Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts

Anders Lunander and Jan-Eric Nilsson

NOTA DI LAVORO 28.2003

MARCH 2003

PRIV – Privatisation, Regulation, Antitrust

Anders Lunander, *Swedish National Road and Transport Research Institute and Department of Economics, Örebro University*

Jan-Eric Nilsson, *Swedish National Road and Transport Research Institute and Department of Economics, Dalarna University*

Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts

Summary

The first part of the paper reports the results from a sequence of laboratory experiments comparing the bidding behavior for multiple contracts in three different sealed bid auction mechanisms; first-price simultaneous, first-price sequential and first-price combinatorial bidding. The design of the experiment is based on experiences from a public procurement auction of road markings in Sweden. Bidders are asymmetric in their cost functions; some exhibit decreasing average costs of winning more than one contract, whereas other bidders have increasing average cost functions. The combinatorial bidding mechanism is demonstrated to be most efficient. The second part of the paper describes how the lab experiment was followed up by a field test of a combinatorial procurement auction of road markings.

Keywords: Multiple units, non-constant costs, asymmetric redemption values, alternative procurement mechanisms

This paper has been presented at the EuroConference on "Auctions and Market Design: Theory, Evidence and Applications" organised by Fondazione Eni Enrico Mattei and sponsored by the EU, Milan, September 26-28, 2002.
Financial support from the Swedish Transport & Communications Research Board, the Swedish National Road Administration and the Swedish Competition Authority is gratefully acknowledged. The authors are indebted to Joakim Fredriksson and Lena Plomér for programming the experimental test bed and to Charles Noussair and three anonymous referees for comments on previous drafts. We also thank Lennart Kamensky, Trade Extensions for additional programming support. One of the authors has previously had a part-time employment at Trade Extensions but has no remaining links other than personal to that firm.

Address for correspondence:

Anders Lunander
Swedish National Road and Transport Research Institute and
Department of Economics
Örebro University
SE-701 82 Örebro
Sweden
E-mail: anders.lunander@esi.oru.se

1. INTRODUCTION

Using the standard first-price sealed bid auction, Sweden's National Road Administration (henceforth the Road Administration) annually awards some 60 contracts for the updating of road markings on national roads, subsequently referred to as road painting: Firms are invited to submit a bid on each contract, prior to an announced point in time. The bids on each contract are then evaluated separately and independently, and the firm submitting the lowest bid on a certain contract is awarded it, the same or another firm submitting the lowest bid on another is awarded that contract and so on. We consider this as a number of simultaneous auctions for identical, or at least very similar, objects.

Previous analyses of the bidding in these procurement auctions have demonstrated that there are two types of bidders for the contracts; 'large' and 'small' (Eklöf & Lunander (1999)). In the present paper, we conjecture that large suppliers submitting bids on more than one contract have decreasing average costs (synergies) in the number of contracts they win. A firm with synergies across combinations of contracts is then exposed to the risk of failing to acquire some contracts of a package, thereby ending up being paid less than its cost for executing the set of won contracts. To curb this risk, the firm may submit less aggressive bids, which then generates a risk that the lowest-cost supplier is not awarded the contracts. If a large firm still wins all contracts in the bundle, it may then earn supranormal profits.

Furthermore, we conjecture that because of capacity constraints, small bidders have increasing average costs in the number of contracts they are awarded. For this reason, small firms may also submit less aggressive bids or may abstain from bidding on some contracts to avoid the risk of ending up with more jobs than they have the capacity to carry out. This jeopardizes the small firms' possibility to stay in business and makes it difficult for new ones to enter, which is harmful for the competitive pressure in the industry at large.

One way of reducing the exposure problem for the procurer would be to substitute the standard sealed-bid mechanism for a simultaneous multiple round (SMR) auction with the opportunity for bid withdrawal or the option to submit package bids. The former type of auction was used in connection with the allocation of spectrum licenses in the United States (cf. Cramton (1997), Milgrom (1998), CRA (1998), Cybernomics, Inc (2000a)). The first use of combinatorial bidding for spectrum licenses in the US is scheduled to 2003; see www.fcc.gov. In the presence of synergies across contracts, the SMR auction format may generate higher efficiency and higher revenue (lower procurement cost) than a simultaneous one-shot auction of independent units, at least if the items that are sold have significant common value components. Despite the fact that public procurement represents about 20% of GDP within the OECD countries, innovative auction designs are not often observed in this area. One reason is that the bidding procedure in public procurement auctions is regulated by rules restricting bidding to a one shot sealed-bid procedure, which do not allow for iterative bidding.[1] The use of a one-shot procedure is also known to reduce the risk of collusion between bidders.

