● Article ●

The effect of bundling several contracts on electricity procurement auctions

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Abstract

After the several years of experience in electricity procurement auctions in the retail electricity market, auctioneers' behavior of bundling several contracts started to appear more frequently. This paper investigates the effect of such bundling behavior on bid price and competition. We regress the bid price, the money left on the table, and participation rates of new entrants on multiple covariates including bundling dummy. We found some interesting facts that are consistent with the previous theories of bundling. First, we found that even after controlling for the scale of auctions, bundling reduces the bid price, implying there exists the bid discounting effect of bundling other than the synergies from scale economy. Second, bundling several electricity contracts in different locations reduces the money left on the table, implying it reduces uncertainty the bidders face. Third, bundling increases the number of bidders in an auction. More specifically, bundling increases the participation rate of strong bidders while reduces that of weak bidders.

1. Introduction

After the several years of experience in electricity procurement auctions in the retail electricity market, auctioneers' behavior of bundling several contracts started to appear more frequently. This paper investigates the effect of such bundling behavior on bid price and competition.

In these electricity procurement auctions, auctioneers decide whether contracts should be bundled or not. When an auctioneer sells a bundle of contracts at auction, bidders submit their bids for the bundle. Therefore, unlike recently well-discussed combinatorial auctions, bidders do not have flexibility to choose between submitting a package and stand-alone bids. It is so called pure bundling in literature.

There are several potential effects from such bundling. The practice of bundling or tying is not limited to auctions and there is a growing body of literature on the rationale for bundling by a multiproduct monopolist. The main reasons for bundling are: (i) complementarity between the different objects and (ii) production synergies such as economies of scale and scope. However, more recent work has shown additional explanations for bundling. For example, consider the case where consumers have unit demand for each of the objects and their valuation for a bundle of objects is just the sum of the valuations for each object. Each consumer's valuation is independently distributed across objects. Then, it has been shown that bundling increases the seller's profit as long as the correlation of each consumer's valuation is not too positive (see Varian 2009). Similarly, Bakos and Brynjolfsson (1999) showed that bundling a large number of information goods, which incurs almost zero marginal cost, raised the seller's revenue. This is because the law of large numbers makes the consumers' valuations converge to a certain value, and it was easier to predict the consumers' valuations. Therefore, by bundling, the seller could extract almost all consumer surplus by setting an appropriate price.

In a procurement auction setting, Olivares et al. (2012) realized that even in the absence of cost synergies, bidders may have incentive to submit discounted bids for bundles. They call such behavior strategic bundling. The discount from strategic bundling arises because, similar to the problem of multiproduct monopolists described above, the dispersion of the minimum valuations by the opponent bidders for a bundle is smaller than that for a component. Such strategic bundling may cause efficiency to deteriorate in the sense that a bidder with lower costs for individual contracts might not obtain the contract.

Chernomaz and Levin (2012) also introduced another type of problem, namely bidder asymmetries due to bundling. Asymmetry may arise when not all bidders can purchase a bundle of objects because of limitations such as capacity, financial, or geographical constraints. Then, auctions become asymmetric, in the sense of Maskin and Riley (2000), and, hence, may result in an inefficient outcome. Olivares et al. (2012) argued that if previous experience matters to form bidders' costs in procurement auctions and if the bundling excludes some bidders because of some form of constraint, then inactive firms would have disadvantages in future auctions and competition may deteriorate.

The current study conducts simple reduced form analyses to investigate the effect of bundling on bid price and competition using the dataset of the electricity procurement auctions in Japan's retail electricity market. The positive aspects of bundling are expected because it is considered that electricity distribution realizes economies of scale and density. On the other hand, there exists the possibility of negative aspects of bundling to prevail, such as the strategic bundling and the exclusion of small bidders. The current study confirms some aspects that the previous literature discusses.

