}{N-1}\frac{1-G(b_i; X, N)}{g(b_i; X, N)}, \tag{11}$$

where $G(b; X, N) = F(b_j^{-1}(b; X, N))$ is the probability that j will bid less than b and $b_j^{-1}(b; X, N) = c_j$. This provides the basis for estimating bidders' cost distributions.

Distribution of Bids. To obtain an estimate for the distribution of bidders' cost, Guerre, Perrigne and Vuong (2000) propose to estimate the distribution of bids first and back out cost then. We adopt a parametric approach and take into account that our sample includes winning bids only (see Section 6). Conditional on the observable auction characteristics X and the number of bidders N, the joint distribution of bids in a given auction is the distribution $G(\cdot|X, N)$. We specify G as the Weibull distribution:

$$G(b_i|X, N) = 1 - \exp\left\{-\left(\frac{b_i}{\lambda(X, N)}\right)^{\rho(X,N)}\right\}, \tag{12}$$

where $\lambda(X, N)$ is the scale and $\rho(X, N)$ is the shape of the Weibull distribution. We parameterize the scale as $\lambda(X, N) = \lambda_0 + \lambda_X X + \lambda_N N$ and the shape as $\rho(X, N) = \rho_0 + \rho_X X + \rho_N N$. We estimate the parameters of the model, (λ, ρ), by maximum likelihood. As we observe winning bids only, we use the (log) density of the first-order statistic of a Weibull distribution.[19,20]

Distribution of Costs. Assuming bidders behave as predicted by the theoretical auction model, the distribution $F(\cdot|X)$ is identified from the distribution of observed winning bids.[21] 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 equation (11).

Expected Winning Bids. To predict winning bids in-sample and out-of-sample, we calculate the expectation of the first-order statistic of a Weibull distribution, i.e.,

$$\hat{b}_{[1]} \equiv \mathbb{E}[b_{[1]}] = N\hat{\lambda}(X, N)\left(\frac{1}{N}\right)^{\left(\frac{1}{\hat{\rho}(X,N)}+1\right)}\Gamma\left(\frac{1}{\hat{\rho}(X, N)}+1\right), \tag{13}$$

[19]Here, the first-order statistic is the lowest of N random variables $X = (X_1, \ldots, X_N)$. The density of this statistic is $h(x_{[1]}) = \frac{n!}{(n-1)!}(1 - G(x))^{(N-1)}g(x)$, where $x_{[1]}$ ist the lowest value of the random variables, G is the distribution function of the random variable X and g the density function. See for example, David and Nagaraja (2004) for more information on order statistics.

[20]In contrast to the theoretical model, the Weibull distribution does not have a finite upper bound. We follow Athey, Levin and Seira (2011) and truncate the very upper tail of the estimated distribution.

[21]For a discussion on identification in first-price auctions, see Athey and Haile (2006).

where $\mathbb{E}[b_{[1]}]$ is the expected winning bid, Γ the gamma function, and $\hat{\lambda}(X, N)$ and $\hat{\rho}(X, N)$ are the estimated scale and shape of the Weibull distribution.[22]

5.3 Determinants of Procurement Choice

We can use linear probability models to estimate the parameter τ measuring the bargaining power of the agency and the administrative cost of an auction captured inversely by φ. We first consider the two alternative models proposed in Section 4.3. First, corresponding to (7), if we assume that the whole bargaining power is with the agency, i.e., $\tau = 1$, competitive procurement is chosen if and only if

$$\log\varphi + \log\left(\frac{\widehat{(c+y)}}{\hat{b}_{[1]}}\right) > 0, \tag{14}$$

here φ, the constant to be estimated, is either constant over all agencies or may vary across them; $\widehat{c+y}$ is the expected price that the agency has to pay under negotiations and $\hat{b}_{[1]}$ is the expected value of the lowest bid in an auction. Second, corresponding to (8), if we assume that there are no cost running an auction, but the procurement decision requires Nash bargaining, we obtain

$$(1-\tau)\log\left(\frac{(\hat{b}_{[1]} - \hat{c}_{[1]})\widehat{(c+y)}}{\hat{y}N\hat{b}_{[1]}}\right) + \log\left(\frac{\widehat{(c+y)}}{\hat{b}_{[1]}}\right) > 0, \tag{15}$$

where $\hat{c}_{[1]}$ is the estimated (backed out) cost of the winning bidder and $\hat{y}$ the expected margin of the incumbent.

We shall also consider a nested model which contains the previous two as special cases. It is straightforward to show that in a Nash bargaining model where the agency takes administrative costs into account, the condition for an auction becomes

$$\tau\log\varphi + (1-\tau)\log\left(\frac{(\hat{b}_{[1]} - \hat{c}_{[1]})\widehat{(c+y)}}{\hat{y}N\hat{b}_{[1]}}\right) + \log\left(\frac{\widehat{(c+y)}}{\hat{b}_{[1]}}\right) > 0, \tag{16}$$

We run this model without and with agency specific fixed effects, which reflect differences in agency specific cost running an auction, i.e, φ_i.

6 Data and Descriptive Statistics

Our data contains information regarding service frequency on about 500 train lines in Germany. We now provide key background and descriptive statistics on this data.

6.1 Data

The empirical analysis uses information on our main dependent variables, service quantity and procurement prices. We first need a measure of the service quantity on a line. Following Lalive and Schmutzler (2008), we use the *frequency of service,* the ratio between train kilometers per year (tkm) and the length of a line (lkm).[23]

[22] For the calculation of the expectation, see Appendix A.4.

[23] Thus, the frequency of service corresponds to the average number of trains per year on each kilometer of tracks.