Using data from both a lab and a field experiment, the purpose of this paper is to explore the efficiency and revenue generation qualities of two sealed-bid alternatives in relation to the standard procedure to award contracts for multiple units; the standard approach is subsequently referred to as *simultaneous* bidding. Under the *sequential* bidding mechanism,

[1] Article XIII:1-3 of the Agreement on Government Procurement (WTO) states that "the opportunities that may be given to tenderers to correct unintentional errors of form between the opening of tenders and the awarding of the contract shall not be permitted to give rise to any discriminatory practice," and that " all tenders solicited ….

firms are allowed to observe the outcome of bidding on the first contract before submitting bids on the second, and so on. The benefit of the sequential approach would be to provide information about the outcome of one contest before bidders submit bids on the next. With *combinatorial* bidding, firms are allowed to submit bids also on packages of contracts in a simultaneous first-price sealed bid setting which is another way of reducing the uncertainty that comes with multiple bids and eliminate the exposure problem.[2]

Theory provides limited guidance as to general predictions concerning revenue and efficiency ranking of multi-unit auction mechanisms, when some bidders have economies and other diseconomies in the number of contracts they are awarded. Within the independent private values model, Krishna and Rosenthal (1996) compare the revenues in a second-price sealed-bid environment where objects are auctioned out simultaneously with package bids and a sequential auction. Given their parameterization of the distribution of bidders' values, the number of global (large) and local (small) bidders and the number of objects auctioned, they show that both the 'standard' simultaneous and the sequential auctions yield higher revenue than does the combinatorial auction, at least when there is only one global bidder. This is due to the more aggressive bidding by the global bidder in order to exploit synergies under the standard bidding format. By submitting bids on separate contracts, which are above the valuation for each separate contract, the bidder makes a loss in case he wins only a fraction of the contracts. This risk of a negative profit is compensated by the global bidders' gains in case of winning all contracts.

shall be received and opened under procedures and conditions guaranteeing the regularity of the openings."

[2] Combinatorial bidding can differ considerably and the lab and field experiments reported here only represent two simple versions of this much more general mechanism.

Several experimental studies have, however, arrived at an opposite revenue ranking. Ledyard *et al*. (1997), and Bykowsky *et al*. (1998) demonstrate that a combinatorial bidding mechanism dominates other mechanisms, both in revenues and efficiency. In a laboratory environment, Cybernomics, Inc (2000b) compares the performance of two multiple round auctions, one without (SMR) and one allowing for package bids (combinatorial). The combinatorial auction generates higher efficiency but lower revenues than the auction without packages bids, the reason being that bidders in the SMR auction make losses because of failed contract aggregations. Further, field applications of procurement auctions where suppliers have had the option to submit bids on bundles of contracts, have generated substantial savings in procurement costs [see Ledyard *et al*. (2000) (transportation services), and Trade Extensions (2001) (wooden packaging material)].

In contrast to the above references, the 'small' or 'local' bidders in our experimental testbed are assumed to have decreasing returns to scale in the number of contracts. While there are results indicating that with only small firms taking part in the auction, it is in the procurer's interest that the contracts are auctioned out sequentially and not simultaneously [see Engelbrecht-Wiggans and Weber (1979), Lang and Rosenthal (1991) and Ungern-Sternberg (1991)], we know less about the combination of small and large bidders. In the absence of clear theoretical predictions, we have difficulties in benchmarking the results and the results reported below therefore rely on a systematic comparison of outcomes from mechanisms for the lab experiment.

The outline of the paper is the following. Section 2 describes the process of a real governmental procurement auction, constituting the basis from which the present paper's lab and field experiments have grown. The lab experiment, its design and results, are presented in section 3, the subsequent field experiment is reported in section 4 and section 5 concludes.

2. THE PROCUREMENT AUCTIONS OF ROAD MARKINGS IN SWEDEN

Every year, the Road Administration contracts firms for the maintenance of road markings. Each of the seven regional offices of the Administration is responsible for the procurement of such services in the counties (being between two and five) under its rule. In each county, there are often two or three separate classes of contracts which are all very similar in nature; up to a linear transformation, painting a road in one place using a certain technique is very similar to this same activity, or a different technical version of it, undertaken elsewhere. In total, there are 50-60 contracts auctioned out, each valid for one year at a time. Between 1993-98, the Road Administration spent an annual average of SEK 100 million (USD 10 million) on the procurement of road painting.