In the related literature, Palfrey (1983) was a pioneer investigator of bundling in an auction setting. He found that the decisions of sellers on bundling depended on the number of bidders in auctions. If the number of bidders was small, sellers had higher incentives to bundle several objects. He also showed that when there were more than two buyers, the buyer with the higher valuation preferred bundling. The reason for this is similar to the multiproduct monopolist's reason for bundling. That is, the distribution of valuations for a bundle becomes a mean-preserving contraction of the distributions of valuations for its component objects. Buyers that are on the upper tail of the distribution of valuations for the bundle are more likely to win the bundled auction than in the separate auctions. Armstrong (2000) investigated the optimal auction for a multiproduct monopolist. He investigated the optimal auction when the monopolist could sell the objects separately on the separate auctions as well as under a certain degree of bundling. He concluded that the optimal auction again depended on the number of bidders.

In the empirical literature, Cantillon and Pesendorfer (2007) investigated the identification problem in the first-price multi-unit auction. The research was motivated by the actual practice of combinatorial auctions to distribute bus routes in London. In those auctions, bidders were allowed to bid on combinations of routes as well as on individual routes. One important finding was that there need not be cost synergies for choices of combinatorial bids because there was a strategic motive for combinatorial bids arising from the competition between combinatorial bids and stand-alone bids (the threshold problem). Those authors developed and applied the estimation methods to the dataset of the London bus routes market to quantify the magnitude of cost synergies. Kim et al. (2014) investigated the performance of the Chilean school meals auction. They developed estimation methods that overcome the computational difficulties arising from the large number of observed bids in a combinatorial auction. Chernomaz and Levin (2012) established the model of combinatorial first price auctions and conducted an experiment to investigate the optimality and efficiency of such auctions. They showed that there was a trade-off between synergies arising from packaging and the threshold problem. The threshold problem could lose efficiency of allocations.

Chernomaz and Levin (2012) argued that the degree of synergies arising from packaging was an important factor in determining whether packaging is optimal for the auctioneer. With the existence of negative aspects of packaging such as the threshold problem, the auctioneer should only allow package bidding when there are enough synergies realized from packaging. Therefore, there are many empirical studies that investigate whether synergies are realized by winning multiple objects. Olivares et al. (2012) estimated the magnitude of cost synergies under the combinatorial auctions using Chilean school meals procurement auctions to answer the question of which packaging should be allowed.

Our goal is to investigate the effect of the current (pure) bundling behavior on revenue and efficiency. Furthermore, because pure bundling can never be solely optimal, it would be interesting if we can investigate the effect of introducing a combinatorial auction. However, our reduced form analyses do not allow us to compare the current outcome with counterfactuals. Therefore, to answer these questions, we need to wait for a structural analysis planned as the next step. Yet, our reduced form analyses found some interesting facts. First, we found that even after controlling for the scale of auctions, bundling reduces the bid price, implying that there exists a bid discounting effect of bundling other than the synergies from scale economy. Second, bundling several electricity contracts in different locations reduces the money left on the table, implying it reduces the uncertainty that the bidders face. Third, bundling also affects the participation behavior of the bidders.

Bundling increases the number of bidders in auctions, but this effect is limited to the strong bidders.

2. Electricity procurement auction and bundling

In Japan's retail electricity market, 10 electric power companies (EPCs) used to supply electricity as local monopolists. The liberalization started in 2000, and the new electricity companies, known as Power Producers and Suppliers (PPSs) started to supply electricity at unregulated rates. The liberalization was conducted gradually. In the starting year of 2000, the PPSs were only allowed to supply users with electric power and voltage requirements greater than 2000 kilowatts (kW) and 20 kilovolts (kV), respectively. The target of liberalization was later expanded to users with power and voltage requirements greater than 500 kW and 6000 V in 2004, then to 50 kW in 2005, and it was entirely liberalized in 2016.

With this wave of liberalization in the retail market, the government and public agencies started to employ first-price sealed bid auctions to procure electric power for public facilities, including waterworks, roadway facilities, schools, hospitals, and government office buildings. The (former monopoly) general electric power companies and the PPSs compete on these auctions. During the period between April 2004 and March 2008, which our dataset covers, 2,334 contracts with 17 million MWh were auctioned.