We chose its value in the year 2004 on a particular line as the quantity to be explained, but we also included a lagged frequency of service (for 1994) as a control variable. The division of the network into different lines follows the 2004 timetable.[24]

We do not have data that measure aspects of service quality such as punctuality, comfort, etc., but we do not expect strong effects of competition. For one thing, many aspects of quality are narrowly specified in most contracts. For another, to the extent that there is flexibility in the choice of quality, anecdotal evidence does not suggest a clear relation between quality and procurement mode.

To identify competition effects, we classified lines as competitive if at least 20% of the services were procured competitively.[25] The fact that a line is served competitively says nothing about ownership: Lines on which DB Regio won a competitive tender are defined as competitive, even though the operator is the incumbent. Conversely, but much less importantly, a few small lines were served by other companies, but prices and quantities were determined in negotiations. We discuss the role of ownership and auctions in a separate analysis below.[26]

Apart from these basic variables, we added further controls, corresponding to the line characteristics discussed in Section 5. These characteristics are mostly determined by geography. We consider the geographic distance to the nearest city with at least 100,000 inhabitants as a measure of remoteness. We also include the number of inhabitants of both the largest and the second-biggest city served by the line in 1994.

Obtaining information on procurement prices is difficult. We were able to get information on the winning bid in auctions.[27] The data contains information on prices for 63 of the 138 competitively procured lines in the sample. We have studied whether these lines represent a selected sample but, conditional on the observed line characteristics, we did not find any differences between the lines with price data and lines without price data.[28]

The prices resulting from direct negotiations are publicly available but only quoted at the state level. We construct individual line-specific estimates of the negotiation price as follows. The downstream firms (the railway operators) have to pay access fees to the network owner, which almost always is *DB Netz*. These access fees, which constitute a substantial part of the costs of downstream firms, vary considerably across lines, even within agencies, with the so-called *Regionalfaktor* measuring the factor by which the price on a given line exceeds the minimum. We reconstruct negotiation prices to reflect the access fee along with a region-specific cost component so as to match the quoted state level price (see the Appendix for details).[29]

[24] In some cases, we had to make small adjustments to avoid double-counting of trains. Lines that were closed down between 1994 and 2004 were not included.

[25] Apart from open competitive tenders announced by the agency, we also included lines of the following – comparatively rare – types (see Lalive and Schmutzler 2008, Definition 1): (i) Services were procured on the basis of offers from at least two firms that were approached directly by the agency; (ii) Apart from the incumbent, at least one firm offered a contract to the agency without having been asked to do so. (iii) A competitor took over the infrastructure and the task of running services from *DB Regio* for a symbolic price (see Lalive and Schmutzler (2008) for examples).

[26] In analogy to our definition of competitive lines, we define a line as operated by DB Regio if at most 20% of the services were run by competitors.

[27] The data were supplied by Felix Berschin from Nahverkehrsberatung Südwest in Heidelberg, a consulting firm that is specialized in regional passenger train services.

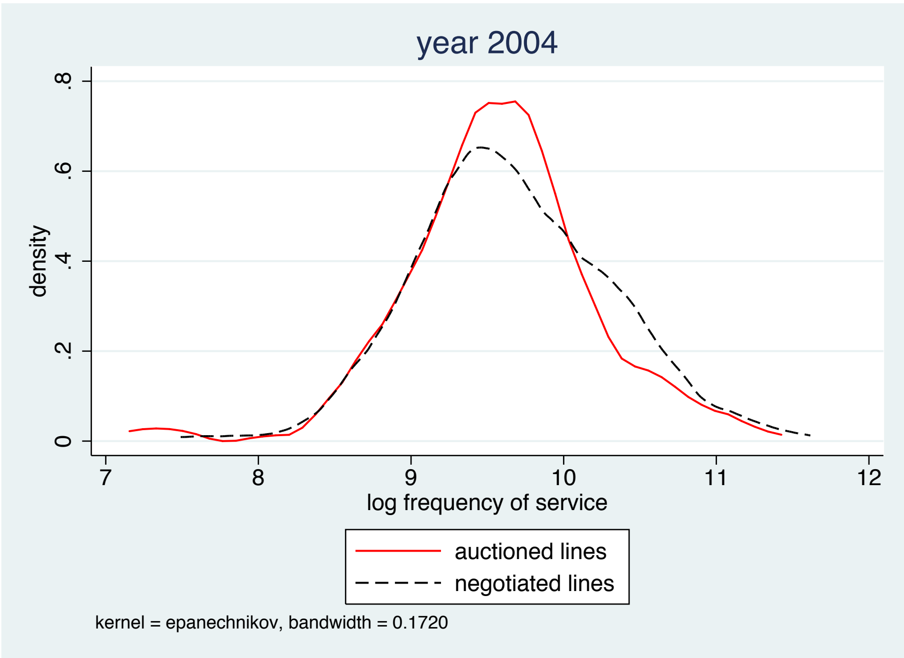
[28] We have also explored another source of data on prices. The official source of the European Union, the databank *Tender Electronic Daily*, contains useful information on which lines were grouped together in a particular auction and what the overall volume of the contract is. However, this source only provides procurement price data in a small number of cases.

[29] We are grateful to DB Netz for providing us with information on the access charges.

6.2 Descriptive Statistics

Figure 1 displays kernel density estimates of the distribution of frequency of service in 2004 for two sets of lines: lines that were auctioned between 1994 and 2004 and lines that were negotiated directly with the incumbent supplier. The auctioned group contains a smaller share of high frequency lines, but a greater share of lines with medium frequency of service. At first glance, Figure 1 therefore suggests that auctions might be detrimental for service frequency. But lines with auctions could also have been served less frequently even before competitive procurement took place.