The procurement process is identical across regions. Each contract is awarded by means of a first-price sealed bid auction and all contracts within the region have the same bidding deadline. Bids on one contract are evaluated independently of the bids submitted on any other contract. A bid consists of a set of prices (price per meter) for various types of road marking lines. The competitive bid is then computed as a weighted average of these separate prices; the weight attached to each individual price is common knowledge. Bidding on packages is not allowed. The periods of time required for evaluating the bids in all regions fully or partially overlap,[3] and the procurement of road markings may thus be described as 50-60 first-price sealed bid auctions, run simultaneously and independently.

[3] In 1999, the number of overlapping auctions was 53 out of a total of 55.

About eight firms are active in bidding for the contracts. Two of them are relatively large and operate in most counties, whereas the others are more or less local, operating in adjacent counties only. The two large firms win about 50% of the contracts. During the period 1993-1999, on average 4.7 bids were submitted on each contract.

Minutes from the procurement auctions provide examples of firms that – except for submitting bids for each of the contracts – have also made offers with either a discount on a bundle (a large firm has, for instance, made an offer to lower its bid on two adjacent contracts by 5%, given that is awarded both) or with restrictions on the number of contracts the firm can fulfill, given that it wins "too many". One motive given by the Road Administration for not taking these side-bids and restrictions into account is the computational problem of finding the optimal cost minimizing allocation.

3. THE LAB EXPERIMENT

Based on the above elements of the real-life process, we have designed a lab experiment with the purpose of comparing three bidding mechanisms to procure multiple units provided by bidders with induced non-constant costs. Each experimental session consisted of a series of auction periods where three identical contracts, *A*, *B* and *C* were subject to bidding. Five subjects participated in each session, two of *type 1* and three of *type 2*. The subjects' costs of fulfilling the fictitious contracts were randomly determined in each period, according to procedures described below, and they made profit by winning one or several contracts. In each period, the low bidder(s) made a profit equal to his (their) low bid(s) less his (their) induced cost of the contract(s); other subjects earned nothing.

Prior to bidding in each period p, the two bidders of *type 1* faced a cost c_i^p (*i=1,2*) randomly and independently drawn from the uniform distribution $[200{,}300]$, one for each bidder. Similarly, the three bidders of *type 2* faced a cost c_j^p (*j=3,4,5*) drawn from the uniform distribution $[160{,}220]$. The superscript *p (p= 1... 15)* denotes that the same set of randomly generated costs, c_i^p and c_j^p was used for each session.

The production costs of the two *type 1* bidders were decreasing in the number of contracts, with identical scale parameters for the two bidders. If a bidder won one of the contracts in the period, his cost equaled c_i^p (cf. table 1). If the same bidder won two contracts in the same period, the cost decreased to 0.9 × c_i^p per contract and if he won all three contracts, the unit cost was 0.8 × c_i^p. The three *type 2* bidders faced an increasing unit cost function, again with identical scale parameters across bidders. The cost was equal to c_j^p if winning one of the contracts, winning two contracts in the same period made the cost increase to 1.1 × c_j^p and, finally, winning all three contracts, the unit cost was 1.2 × c_j^p.

The purpose of this design was to mimic the observed number and size composition of bidders. First, it is difficult to believe that entrepreneurs would continue to be of different sizes if there were no real reasons for this; the presence of scale (dis-) economies being one such reason. Second, it would have been feasible to represent 'small' entrepreneurs with constant-cost functions. Such bidders, however, often want to restrict the number of contracts they can win, one possible reason being that they have capacity restrictions, here modeled as increasing costs. The random draw for the small bidders (*type 2*) then had to be made from a different support than that of the large bidders (*type 1*). If the cost for both types had been drawn from the same distribution, then the chances for *type 2* of winning any contract would have been small, given the number of contracts auctioned out and the size of the scale parameters.

Table 1. Induced costs for bidders of type 1 and type 2.