The auction-letting process is as follows. Each public agency advertises auctions on its webpage, in its official gazette, or in newspapers. These advertisements include detailed information including the contract period, the required maximum (peak) power (kW), the (expected) amount of electricity they use during the contract period (kWh), the detailed plan for usage including the peak demand, daytime demand, nighttime demand and summer demand, the place of delivery, the qualifications needed for participating in the tendering process, and the time limit for tenders. The participants submit the total charge, including the fixed and variable rates, for the amount of electricity they would supply for the whole contract period. They compete on the total charge. The bidder submitting the lowest bid that is lower than the reserve price wins the auction. If the lowest bid is higher than the reserve price, then the agency either conducts a second auction (usually scheduled a few weeks after the original auction) or enters into bargaining with one of the bidders.

Contracts are sometimes bundled together to be auctioned. After the several years of auction experience, this practice of bundling several contracts started to be observed more frequently. For example, Osaka Legal Affairs Bureau used to offer contracts for its agency office buildings separately in 2006. But, in 2007, it bundled the 12 contracts for individual office buildings together, and conducted one auction for the bundled contracts. Similarly, Tokyo Regional Taxation Bureau started to bundle the contracts for 76 tax offices together in 2005. On the other hand, Nagoya Regional Taxation Bureau continued to offer individual auctions for each tax office in both 2006 and 2007.

3. Data and descriptive statistics

All electric power procurement auctions conducted throughout Japan between 2004 and 2007 fiscal years are identified by the Electric Daily News, a newspaper specializing in electricity markets. The Electric Daily News data contain information on the date when bids opened, the government agency (the auctioneer), the required peak power (kW), the amount of electricity required (kWh), the load factor, the contract period, the place of delivery, the winner of each auction, the winning bid, either the identity or number of other bidders, and other descriptive auction information, including whether there is a restriction on CO2 emissions. Whereas the data contain a large number of observations, they do not include losing bids (i.e., we only have winning bids) and for most cases, the identity of losing bidders. Therefore, we asked each auctioneer to reveal the identities of all bidders and their bid amounts by sending letters through the official information disclosure system in Kanto area where the largest EPC, TEPCO, used to operate as a local monopoly. We use these auction data from Kanto area between the fiscal years 2004 and 2007.

Table 1 presents the summary statistics of the data. In our datasets, 425 auctions were identified after excluding missing information. The table shows the characteristics of such auctions. We can see from the sixth row that these auctions were not very competitive. The average number of participants was less than two, which means for many auctions, there was only one participant, TEPCO. The variable *Incumbent only* had the value of 1 if there was only one participant in the auction. We can see that about 58 % of auctions had only one participant. The variable *Incumbent win* had the value of 1 if the general electric company (the former monopolist) won the auction. We can see that about 70% of auctions were won by the former monopolist or incumbent. The variable CO2 had the value 1 if the contract had CO2 emission restrictions. Because the PPSs usually had fossil fuel power stations that generate more CO2, they tended to be disadvantaged in auctions with CO2 emission restrictions (see Hattori and Saegusa 2010). *Load factor* is the ratio between the average and maximum (peak) usage of electricity during the contract period. This was calculated as the required amount per year divided by the required capacity, that is, the kWh divided by "the maximum power (kW) × 24×365". A low load factor induces inefficiency because electricity companies need to hold capacity that is not used most of the time. On the other hand, high load factor can be a burden for the PPSs because fuel power plants are usually used for peak usage. The variable *high voltage* is a dummy variable that takes the value of 1 if the contract for auction is for voltage greater than 20,000V. The last row of the table shows the average unit bid (yen/kWh). There are 778 observations, and, naturally, the average unit bid is higher than average unit winning bid (*unit winning bid*).