Figure 1: Frequency of Service by Procurement Mode, in 2004



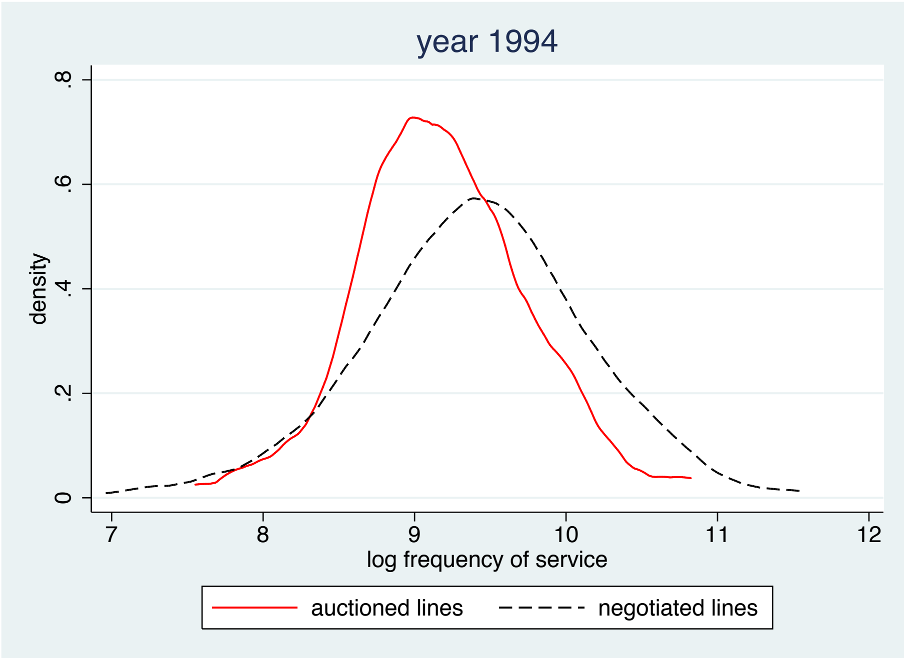
Notes: Figure displays log train kilometers per line kilometers in the timetable year 2003/2004. Services on auctioned lines were procured competitively by 2004 at the latest. Services on negotiated lines were negotiated between the incumbent supplier and the regional transport agency.

Source: Own calculations.

A simple way to test this selection hypothesis is to assess service frequency in 1994. Figure 2 shows kernel density estimates of frequency of service in 1994, before any of the lines were auctioned. Auctioned lines had much lower frequency of service than negotiated lines. This figure suggests that the selection hypothesis is correct. Indeed, contrary to the first impression, auctions appear to have helped railway lines to improve substantially. Auctioned lines were less well served than negotiated lines in 1994, but the difference was much smaller in 2004 after competitive procurement was introduced.

Our main empirical strategy will work only with frequency of service in 2004. In all regressions, we will condition on technical aspects of a line (whether the line has electric traction, length of the line), proxies for demand (distance to next city in km, population in the largest and 2nd largest city along the line), determinants

Figure 2: Frequency of Service by Procurement Mode, in 1994



Notes: Figure displays log train kilometers per line kilometers in the timetable year 1994. Services on auctioned lines were procured competitively by 2004 at the latest. Services on negotiated lines were negotiated between the incumbent supplier and the regional transport agency.

Source: Own calculations.

of the cost or service provision (regional factor, incumbent). We now assess whether differences between lines that were auctioned in 2004 and those that were not are due to differences in these observed characteristics. Table 1 shows how line characteristics affect (log) frequency of service in 1994, separately for lines that were auctioned in 2004 and lines that were not.[30] Results indicate that short lines, with electric traction, and with populated largest and 2nd largest cities are more frequently served than their counterparts, with similar coefficients in models for auctioned lines and negotiated lines. Observed line characteristics significantly predict service frequency. But this is not enough, there may also be differences in unobserved characteristics of lines that drive service frequency. Do unobserved characteristics matter? To see this, consider the constant terms in both regressions. The constant term in regression for auctioned lines is the same as the constant term in the regression for negotiated lines. This finding suggests that there were no unobserved differences between the two groups of lines before the market was opened up. Our strategy is to include the characteristics we observe in order to isolate the components of service frequency (and prices) that are plausibly due to procurement.

[30]Table A1 presents summary statistics for our main variables.

Table 1: Determinants of quantities in 1994

	Negotiations			Auctions		
	(1)		(2)	(3)		(4)
incumbent	0.128		(0.127)	0.084		(0.094)
electric traction	0.336	***	(0.078)	0.271	***	(0.096)
distance to city (km)	-0.004	**	(0.002)	-0.004	***	(0.001)
log track length	-0.114	***	(0.043)	-0.005		(0.043)
log pop largest city	0.059	**	(0.030)	0.073	**	(0.037)
log pop 2nd largest city	0.114	***	(0.028)	0.181	***	(0.046)
regional factor	-0.119		(0.143)	-0.064		(0.127)
Constant	9.364	***	(0.181)	9.375	***	(0.150)
Adjusted R-Squared	0.305			0.417		
Number of observations	420			139		
Mean predicted values	9.399			9.186		

Notes: Results from OLS estimations. Dependent variable is the log of quantity in 1994. Columns (1) and (3) shows the estimated coefficients and columns (2) and (4) the standard errors. Standard errors are adjusted for 17 clusters (on agencies). $***$ ($**$, $*$) stands for significance at the 1% (5%, 10%) level.

Source: Own calculations.