	Type 1	***Type 2***
Number of bidders	2	3
Support $\left[\underline{c}_{i,j}, \overline{c}_{i,j}\right]$	$[200, 300]_i$	$[160,220]_j$
Average cost for one contract (A, B or C)	c_i	c_j
Average cost for two contracts (AB, AC or BC)	$0.9 \times c_i$	$1.1 \times c_j$
Average cost for three contracts (ABC)	$0.8 \times c_i$	$1.2 \times c_j$

When arriving at the lab, each subject was randomly assigned to be either *type 1* or *type 2* and remained the same type throughout the session. A show-up fee of SEK 100 was paid.[4] In addition, each bidder was provided with SEK 50 for the purse, meaning that bids generating losses were accepted up to a deficit of this amount. The first five bidding periods made use of an exchange rate of SEK 0.5 for each experimental currency unit, the next five periods had a one-to-one exchange rate and the final five periods paid SEK 3 for each experimental currency unit. In addition, bidders did not have to carry the losses from the first five periods with them. These design aspects were used to reduce the risk of having to terminate a session before the participants had understood the logic of the game.

The contents of table 1 were common knowledge prior to bidding, meaning that bidders knew their own valuation and type, the distribution from which the valuations of the others were drawn, and the number of bidders of each type. A session was initiated with two shorter training periods. The subjects were students from the business administration and economics programs at Uppsala University and Dalarna University. Each session took up to two hours to conclude. Earnings ranged from the guaranteed amount up to SEK 400. The treatment variable was the auction mechanism with the following three one-shot bidding mechanisms being tested.

Simultaneous first-price sealed bid. In each period, the subjects submitted bids simultaneously for all three contracts. The bids on one contract were evaluated independently of the bids on the others, and the contract was awarded to the lowest bidder on that contract. In order to avoid an ordering effect (always place the highest/lowest bid in the first empty field on the screen), the three contracts were displayed on the screen in a randomized order; sometimes *A*, *B*, *C*, on other occasions *B*, *A*, *C*, etc. After each period, the winner(s) and the winning bids were reported to everyone and the profits reported to those who were awarded a contract.

Sequential first-price sealed bid. Subjects submitted bids in a sequential order for the three contracts; the assignment of the first contract (contract *A*) was reported prior to bidding for the second contract (contract *B*), and the assignment of the second contract was reported prior to bidding for the third. It was not announced whether a contract had been awarded to a small or a large bidder. When all contracts had been awarded, the winner(s) was (were) informed about his (their) profits.

Combinatorial first-price sealed bid. In addition to placing separate and independent bids for contracts *A*, *B* and *C*, subjects were also allowed – but not required – to place bids on all other combinations of contracts. Each subject could therefore submit seven bids; one on each single

[4] The exchange rate during the fall of 1999 was about SEK 8 for each $US.

contract and bids on packages *AB*, *AC*, *BC* and *ABC*.[5] The winning combination was the combination of bids on the three contracts yielding the lowest procurement cost. Subjects part of the winning combination were awarded their contract(s) and their profit equaled their bid(s) less their cost for the number of contract(s) won.

4. EXPERIMENTAL RESULTS

Nine experimental sessions were conducted, each mechanism replicated in three sessions, where each session consisted of 12 or 15 periods (cf. table 2).

Table 2. Number of periods performed across mechanisms

Bidding mechanism		
Simultaneous	Sequential	Combinatorial
12	12	12
12	15	15
15	15	15
39	42	42

One way of measuring efficiency under the three mechanisms is to take the ratio between the lowest induced cost of fulfilling the three contracts and the induced cost for the winner(s). We have, however, applied a normalized efficiency measure taking the level of drawn costs into account. The efficiency measure is defined in (1).

$$E = 1 - \frac{A - M}{N - M} \tag{1}$$

A is the actual costs for the winners of fulfilling contracts, *M* is the lowest induced cost of fulfillment and *N* is the expected induced cost of a random allocation. For each period, *N* is computed as the total sum of the induced cost of all possible allocations of the three contracts

[5] The bidders were also told that they could only win all three contracts on the *ABC* package bid, not on a combination of the three separate bids on contracts *A*, *B* and *C*, or a two-plus-one combination. In the same way, a two-pair could only be awarded by a bid on this two-pair, not from a combination of two single-contract bids. These restrictions were introduced in order to avoid bidders accidentally placing bids on singletons or two-plus-one combinations that made them win contracts at bids below costs, which was a real risk in view of the non-

among the five bidders, taking the economies and diseconomies of scale into account. This sum is then dived by the number of possible allocations, which are (5^3) 125.