Table 1 : Summary statistics of the variables

Variable	# of observations	Mean	Std. Dev.	Min	Max
Unit winning bid	425	14.27	3.99	7.88	46.16
Peak power (kW)	424	2,254.73	4,703.17	12.00	68,000.00
Load factor	424	0.17	0.11	0.00	0.85
Amount (thousand kWh)	425	10,500	27,200	36	332,000
# of participants	425	1.97	1.40	1.00	7.00
High voltage	425	0.28	0.45	0.00	1.00
Contract length	425	1.12	0.47	1.00	3.00
CO2	425	0.32	0.47	0.00	1.00
Incumbent only	425	0.58	0.49	0.00	1.00
Incumbent win	425	0.69	0.46	0.00	1.00
Unit bid	778	15.69	6.34	7.88	81.43

In Kanto area, there were 34 auctions observed in which several contracts were bundled. For example, Tokyo Legal Affairs Bureau bundled the contracts of electricity for 18 local offices. Yokohama city bundled the contracts for nine public high schools together. These auctions bundle the electricity contracts for distinct locations. On the other hand, some auctions bundle several contracts for the same location. For example, Kanagawa, Ibaragi, and Chiba prefectures bundled the contracts for different office buildings within the same site. Ibaragi prefecture bundled the contract for the public hospital and that for the related facilities in the same site. Although both types similarly bundled several contracts, they might be considered differently by the electricity companies because supplying electricity to different areas might not be the same as supplying electricity to the same area because of differences in the transmission and distribution networks. Therefore, we call the first type as Type-I bundling and second as Type-II bundling, and try to see the effect of bundling by distinguishing them. "Bundling", however, includes both types otherwise specified.

Table 2 compares the auction characteristics between ordinary auctions and auctions under which several contracts are bundled. The asterisks next to the differences in the last column indicate the significance level of the t-test. We can see that the maximum power (*peak power*) is higher under the bundled auctions, but this difference is not statistically significant. The total amount of electricity to be supplied (*amount*) is lower under the bundled auctions but this is again not statistically significant. Higher power and lower amount are reflected in a lower load factor under the bundled auctions with statistical significance. We can also see that under the bundled auctions, the unit winning bid is higher with statistical significance. The ratio of auctions where only the incumbent participates (*incumbent only*) is lower whereas the number of participants is higher with statistical significance under the bundled auctions. The winning rate of incumbent (*incumbent win*) is lower with statistical significance as well. This suggests that the PPSs are more likely to participate into bundled auctions and therefore win such auctions. However, this might merely be the effect of the differences in the characteristics of bundling and ordinary auctions, such as lower load factor under the bundled auctions. To see whether bundling itself affects the participation of the PPSs, we undertook regressions to account for these differences in characteristics.

Table 3 presents the differences in auction characteristics between the ordinary and Type-I bundled auctions. As noted above, Type-I consists of the auctions in which the contracts for the different locations are bundled together. We can see from Table 3, when we exclude the bundled auctions under which the several auctions for the same sites are bundled (Type-II), that there are no statistically significant differences in the numbers of participants, incumbent only, and incumbent win. This implies that the PPSs are more likely to participate in the Type-II bundling auctions. The reason might be that distributing electricity to different locations at the same time might be costly for the PPSs.

Table 2 : Differences in auction characteristics between ordinary and bundled auctions

	Ordinary auctions			Bundled auctions			Difference
Variable	# of observations	Mean	Std. Dev.	# of observations	Mean	Std. Dev.	Mean
Unit winning bid	391	14.09	3.71	34	16.29	6.16	2.20 ***
Peak power (kW)	390	2156.09	4696.30	34	3386.24	4702.81	1230.15
Load factor	390	0.17	0.11	34	0.12	0.07	−0.05 ***
Amount (thousand kWh)	391	10600	27500	34	10000	22700	−600
# of participants	391	1.91	1.36	34	2.65	1.65	0.74 ***
High voltage	391	0.27	0.44	34	0.38	0.49	0.12
Contract length	391	1.12	0.47	34	1.12	0.48	0.00
CO2	391	0.32	0.47	34	0.41	0.50	0.09
Incumbent only	391	0.60	0.49	34	0.29	0.46	−0.31 ***
Incumbent win	391	0.71	0.45	34	0.47	0.51	−0.24 ***
Unit bid	698	15.47	5.60	80	17.60	10.71	2.13 ***

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively.