7 Empirical Results

We now present our main observations about the frequency of service and procurement prices on lines with and without competitive procurement. Then we will compare the two procurement modes in an econometric analysis based on the model of Section 5.

7.1 Determinants of Quantities and Prices

We now discuss the estimation results for quantities and prices. As a preparation for our counterfactual analysis, we first focus on the effects of line characteristics for given procurement mode.

Table 2 presents the results from our model on quantities, depending on whether negotiations or auctions were used for procurement. Both models control for observed line characteristics including lagged frequency of service. Unsurprisingly, we find that lines that were served frequently in 1994 tended to be served more frequently in 2004.[31] Lines with a high regional factor, which typically lie in remote areas, are also served less frequently than lines in urban areas. Results also indicate that longer lines are served less frequently than shorter lines. The remaining control variables are not significant mainly due to the fact that we condition on lagged frequency of service and the regional factor.

[31] Note that we include lagged frequency of service to correct for time-invariant unobserved effects in our analysis, so that the coefficient attached to lagged frequency of service has no causal interpretation.

Table 2: Determinants of quantities

	Negotiations			Auctions		
	(1)		(2)	(3)		(4)
incumbent	0.007		(0.065)	-0.054		(0.080)
log frequency	0.789	***	(0.025)	0.646	***	(0.074)
electric traction	0.008		(0.041)	-0.001		(0.084)
distance to city (km)	-0.001		(0.001)	0.000		(0.001)
log track length	-0.062	***	(0.022)	-0.137	***	(0.044)
log pop largest city	0.005		(0.015)	0.073	**	(0.037)
log pop 2nd largest city	0.018		(0.015)	0.055		(0.041)
regional factor	-0.190	**	(0.073)	-0.374	***	(0.108)
Constant	9.805	***	(0.092)	10.188	***	(0.127)
Adjusted R-Squared	0.795			0.638		
Number of observations	420			139		
Mean predicted values	9.645			9.579		

Notes: Results from OLS estimations. Dependent variable is the log of quantity. Columns (1) and (3) shows the estimated coefficients and columns (2) and (4) the standard errors. Standard errors are adjusted for 17 clusters (on agencies). $***$ ($**$, $*$) stands for significance at the 1% (5%, 10%) level.

Source: Own calculations.

The effects of lagged frequency of service, the length of lines and the regional factor differ significantly for auctions and negotiations. The results show a stronger effect of lagged frequency of service on negotiated lines. In contrast, the negative effects of the length of lines and the regional factor are stronger for auctioned lines.

Tables 3 shows the determinants of prices. Columns (1) and (2) present the results from our price model on negotiations. The dependent variable is the log price of lines from the negotiation sample. We explain about 20% of the variation in log prices with our explanatory variables. We find that prices are significantly lower on those lines that are close to cities and are frequently served. By contrast, the effects of electric traction and the regional factor are significantly positive. Regional factors are typically high for lines with a low frequency of service, typically in rural areas. The indicator variable for the incumbent has a marginally significant positive effect.

Columns (3) to (6) of Table 3 presents the results for the auction model. Column (3) of this table shows the estimates for the scale parameter λ, and column (5) the estimates for the shape parameter ρ. Variables that significantly influence the shape parameter of the Weibull distribution are the distance to the next largest city, the log of track length, the log of the population of the largest city along the line, and the regional factor. An increase in the distance to the next largest city leads to higher bids. The same is true for track length and the population of the largest city along the line. The regional factor has a negative sign, implying that bids are lower in less urban areas. The shape parameter is significantly influenced by distance to city and the log population

Table 3: Determinants of negotiated prices and the distribution of winning bids

	Negotiated prices			Winning bids					
				Scale λ			Shape ρ		
	(1)		(2)	(3)		(4)	(5)		(6)
incumbent	0.046	*	(0.026)	0.037		(0.058)	0.483		(5.324)
log frequency	-0.030	***	(0.010)	0.047		(0.044)	3.770		(4.837)
electric traction	0.068	***	(0.016)	-0.058		(0.042)	4.294		(4.206)
distance to city (km)	-0.001	***	(0.000)	0.003	**	(0.002)	-0.177	**	(0.077)
log track length	-0.009		(0.009)	0.086	*	(0.046)	-4.770		(4.100)
log pop largest city	-0.007		(0.006)	0.042	**	(0.020)	-0.734		(2.137)
log pop 2nd largest city	-0.005		(0.006)	-0.036		(0.022)	-5.138	*	(2.709)
regional factor	0.248	***	(0.029)	-0.146	*	(0.085)	22.783		(22.414)
Constant	1.828	***	(0.036)	2.302	***	(0.105)	-6.740		(24.823)
Adjusted R-Squared	0.197								
Log pseudo-likelihood				35.383					
Number of observations	420			59					

Notes: Results from OLS and MLE estimations. Dependent variables are the log of price from negotiations and the log of winning bid. Column (1) shows the estimated coefficients of the determinants of negotiated prices. Column (3) shows the coefficients estimated for the scale parameter λ of the Weibull distribution of bids. Column (5) is for the shape parameter ρ. Standard errors are adjusted for 17 clusters (on agencies) and shown in columns (2), (4) and (6). $***$ ($**$, $*$) stands for significance at the 1% (5%, 10%) level.