Table 3 shows the average and median efficiency for the three mechanisms. We apply a Wilcoxon rank test to test for significant differences in efficiency across mechanisms, given identical periods. Table 4 demonstrates that the combinatorial mechanism generated fully efficient allocations in 28 periods out of 42 and is significantly more efficient than the other two mechanisms.

Table 3. Efficiency Across Mechanisms

	Mechanism		
	Simultaneous	Sequential	Combinational
Average efficiency	0.70	0.68	0.91
Median efficiency	0.66	0.68	1.00
# observations	39	42	42

Table 4. Wilcoxon matched-pairs signed-rank tests of efficiency

	z-statistics	*N*
Simultaneous = Sequential	-0.45	39
Simultaneous = Combinatorial	-3.28	39
Sequential = Combinatorial	-3.64	42

Next, we compare the procurer's cost under each mechanism. One complication in this is that bidders have now and then incurred losses, i.e. been awarded contracts with bids below their costs, in various periods of all three mechanisms. In 15 periods out of 39, the simultaneous mechanism has generated losses for at least one bidder, the sequential mechanism in 10 out of 42 while the combinatorial mechanism resulted in losses in only 2 (early periods) out of 42.

linearities in costs.

To take the impact of such behavior into account when comparing the procurement costs in pairs for identical periods across mechanisms, we apply the Wilcoxon rank-test both to all possible pairs of identical periods, irrespective of outcome, and all possible pairs of identical periods in which the winner(s) did not make a loss.

Table 5 demonstrates that the combinatorial mechanism generates significantly lower procurement costs than the other two mechanisms. By only considering periods with no losses, the average reduction in procurement costs of using the combinatorial mechanism increases from 2-3% to 4%. This is due to the decreasing effect of the winners' incurred losses on the procurer's cost within the simultaneous and the sequential mechanisms.

Table 5. Wilcoxon matched-pairs signed-rank tests of procurer's cost

Tested pair			All periods			Periods with no losses		
			z-statistics	*n*	*Relative difference*	*z-statistics*	*n*	*Relative difference*
$Cost_{Simultaneous}$	=	$Cost_{Sequential}$	0.47	39	0.008	0.22	14	-0.001
$Cost_{Simultaneous}$	=	$Cost_{Combinatorial}$	3.08	39	0.028	3.05	22	0.041
$Cost_{Sequential}$	=	$Cost_{Combinatorial}$	2.74	42	0.022	3.49	21	0.037

Table 6 compares the outcome of an efficient allocation with the observed allocation of contracts to bidders of *type 1* and *type 2*, respectively. Given our random draw from the two distributions of costs, an efficient allocation would have about 50 % of the contracts awarded to each type. The observed allocation of contracts to each type of bidder in the combinatorial mechanism almost coincides with the efficient allocation. In contrast, an average *type 2* bidder won a larger number of contracts under the sequential than under the other two mechanisms.

Table 6. Efficient and observed relative allocation of contracts to each type

Bidder	Efficient allocation	Mechanism: Simultaneous	Sequential	Combinatorial
Type 1	52%	34%	23%	49%
Type 2	48%	66%	77%	51%

Finally, there is reason to ask whether our conclusions regarding (relative) efficiency and revenue generation qualities materialize for the right reasons, or if the results emanate from some arbitrary or unknown underlying process. To test for this, we have formulated a set of conjectures regarding the individually rational bidding behavior of subjects of the respective type under each mechanism. The overall conclusion is that observed behavior periods can indeed be seen to be rational, at least under the simultaneous and the combinational mechanisms. Some deviations from what we expected to find under the sequential mechanism could possibly be explained by the fact that subjects were not informed about whether the first contract was awarded to a large or small bidder, which was also the case when contract two was awarded. This might have confused bidders somewhat; to economize on space, the analysis is placed in an appendix.

5. THE FIELD TEST

The results from the lab experiment were reported to the Road Administration in September 2000, and it was decided to make a field test of combinatorial bidding when procuring road paintings in 2001. The agency did not want to let all 50-60 contracts be auctioned out simultaneously in a nationwide first-price sealed bid combinatorial auction. Instead, it restricted combinatorial bidding to be partially implemented in two of its regions, the procedure for contracts in the remaining five regions being left unchanged. Software for evaluating a possibly complex set of combinatorial data was programmed by Trade Extensions. The software could, in principle, deal with any types of bids, both package bids and so-called XOR bids. We first present the bidding rules of the field test and the results at large (in subsection 5.1) and also try to understand what savings, if any, the Road Administration actually made from the test (5.2).