Table 3 : Differences in auction characteristics between ordinary and Type-I bundled auctions

	Ordinary auctions			Type I bundling			Difference
Variable	# of observations	Mean	Std. Dev.	# of observations	Mean	Std. Dev.	Mean
Unit winning bid	410	14.15	3.82	15	17.30	6.85	3.15 ***
Peak power (kW)	409	2176.36	4622.52	15	4391.60	6367.47	2215.24 *
Load factor	409	0.17	0.11	15	0.12	0.08	−0.05
Amount (thousand kWh)	410	10400	26900	15	15200	33400	4800
# of participants	410	1.97	1.41	15	1.87	1.13	−0.11
High voltage	410	0.27	0.45	15	0.33	0.49	0.06
Contract length	410	1.12	0.46	15	1.27	0.70	0.15
CO2	410	0.31	0.46	15	0.80	0.41	0.49 ***
Incumbent only	410	0.59	0.49	15	0.40	0.51	−0.19
Incumbent win	410	0.70	0.46	15	0.60	0.51	−0.10
Unit bid	754	15.56	6.10	24	19.76	10.99	4.20 ***

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively.

4. Empirical results

Unit bid

We first estimate the effects of auction characteristics on unit bid. The unit bid is defined as the bid divided by the amount of electricity to be supplied. Table 4 presents the empirical results on the unit bid. Estimation (1) includes the load factor, quadratic of load factor, inverse of load factor, logarithm of peak power (kW) and its quadratic, high voltage dummy, the number of participants, the contract length, CO2 dummy, and the bundling dummy variable that takes a value 1 if the auction bundles several contracts. We also include the interaction term between the bundling dummy and the logarithm of peak power. We can see from the table that all variables, except the high voltage dummy, the interaction term of bundling dummy and the logarithm of peak power, and the CO2 dummy, statistically significantly affect the unit bids. Higher load factor reduces the unit bid for a certain value of load factor. However, if the load factor is sufficiently high, the higher load factor increases the unit bid. This makes sense because contracts with extremely low and high load factors are very costly for electricity companies.

The logarithm of peak power and its quadratic are both statistically significant. We calculate the marginal effect of peak power. The average value of the marginal effect is –0.595, implying that there is a scale merit on electricity contracts on average. We see that the unit bid is lower under the bundling auction. This discounted bid of bundling exists even after controlling for the peak power. In addition, the unit bid is lower when the number of bidders is higher, and the unit bid is higher for contracts with longer periods. The lower unit bid with the larger number of bidders is consistent with auction theory. The reason for the higher unit bid with a longer contract period may be that risk and uncertainty increase with the longer period and therefore the costs to the electricity companies increase.

The right panel of Table 4 shows the results of Estimation (2). Estimation (2) includes the same variables as Estimation (1), except that the definition of bundling is changed. In Estimation (2), the bundling dummy takes a value of 1 if the auction is Type-I bundling, i.e., auctions that bundle the contracts in different locations. We can see that in Estimation (2), the coefficient on bundling is no longer statistically significant, and its sign is changed to positive. From the results on Estimations (1) and (2), we conclude that bundling reduces bid price only when the bundled contracts are for the same site. When the companies need to distribute electricity to different locations, their costs seem to increase to offset the any discounting effect of bundling.

Table 4 : Empirical results on unit bid

	Estimation (1) with bundling			Estimation (2) with Type-I bundling		
Unit bid	**Coefficient**	**Std. Err.**		**Coefficient**	**Std. Err.**	
Load factor	−42.27	3.79	***	−42.05	3.80	***
Load factor^2	37.42	6.08	***	37.56	6.11	***
1/load factor	0.22	0.01	***	0.22	0.01	***
Log (kw)	1.91	0.85	**	1.86	0.86	**
Log (kw)^2	−0.16	0.06	**	−0.15	0.06	**
High voltage	−0.23	0.38		−0.36	0.38	
Bundling	−1.08	0.42	**	3.13	4.46	
Bundling × log(kw)	0.07	0.10		−0.46	0.58	
The number of participants	−0.17	0.09	*	−0.18	0.10	*
Contract length	2.57	0.46	***	2.54	0.46	***
CO2	−0.02	0.29		0.01	0.29	
Constant	10.13	3.07	***	10.20	3.10	***
Fiscal year dummy	Yes			Yes		
F (14, 761)	208.82			206.71		
Adj R-squared	0.7897			0.788		
The # of observations	776			776		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively.