Source: Own calculations.

of the second largest city along the line.[32]

7.2 Comparison of outcomes of negotiations and auctions

We now compare the outcomes of negotiations and auctions. We first provide the predicted means for negotiations and auctions for both sets of lines. In Table 4, we depict the means for the log variables and their levels. In line with Figure 1, we observe that, on average, the frequency of service on lines with negotiations is higher than on lines with auctions (18648 trains per kilometer vs. 16408). This indicates that negotiations are more common on more important lines. Controlling for line characteristics, we however find a positive effect of auctions on the frequency of service. We estimate that the frequency of service on lines in the negotiation sample would have been almost 12% higher if they had been subjected to competitive procurement ($\frac{20815-18648}{18648} = 0.116$). Similarly, the frequency of service on lines in the auction sample is almost 15% higher than it would have been

[32] We are aware that the number of observations for a structural model is rather low. We experimented with several specifications for the winning bid. We restricted the scale parameter to be a constant only or used a log normal distribution instead of the Weibull distribution. The chosen specification gives the best fit and most sensible estimated coefficients.

had these lines been procured using negotiations ($\frac{16408-14280}{14280} = 0.149$). This relates to the discussion of Table 2, where we saw that the effect of the lagged frequency of service was stronger on lines with negotiations than on lines with competitive procurement. This is equivalent with a statement that the auction-related quantity improvements are smaller on lines that were served very frequently already before the reform. As the lines that are not procured competitively tend to be among those that were served frequently, this is consistent with the observation that the auction effects on these lines are somewhat smaller than in the other group.

Table 4 also compares prices with auctions and negotiations. Controlling for line characteristics, we find that on average predicted prices in negotiations are higher than predicted prices in auctions. We estimate that prices on lines in the negotiation sample would have been around 20% lower if these lines had been subjected to competitive procurement ($\frac{8.632-6.857}{8.632} = 0.206$). Similarly, the price on lines in the auction sample is about 19% lower than it would have been had these lines been procured using negotiations ($\frac{8.383-6.785}{8.383} = 0.191$). This suggests that auctions not only increase quantity but they also lower the procurement price by a substantial amount.

Table 4: Comparison of predicted quantities and prices

	Mean quantities			Mean prices		
	Auctions	Negotiations	Difference	Auctions	Negotiations	Difference
	(1)	(2)	(3)	(4)	(5)	(6)
in logs						
Negotiated lines	9.767	9.645	0.122	1.911	2.153	-0.242
Auctioned lines	9.579	9.439	0.140	1.897	2.123	-0.226
in levels						
Negotiated lines	20815	18648	2167	6.857	8.632	-1.775
Auctioned lines	16408	14280	2127	6.785	8.383	-1.598

Notes: Results based on OLS and MLE estimations in Tables 2 - 3. Mean predicted values in logarithm and levels are shown.

Source: Own calculations.

So far, the analysis has established that competition increases the frequency of service and reduces procurement prices. As we argued before, a price reduction could potentially reflect an increase in competitive pressure, as well as a selection of more efficient supplier (and hence lower costs). We now analyze two which extent these two channels are responsible for the reduction in procurement prices.

Table 5 provides information on mean estimated cost and markups under auctions and negotiations. Estimated cost are backed out from the first order condition of optimal bidding of the winning bidder for auctioned lines and predicted out of sample for negotiated lines. Markups are then calculated using the standard Lerner index, i.e., (price - cost)/price. In the auction sample, estimated costs are 6.39 Euro for the winning bidder and 7.73 Euro for the incumbent. In the negotiation sample, the values are 6.56 Euro and 7.94 Euro, respectively.[33]

[33] Markups for the incumbent are calculated by assuming that its cost are the mean value from the bidders' cost distribution. For a few cases this gives negative markups, which we set to zero.

Thus, we estimate that competitive procurement reduces the costs of providing the service by almost 18%, reflecting a substantial selection effect: The successful bidder in an auction is usually considerably more efficient than the incumbent.

Markups are also lower on lines where auctions took place. On average, we obtain a value of about 4.3% for competitively procured lines and 5.0% for the remaining lines. Markups under negotiations are considerably higher than under auctions, giving values of about 7.1% for competitively procured lines and 7.6% for the remaining lines. This corresponds to markup reductions of around 35%. To sum up, therefore, the overall reduction in transfers reflects both an increase in competitive pressure and a selection effect.

Table 5: Comparison of estimated cost and markups

	Estimated cost			Markups in %		
	Auctions	Negotiations	Difference	Auctions	Negotiations	Difference
	(1)	(2)	(3)	(4)	(5)	(6)
in logs						
Negotiated lines	1.858	2.069	-0.211	5.344	8.475	-3.131
Auctioned lines	1.841	2.043	-0.202	4.563	7.999	-3.436
in levels						
Negotiated lines	6.556	7.943	-1.387	5.011	7.607	-2.596
Auctioned lines	6.385	7.731	-1.346	4.335	7.132	-2.797

Notes: Results based on OLS and MLE estimations in Tables 2 - 3. Mean predicted values in logarithm and levels are shown. Markups in levels are the Lerner index, i.e., (price - cost)/price multiplied by 100; markups in logs are the difference of log prices and log costs multiplied by 100. Differences are calculated by taking the difference of the means.

Source: Own calculations.

7.3 Implications for agency surplus

Based on the (in-sample) predicted quantities and prices, we are then able to calculate the surplus. We compare the predicted ex-ante agency surplus under negotiations and auctions using equations (1) and (4). In Table 6, we show mean values for negotiations and auctions for both sets of lines in logs and levels. The effect of competition is as follows. By switching from negotiations to auctions, agencies could have increased their surplus by about 18% on negotiated lines. The loss from switching auctions to negotiations on auctioned lines would have been 35%. The respective numbers in levels are about 28583 (26546) Euro per line kilometer and year on negotiated (auctioned) lines.

To show the effect of competition over the complete distribution, we also provide a kernel density estimate of the log surplus difference between procurement by auction and by negotiations in Figure 3. We observe that surplus per line kilometer and year is higher on most lines. This is true for negotiated lines and auctioned lines. Only for a few lines a switch from negotiations to competition would have been detrimental to surplus.