5.1 Bidding Rules and Results

The number of contracts subject to bidding was nine and ten, respectively, in the two choice regions. Half of the contracts in each region were relatively small, with the cost of carrying out a small contract being about a sixth compared to the other contracts. Firms were not allowed to submit bids on own-formed bundles of contracts. Instead, prior to bidding, the Road Administration specified which – and in one region how many – of the contracts could be included in a package bid. The agency feared that if firms were allowed to submit bids on the whole sample or various combinatorial bids on arbitrary sub samples, there was a risk that larger firms would "take it all" with one aggressive combinatorial bid. For unexplained reasons, it was stipulated that a firm submitting a combinatorial bid also had to tender a single separate bid for each of the contracts included in the combination. We comment on these aspects of the field test below. In addition, firms were given the opportunity to declare how many contracts they could accept in case they were awarded more contracts than they had the capacity to fulfill.

Nine separate contracts were advertised in *Region Middle*. Firms could submit an arbitrary number of combinatorial bids for a specified sub sample of four contracts. In table 7, bold letters represent contracts that could be included in a combinatorial bid. A firm submitting a bid for contracts C1, C2, D1 and D2 and ticking the C1-C2 combination with a discount of five would then reduce its price by 5% if awarded this pair.

Table 7. Contracts auctioned out in Region Middle.

Contract	*Single bid (SEK)*	*Comb. Bid 1 (mark with √)*	*Comb. bid 2 (mark with √)*	*Comb.bid n (mark with √)*
T1				
T2				
D1				
D2				
E2				
C1				
C2				
U1				
U2				
	Discount in %			

Contracts numbered "1" are large, and contracts numbered "2" are small contracts.

Five firms took part in the bidding in this region. One of them submitted separate bids on *C1*, *U1*, *D1* and *T1* with the restriction that it could take two contracts at most; this bidder won no contract. Only one of the bidders, here labeled *CLE*, used the option to submit a combinatorial bid on two of the four contracts that could be included, *U1* and *C1*. Table 8 displays *CLE's* separate bids and the two-combinatorial bid on these two contracts. The discount was 2% of the sum of the single bids, meaning that the combinatorial bid was about SEK 142 000 lower than the sum of the two single bids on the same contracts.

Table 8. CLE's Bids in Region Middle, thousand SEK

. Contract	Lowest stand-alone bids	Combinatorial bid (2 % discount)	Lowest bids including discount for package
C1	2 722	√	2 668
C2	602		602
U1	4 383	√	4 295
U2	804		804
Sum of winning bids	8 511		8 369

It turned out that this firm had also submitted the lowest single separate bids on each of the nine contracts; the combinatorial bid made no difference for the outcome of the contest.[6] Ten contracts were awarded in *Region West*. Three of these were open to combinatorial bidding (cf. bold letters in table 9). Firms could only submit two-contract package bids, that is, a firm could submit three combinatorial bids at most.

Table 9. Contracts auctioned out in Region West

Contract	Single Bid (SEK)	Combinatorial bid 1	Combinatorial bid 2	Combinatorial bid 1
H1		√	√	
H2				
G1		√		√
G2				
V1			√	√
V2				
M1				
M2				
K1				
K2				
	Discount in %			

Five firms took part in the bidding also in Region West, two of which submitted combinatorial bids. One firm chose to submit all three possible two-contract combinatorial bids, each with a discount of 3%, whereas the other firm submitted one combinatorial bid with a 3.5% discount. The former firm, again *CLE*, won seven of the ten contracts in the region, including the three contracts *H1*, *G1* and *V1*. As can be seen from table 10, the combination yielding the lowest cost is the package bid on (*H1+G1*), together with the single bid on *V1* (with a total cost of SEK 4 415 000). The difference between this sum and the sum of the separate bids on the three contracts (column one) amounts to 96 000 SEK. In the same way as in Region Middle, the combinatorial bids did not affect the allocation of contracts; *CLE* would also have won the seven contracts without them.

[6] The table does not include the outcome of the bidding on the other five contracts since they could not be included in the combinatorial bid.