Money left on the table

We now investigate the effect of bundling on money left on the table, i.e., the difference between the lowest and the second lowest bids. The higher money left on the table may result from higher uncertainty. Therefore, if bundling reduces uncertainty or dispersion of the cost distribution, as suggested by the theories such as Bakos and Brynjolfsson (1999), it would reduce the money left on the table. We regress the money left on the table on the same covariates as the above estimation. The left panel of Table 5 shows the empirical results obtained from this regression. We can see that bundling does not affect the money left on the table. The right panel of the table shows the empirical results when we change the definition of bundling. In the Estimation (2) in Table 5, the dummy variable *bundling* takes the value of 1 if the auction bundles the contracts in different locations (Type-I bundling). We see that under the Estimation (2), bundling does affect money left on the table as well as the interaction term between bundling and the logarithm of peak power. We calculate the marginal effect of bundling for each value of log (kW). The average value of the marginal effect of bundling is –0.150. It seems that, on average, bundling reduces uncertainty. However, this is only the case of bundling with contracts in different locations. This is consistent with the theories such as Bakos and Brynjolfsson (1999) because they showed that to reduce the uncertainly, each individual contract needs to be sufficiently negatively correlated. This is probably not the case for auctions that bundle the contracts within the same site.

Table 5 : Empirical results on money left on the table

	Estimation (1) with bundling			Estimation (2) with Type-I bundling		
Money left on the table	**Coefficient**	**Std. Err.**		**Coefficient**	**Std. Err.**	
Load factor	–22.54	13.68		–27.28	13.11	**
Load factor^2	61.30	53.76		75.25	51.20	
1/load factor	0.04	0.01	***	0.04	0.01	***
Log (kw)	9.36	3.41	***	8.97	3.33	***
Log (kw)^2	–0.65	0.23	***	–0.61	0.23	***
High voltage	1.70	0.59	***	1.56	0.58	***
Bundling	–0.49	0.49		14.61	5.29	***
Bundling × log(kw)	–0.13	0.11		–2.09	0.69	***
The number of participants	–0.24	0.15		–0.24	0.15	*
Contract length	–4.65	7.10		–4.31	6.93	
CO2	0.32	0.41		0.21	0.40	
Constant	–27.00	13.75	**	–26.36	13.43	**
Fiscal year dummy	Yes			Yes		
F (14, 139)	6.65			7.44		
Adj R-squared	0.3408			0.3707		
The # of observations	154			154		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively.

Participation

We now investigate the participation behavior of electricity companies. First, we regress the number of participants on the same covariates (except the number of participants) as above to see whether bundling affects participation. The left panel of Table 6 shows the empirical results of the number of participants. We see that the bidder's participation depends on the load factor, the scale, the high voltage dummy and the bundling dummy. We show only the results of Type-II bundling because we found other bundling definitions do not affect the bidder's participation behavior. We see that the bundling dummy and the interaction term between bundling and logarithm of peak power are statistically significant. We calculate the marginal effect of the bundling, and its average value is 0.118. We conclude that, on average, bundling increases the number of participants. This implies that bundling attracts bidders not merely because it increases scale. The middle panel of Table 6 shows the empirical results of the ratio of auctions where only the incumbent participates (incumbent only). We see that the bundling-related variables are not statistically significant. This may imply that along with the results of the number of participants, bundling increases the number of participants in the auctions where there are already some PPSs participating. The right panel of Table 6 shows the empirical results of the winning rate of

Table 6 : Empirical results of the number of participants, the ratio of the auctions where only the incumbent participates, and the ratio of the auctions where the incumbent wins