Table 6: Comparison of mean predicted welfare

	Auctions	Negotiations	Difference
	(1)	(2)	(3)
in logs			
Negotiated lines	11.977	11.799	0.179
Auctioned lines	11.476	11.129	0.347
in levels			
Negotiated lines	187495	158912	28583
Auctioned lines	109126	82580	26546

Notes: Results based on OLS and MLE estimations in Tables 2 - 3. Mean predicted values in logarithm and levels are shown.

Source: Own calculations.

To interpret these numbers, recall that an increase of the frequency of service creates more surplus in two ways. First, there is a higher agency surplus (from the higher demand, but also from the higher utility per unit consumed). Second, the demand shift involves a road-rail substitution, which creates additional benefits from reductions in negative externalities. The functional form for the surplus, $S(q) = s\sqrt{q}$, imposes restrictions on the relation between quantity and surplus. Specifically, the elasticity of surplus with respect to q is $1/2$ by assumption. Thus, we are not allowing any flexibility in this respect. Our estimation if s gives us the surplus from one unit of q, $S(1)$, but we learn nothing about the elasticity. However, at least the value of $1/2$ for this elasticity appears to be reasonable. One way to rationalize it would be to say that (1) a 10% increase of q creates a 5% increase of demand and (2) that each unit of demand is equally valuable in terms of surplus generated. Part (1) seems in line with what other papers have shown (Evans 2004). Part (2) is more debatable, as one might expect decreasing marginal benefits. It is not clear, however, how big this effect is in the relevant region.

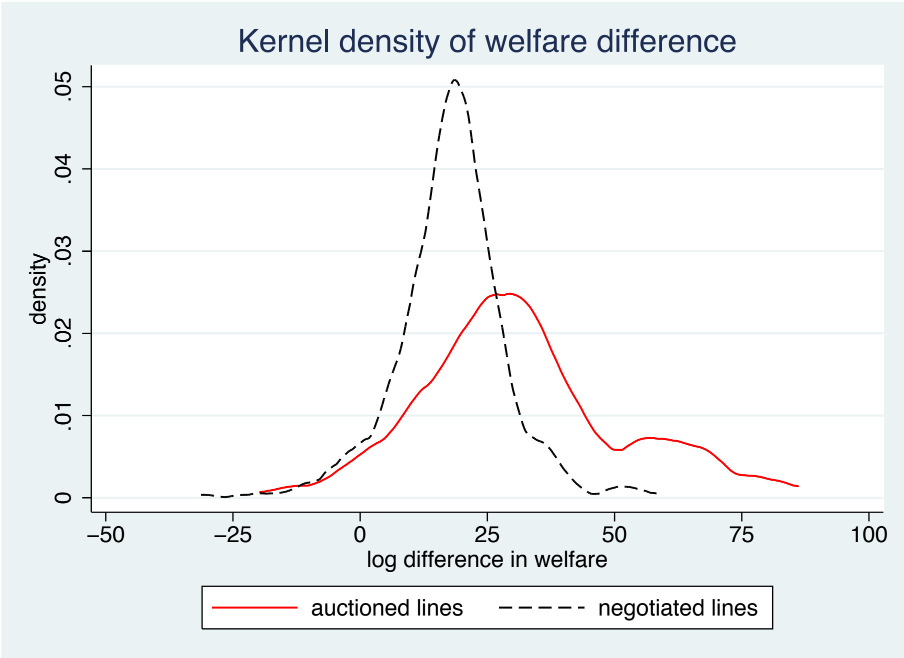
7.4 Bargaining Power vs Auction Costs

We now discuss how to recover estimates of the agency's bargaining power (τ), or the administrative cost of running an auction (ϕ). Recall that these key parameters affect the procurement mode decision. Agencies with low administrative costs retain a large share of the surplus generated by the auction. Also, incumbents have less say in the bargaining process if the agency has strong bargaining power. The decision to auction a line or not, conditional on the surplus gain generated by the auction, reveals information on precisely those two parameters.

In Table 7, we show the results from the three linear probability models implementing equations (14), (15) and (16), respectively. The dependent variable is 1 for lines with competitive procurement, 0 for the remaining lines. We run each model without and with agency specific fixed effects, thereby accounting for differences in the agencies' abilities to set up an auction.

We find that the parameter τ measuring the bargaining power of the incumbent is always larger than one, indicating that the whole bargaining power is with the agency. We also find that the perceived cost of the agency of running an auction, i.e., $1 - \varphi$, is about 50-60% of the (gross) surplus. The high value of these costs suggest

Figure 3: Kernel density estimate of log difference in welfare



Notes: Kernel density estimates of the log difference of welfare for auctioned and negotiated lines.

Source: Own calculations.

that they do not correspond to actual administrative costs. Our preferred interpretation is that a large part of these perceived costs corresponds to foregone surplus increases which come from a reluctance of agencies to apply competitive procurement. This is particularly plausible, as our analysis refers to the first ten years after the reform where agencies had little or no experience with competitive procurement.

8 Summary and Discussion

The reorganization of German railway passenger transportation after 1994 provides a unique setting for obtaining insights on the relative performance of the most important institutions for public procurement, auctions and negotiations. At the same time, the analysis allows us to contribute to the evaluation of reforms in network industries such as railways that took place in many European countries towards the end of the last century.