Table10. CLE's Bids in Region West, thousand SEK

.Contract	Lowest separate bid	Combinatorial bid H1+ G1 (3 % discount)	Combinatorial bid H1+ V1 (3 % discount)	Combinatorial bid V1+ G1 (3 % discount)
H1	1 372	**1 331**	1 331	
G1	1 849	**1 794**		1 794
V1	1 290	(1 290)	1 252	1 252
Sum	4 511			
Winning sum		4 415		

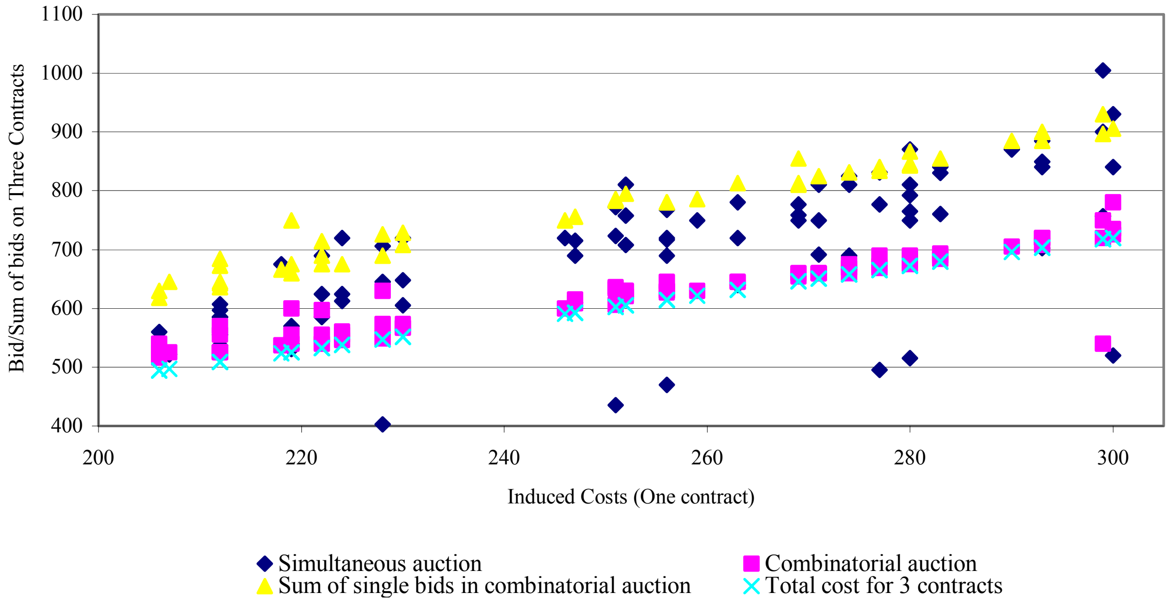
5.2 Did the field test save money for the Road Administration?

An important question is whether the option to submit package bids made the Road Administration save any money. This is certainly the case if a firm's bid on each of the contracts included in a package, mirrors the bid the firm would have submitted in an auction without combinatorial bids; if so, the Road Administration saved SEK 238 000. There are, however, grounds for calling this into question.

First, Krishna and Rosenthal (1996) show that when bidders face increasing returns of winning multiple objects, the separate bids on each object in a (second-price) sealed bid auction do not coincide with the corresponding bids in a (second-price) sealed bid auction without package bidding. In the former case, the bidder's dominant strategy is to bid his value for the single objects as well for the bundle. In the absence of package bidding, the bidder would optimally, in equilibrium, submit a bid on each object that is above his value. If similar results held for first-price auctions, the single bids in the auction without combinatorial bidding would be lower than the corresponding separate bids in an auction allowing for package bids. This result is at least valid when there are a few bidders only.

Second, by considering the behavior of *type 1* bidders in the lab experiment, we get indications that this may indeed be the case. Figure 1 plots the observed behavior of *type 1* bidders against their induced values. Diamonds indicate the bid-sum of the three separate bids on contracts *A*, *B* and *C* in the simultaneous auction with no package bids, triangles show the bid-sum of the separate bids on contracts *A*, *B* and *C* in the combinatorial setting and the quadrants illustrate the package bids in the same auction.

Figure 1. Bidding behavior for bidders with decreasing costs in simultaneous and combinatorial auctions.



The total cost of winning all three contracts for each induced value is marked with a cross. Markings below the crosses indicate that individuals have been bidding below their induced costs.[7] Figure 1 therefore indicates that bids in the simultaneous auction that does not allow for package bids are lower than the corresponding separate bids when allowing for package bids.[8]

Third, we also have field observations supporting the hypothesis that there is a difference

[7] It should be noted that a number of individuals in the combinatorial auction did not submit a separate bid on each of the three contracts, thus only bidding on the ABC-package.

between the single bids on each contract in a first-price auction that allows for package bids and not, respectively. Table 11 shows *CLE's* bids in the different counties in Region Middle and Region West over the period 1998-2001.[9] During the period 1998-2000, *CLE* submitted identical sets of prices across the four Region Middle counties. For the year 2001, the firm seems to have abandoned this strategy, instead submitting different sets of prices across the counties. The highest bids in 2001 were submitted for those contracts that could be included in a package bid.