	The # participants			Incumbent only			Incumbent win		
	Coefficient	Std. Err.		Coefficient	Std. Err.		Coefficient	Std. Err.	
Load factor	−13.89	1.47	***	4.52	0.56	***	4.93	0.52	***
Load factor^2	13.16	2.28	***	−3.95	0.87	***	−4.58	0.81	***
1/load factor	0.00	0.00		0.00	0.00		0.00	0.00	
Log (kw)	1.01	0.31	***	−0.41	0.12	***	−0.37	0.11	***
Log (kw)^2	−0.06	0.02	***	0.03	0.01	***	0.02	0.01	***
High voltage	0.47	0.17	***	−0.08	0.06		−0.06	0.06	
Type II Bundling	−7.24	1.98	***	0.89	0.76		1.20	0.70	*
Type II Bundling × log(kw)	1.04	0.27	***	−0.13	0.10		−0.17	0.09	**
Contract length	0.23	0.16		−0.09	0.06		−0.15	0.06	***
CO2	0.07	0.13		−0.06	0.05		0.07	0.05	
Constant	−0.56	1.13		1.76	0.43	***	1.61	0.40	***
Fiscal year dummy	Yes			Yes			Yes		
F (13, 409)	29.43			20.34			21.35		
Adj R-squared	0.4669			0.3733			0.3853		
The # of observations	423			423			423		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively.

the incumbent. We see that here bundling-related variables are statistically significant. We find that the average marginal effect of the bundling is –0.011. We see that, under bundling, the winning rate of the incumbent is reduced because there are more PPSs participating in such auctions.

We also investigate the effect of bundling on the participation decision of each bidder. Because the incumbent company participates in almost all auctions, we focus on the behavior of the PPSs. We investigate the top five most frequently participated PPSs. PPS1 participated in 28.7% of auctions, PPS2 participated in 20.0%, PPS3 participated in 13.0%, PPS4 participated in 10.0%, and PPS5 participated in 7.1% of auctions. We show only the effect of Type-II bundling because Type-I bundling did not affect any PPS's behavior.

Table 7 shows the empirical results of each PPS's participation decision. The first panel represents the regression results of PPS1's participation rate on the covariates. It is shown that Type-II bundling affected its participation decision. We calculate the marginal effect of the bundling on PPS1's participation rate, and calculate its average. The average marginal effect of bundling was 0.035, implying that Type-II bundling on average increases the participation rate of PPS1 by 3.5%. Similarly, the effect of bundling is statistically significant for PPS2's and PPS3's participation rates, as shown in the second and third panels, respectively. The average marginal effects of bundling are calculated as 0.009 and 0.062 for PPS2 and PPS3, respectively. That is, bundling increases the participation rates of PPS2 and PPS3 by 0.9% and 6.2%, respectively. On the other hand, the effect of bundling is not statistically significant for PPS4.

The effect of bundling is statistically significant for PPS5, but the calculated average marginal effect of bundling is –0.001. Thus, it seems that bundling lowers the participation rate of PPS5 by 0.1%.

From the above regression results for an individual bidder's participation decision, we conclude that bundling increases the participation rate of the PPSs that have already had a certain level of experience. Bundling is not attractive for fringe bidders that participate in less than 10% of auctions. If the bidders with more experience are low cost bidders, this finding is consistent with the theory of the previous researches such as Palfrey (1983).