Our analysis indicates that auctions are successful. The frequency of service is 12% higher, and procurement prices are 20% lower on lines that agencies chose to auction rather than to procure in direct negotiations with the incumbent. Moreover, structural auction estimation allows us to back out also bidders' marginal cost and their markups. We find that markups decrease by about 35% when lines are auctioned instead of negotiated. They decrease from about 7.6% in negotiations to about 5% in auctions on negotiated lines. These results indicate that besides the selection effect – more efficient bidders win auctions, yielding a cost decrease of about 18% – there is a sizeable competition effect due to the increase in participation.

Table 7: Estimated bargaining power of incumbent and agency cost

	φ only		τ only	φ and τ	
	(1)	(2)	(3)	(4)	(5)
τ			1.0077	1.12012	1.2064
			(0.0079)	(0.0358)	(0.0416)
φ	1.0068			0.5451	
	(1.0387)			(1.1858)	
φ_i (mean)		1.0834			0.4825
φ_i (minimum)		0.7369			0.3418
φ_i (maximum)		2.0786			0.7436
Agency specific fixed effects	No	Yes	No	No	Yes
Number of observations	558	558	558	558	558

Notes: Results from linear probability models. Dependent variable is one if the regional passenger line was procured by auction and it is zero if the line was procured by negotiation with the incumbent. Columns (1), (3) and (4) show results without agency fixed effects; columns (2) and (5) with agency fixed effects. Standard errors are calculated with the delta method and adjusted for 17 clusters (on agencies). They are shown in parentheses below the parameter estimates. $***$ ($**$, $*$) stands for significance at the 1% (5%, 10%) level.

Source: Own calculations.

Auction efficiency gains translate into sizeable gains in terms of agency surplus, which was about 30% higher on lines that were auctioned compared to direct negotiations. Total surplus would also have been higher on lines that were negotiated, by 16%, had they been auctioned. We explain the dominance of negotiations over competitive procurement with the existence of (actual or perceived) administrative costs. Our preferred estimates indicate that set-up costs amounted to 45% of total surplus.

These results contain several interesting implications. Procurement auctions can substantially dominate direct negotiations and lead to strong efficiency gains. Auctions should be the preferred mode of procurement for regional rail service in a context like the one we study. The key impediment appears to be the willingness of the agency to set up the auction. Policies that support regional agencies in running the auctions (or make auctions compulsory) would therefore appear plausible.

There may be specific aspects of the market situation that fostered the positive effects of competition. Most importantly, the analysis concerned an early phase after the reform. At the time, there was substantial entry into the market, which limited the ability of suppliers to ask for high transfers in auctions. In the meantime, there has been some consolidation of the market, with several big players interacting repeatedly. It is not obvious that competitive procurement works equally well under these circumstances. It also seems likely that the success of competitive procurement was related to the possibility (and willingness) to specify the desired services quite clearly ex ante. In other contexts, for instance in large construction projects, there may be more unforeseen contingencies which limit the potential for auction procedures, as renegotiation may be important. An interesting task for future work would be to identify the circumstances under which competitive procurement dominates negotiations. The task is challenging, as it would most likely involve the comparison of experiences in different industries and different countries.

A Appendix: Derivations

A.1 Proof of Proposition 1

(i) $p = c + y$ follows from our assumptions. Inserting this into the agency payoff and taking the first-order condition with respect to q yields $2c\sqrt{q} - s + 2\sqrt{q}y = 0$. The unique solution is $q = \frac{1}{4}\frac{s^2}{(c+y)^2}$. The second-order condition holds globally.

(ii) Using (i), the payoff of the agency is $\left(s\sqrt{q} - pq\right) = \frac{1}{2}\frac{s^2}{(c+y)} - (c+y)\frac{1}{4}\frac{s^2}{(c+y)^2} = \frac{1}{4}\frac{s^2}{c+y}$. As the expected margin $p - c$ of the incumbent is y, his expected profit is $mq = \frac{ys^2}{4(c+y)^2}$.

A.2 Proof of Proposition 2

(i) The expected lowest bid in a procurement bid is $p^A = c_{(2)}$. Thus, the first-order condition for the agency is $\left(s - 2c^{(2)}\sqrt{q}\right)/2\sqrt{q} = 0$. Hence $q = s^2/4c_{(2)}^2$. The second-order condition holds globally.

(ii) The agency payoff is $\left(s\sqrt{q} - c_{(2)}q\right) = \left(\frac{s^2}{2c^{(2)}} - c_{(2)}\frac{s^2}{4\left(c_{(2)}\right)^2}\right) = s^2\left(\frac{1}{4\left(c_{(2)}\right)}\right)$. The expected incumbent payoff from an auction is is $\frac{mq}{N} = \frac{s^2\left(c_{(2)} - c_{(1)}\right)}{N4\left(c_{(2)}\right)^2}$.

A.3 Derivation of (8)

Inserting W_N^* and Π_N^* from Proposition 1 and W_A^* and Π_A^* from Proposition 2, we obtain

$$\left(\frac{s^2}{4c^{(2)}}\right)^{\tau}\left(\frac{s^2\left(c_{(2)} - c_{(1)}\right)}{4N\left(c_{(2)}\right)^2}\right)^{1-\tau} > \left(\frac{1}{4}\frac{s^2}{c+y}\right)^{\tau}\left(\frac{ys^2}{4\left(c+y\right)^2}\right)^{1-\tau}.$$