Table 7 : Empirical results of each PPS's participation rate

	PPS1			PPS2			PPS3		
	Coefficient	Std. Err.		Coefficient	Std. Err.		Coefficient	Std. Err.	
Load factor	−4.64	0.52	***	−3.66	0.45	***	−2.99	0.43	***
Load factor^2	4.52	0.81	***	3.57	0.70	***	2.98	0.67	***
1/load factor	0.00	0.00		0.00	0.00		0.00	0.00	**
Log (kw)	0.35	0.11	***	0.16	0.10	*	0.14	0.09	
Log (kw)^2	−0.02	0.01	***	−0.01	0.01		−0.01	0.01	
High voltage	0.07	0.06		0.07	0.05		0.08	0.05	
Type Ⅱ Bundling	−1.67	0.70	**	−2.29	0.61	***	−0.97	0.58	*
Type Ⅱ Bundling × log(kw)	0.24	0.10	**	0.33	0.08	***	0.15	0.08	*
Contract length	0.07	0.06		0.09	0.05	*	0.07	0.05	
CO2	0.03	0.05		−0.04	0.04		−0.05	0.04	
Constant	−0.56	0.40		−0.10	0.35		−0.10	0.33	
Fiscal year dummy	Yes			Yes			Yes		
F_value	18.73			21.45			8.81		
Adj R-squared	0.3533			0.3871			0.1943		
The # of observations	423			422			422		

	PPS4			PPS5		
	Coefficient	Std. Err.		Coefficient	Std. Err.	
Load factor	−0.41	0.40		−1.76	0.34	***
Load factor^2	0.00	0.62		1.65	0.52	***
1/load factor	0.00	0.00		0.00	0.00	***
Log (kw)	0.10	0.08		0.10	0.07	
Log (kw)^2	−0.01	0.01		−0.01	0.01	
High voltage	0.04	0.05		0.08	0.04	**
Type Ⅱ Bundling	−0.12	0.54		−1.53	0.45	***
Type Ⅱ Bundling × log(kw)	0.02	0.07		0.22	0.06	***
Contract length	0.05	0.04		0.04	0.04	
CO2	−0.01	0.03		−0.07	0.03	**
Constant	−0.33	0.30		−0.05	0.26	
Fiscal year dummy	Yes			Yes		
F_value	6.41			7.17		
Adj R-squared	0.1431			0.1596		
The # of observations	422			423		

Note: ***, ** and * represent the significance levels of 1%, 5% and 10%, respectively.

5. Conclusion

Our reduced form analyses show some interesting findings. The regression of unit bid shows that even after controlling for the scale of auctions, there is a bid discount on bundled auctions. That is, there seems to be a bid discounting effect of bundling other than the synergies from economy of scale. This evidence is found only for Type-II bundling probably because the cost of distributing electricity to different locations in Type-I bundling offsets the discounting effect of bundling. There are some possible reasons for the discounting effect (other than the synergies from scale economy) of bundling. The first candidate is the strategic bundling discussed in Olivares et al. (2012). Because the distribution of the minimum cost of the other bidders for a bundle has lower dispersion, a bidder can submit a lower bid. The second candidate is that bundling reduces bidders' risk and therefore shifts their cost distribution to the lower side. The bidders in the retail electricity auctions bear risk such that consumers may use more electricity than they planned. In such a case, the retail electricity companies still need to supply electricity to meet the extra demand and there is a cost of preparing electricity supply to meet such sudden increasing demand. If a company cannot supply electricity to meet demand, it is required to pay monetary penalty. Under bundling, such unexpected deviation between planned and actual demand may be diversified, and therefore, bidders might have lower costs under bundling.

The two scenarios above, the strategic bundling and the risk lowering effect, are different in terms of the effect of bundling on cost distributions. The first scenario is based on the effect to reduce the dispersions of cost distributions while the second one is based on the effect to shift the distributions. If the dispersions of cost distributions is smaller, then the money left on the table should be smaller, but we did not find such evidence on Type-II bundling. Therefore, we conclude that the bid discounting effect from Type-II bundling is due to lower risk on bundling contracts. It seems that we do not need to worry about inefficiency arising from strategic bundling.

We find, however, that bundling selects particular PPSs to participate auctions. More specifically, bundling increases the participation rate of the PPSs with more experience. Such selection may deteriorate future competition by reducing the number of bidders and by reducing experience of the fringe bidders.

Our next step is to conduct a structural analysis that allows us to investigate the counterfactuals. Under a structural analysis, we can compare the current bundling outcome to the counterfactual outcome when the contracts had not been bundled. Furthermore, we can investigate the effect of introducing counterfactual auction systems, including a combinatorial auction system, in these electricity procurement auctions.

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