Simple rearrangements yield

$$\begin{aligned}\left(\frac{1}{c_{(2)}}\right)^{\tau}\left(\frac{\left(c_{(2)} - c_{(1)}\right)}{N\left(c_{(2)}\right)^2}\right)^{1-\tau} &> \left(\frac{1}{c+y}\right)^{\tau}\left(\frac{y}{\left(c+y\right)^2}\right)^{1-\tau} \Leftrightarrow \\ \left(\frac{c_{(2)}}{c+y}\right)^{\tau-2}\left(\frac{\left(c_{(2)} - c_{(1)}\right)}{N}\right)^{1-\tau} &> y^{1-\tau} \Leftrightarrow \\ \left(\frac{\left(c_{(2)} - c_{(1)}\right)}{Ny}\right)^{1-\tau} &> \left(\frac{c_{(2)}}{c+y}\right)^{2-\tau}.\end{aligned} \tag{17}$$

A.4 Derivation of (13)

$$\begin{aligned}\mathbb{E}[b_{[1]}] &= \int_{-\infty}^{\infty} xf(x_{[1:n]})dx = \frac{n!}{(n-1)!}\int_{-\infty}^{\infty} x[1 - F(x)]^{n-1}f(x)dx \\ &= n\int_0^{\infty} x\{\exp[-(x/\lambda)^{\rho}]\}^n(\frac{\rho}{\lambda})(\frac{x}{\lambda})^{\rho-1}dx \\ &= n\rho\int_0^{\infty}(\frac{x}{\lambda})^{\rho}\{\exp[-(x/\lambda)^{\rho}]\}^n dx = \text{integration by substition} \\ &= n\lambda\int_0^{\infty}(\frac{1}{n})^{(1/\rho+1)}y^{(1/\rho)}\exp(-y)dy \\ &= n\lambda(\frac{1}{n})^{\left(1/\rho+1\right)}\Gamma\left(1/\rho+1\right) \text{ with } \Gamma(t) = \int_0^{\infty} x^{t-1}\exp(-x)dx\end{aligned} \tag{18}$$

B Appendix: Procurement prices under negotiations

We now show how we constructed line-specific prices with negotiations from the average price in the agency and from information on line-specific access charges. We make the following assumptions. For each individual line $i = 1, ..., I$, the price charged by DB Regio is calculated using the expected costs of delivering the service. These reflect two cost components: The costs of using infrastructure and the costs of running the service (a total number $k_i = q_i l_i$ of train kilometers, where q_i is the frequency of service, and l_i is the length of the line in kilometers). First, note that the costs of using infrastructure are the access charges that have to be paid to DB Netz. These costs differ across lines. We have detailed information on these access costs for each line. Let a_i be the access charge for a line. We calculated the detailed access prices for 504 out of the 551 lines, or 91 %, of the lines observed in our sample (the percentage with information on access price is 92 % on lines that were negotiated with the incumbent). For the remaining 47 lines we could not match the start and end station with the data base providing information on access prices. We impute missing prices using linear regression.

Second, for simplicity, we suppose that the remaining costs of running the service are identical on the different lines but they differ across German states. Let x_j denote the remaining costs of running the service, with $j = 1, ..., J$ indexing German states (*Bundesländer*). The resulting negotiation price is

$$t_i^N = a_i + x_j.$$

We also use information on the average negotiation price by state p_j. We estimate x_j assuming that the average (frequency of service weighted) negotiation price is identical to the state level negotiation price. Let $b_{ij} = 1$ if line i is situated in state j, and $b_{ij} = 0$ otherwise, and $D_i = 1$ if the line is auctioned, and $D_i = 0$ otherwise. It follows that

$$p_j = \frac{\sum_i^I b_{ij}(1 - D_i)k_i^N t_i^N}{\sum_i^I b_{ij}(1 - D_i)k_i^N}.$$

This means we can back out an estimate of the state specific cost of running the service is

$$x_j = \frac{p_j \sum_i^I b_{ij}(1 - D_i)k_i^N (p_j - a_i)}{\sum_i^I b_{ij}(1 - D_i)k_i^N}.$$

The resulting negotiation prices t_i^N have a number of properties. First, the state average negotiation prices match the quoted prices exactly. Second, the resulting negotiation price components match published sources well. The average total negotiation price was 8.73 EUR per train kilometer, with the access charge amounting to 3.53 EUR on average. Thus, the access charge makes up 40 % of the total price. This is consistent with LNVG (2010) who argue that infrastructure costs amount to about 40% of the costs of railway services.

Table A1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
	(1)	(2)	(3)	(4)	(5)
Panel A. Negotiated lines					
incumbent	420	.9333333	.2497413	0	1
log price	420	2.153423	.1374255	1.822475	2.495075
log frequency	420	.0531745	.7345221	-2.385227	2.221432
electric traction	420	.0676378	.5000284	-.4561717	.5438282
distance to city (km)	420	-2.097546	26.38691	-17.62612	105.3739
log track length	420	.0109127	.7812467	-2.41521	1.888855
log pop largest city	420	.1594694	1.573104	-5.234045	3.136331
log pop 2nd largest city	420	.1001328	1.452812	-5.063012	4.053715
regional factor	420	1.124881	.2426893	1	2.45
Panel B. Auctioned lines					
incumbent	139	.2014388	.4025257	0	1
log price	64	1.875495	.2707111	.8415672	2.198335
log frequency	139	-.1606713	.5693123	-1.793727	1.477479
electric traction	139	-.2043732	.4356159	-.4561717	.5438282
distance to city (km)	139	6.337911	35.56386	-17.62612	124.3739
log track length	139	-.0329737	.8348207	-2.41521	1.592123
log pop largest city	139	-.4818498	1.378029	-3.747652	2.422949
log pop 2nd largest city	139	-.3025594	1.312144	-4.126604	2.926466
regional factor	139	1.195396	.3186436	1	2.45
number of bidders	41	4.609756	1.686387	2	8

Notes: Summary statistics for negotiated and auctioned lines.

Source: Own calculations.

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