Table 11. CLE's submitted bids (SEK) for a specific type of road marking line across counties 1998-2000

(a) Region Middle

	Contract			
Year	T1	D1	*C1*	*U1*
1998	9.13	9.13	9.13	9.13
1999	9.45	9.45	9.45	9.45
2000	6.40	6.40	6.40	-
2001	5.85	5.90	5.90	6.00

(b) Region West

	Contract				
Year	*H1*	*G1*	*V1*	M1	K1
1998	9.45	8.8	8.8	9.45	9.65
1999	10.2	9.5	9.5	10.2	-
2000	6.8	6.8	6.8	9.5	-
2001	7.25	7.1	6.8	6.6	6.6

CLE exhibits a similar bidding pattern in Region West. In previous years, it has submitted a set of prices for contracts *H1*, *G1* and *V1* that have not been higher than the bids for the other contracts. When *CLE* is then given the option to submit package bids, each bid combining two of the contracts *H1*, *G1* and *V1,* the firm raises its single bids on these contracts above the prices on the other two contracts (*M1* and *K1*), which cannot be included in a package bid.

To sum up, theoretical predictions, the lab experiment and our field data indicate that the separate bids on contracts, which are also involved in a package bid, do not reflect the separate bids that would have been submitted in a world without package bids. Therefore, it is hard to estimate if and to what extent the Road Administration reduced their procurement cost

[8] This result also shows up when comparing the regression results for *type 1* in tables A1 and A3 (appendix).
[9] The numbers in the table denote the bid/price *CLE* charges for painting one meter of road marking, a line

by letting firms submit package bids within the first-price sealed bid auction.[10]

6. Summary

The research reported in this paper focuses on the fact that procurement auctions may involve contracts for a large number of similar activities, each contract – except for up to a linear transformation – being very similar to others. Based on the observed outcome of the procurement processes conducted in the last few years, it is clear that two categories of entrepreneurs, here referred to as 'large' and 'small', are awarded contracts.

Using an experimental testbed, we have demonstrated that efficiency may suffer from employing the standard, one shot, sealed bid procurement process under these circumstances. The experiments also show that efficiency is enhanced and procurement costs reduced by admitting for combination bids within the standard simultaneous mechanism. The results are based on a particular way of modeling bidders; they have economies and diseconomies in the number of contracts awarded and their costs are drawn from different supports. Moreover, one specific way of designing combination bidding has been tested while combinations may take on a number of different forms. Generalizations from our results should be drawn with these facts in mind.

Furthermore, the lab experiment was based on induced private values (costs), whereas the cost of the bidding firms in the field may, to some extent, be uncertain and affiliated. For all firms, it is somewhat more difficult and more costly to paint roads in bad weather, but, prior

which is 10 cm wide and 3 mm thick.

[10] As an illustration, if we make the assumption that, in the absence of package bids, *CLE* would have submitted the same set of prices for *C1* and *U1* as it did for contract *T1,* that is, 5,85, in Region Middle*,* then the Road Administration would have obtained a lower procurement cost than with package bids.

to bidding, no firm knows what the weather will be during the 'painting season'. An open bidding mechanism, where bidders can, to some extent, observe each other's behavior, may therefore affect the firms' perceptions of their true cost of fulfilling the contracts and, hence, the Administration's procurement cost.[11] This points towards the possible benefits of a SMR auction format, which also allows for package bids.

Based on the experimental results, we suggested that the Road Administration should test combinatorial bidding and such a test has also been undertaken, albeit with many restrictions. Two regions out of seven tried out versions of combinatorial bidding on a restricted number of contracts. Firms could submit bid combinations on only a few of the contracts, and they were also permitted to place an upper limit on the number of contracts they could accept; this is a way of giving, in particular small firms, the possibility of participating in the bidding for many contracts while not risking to win 'too many'. Despite the restrictions, this first trial saw in total 6 bids out of 32 being submitted in one way or another, making use of the possibility to submit combinational bids, and it was also these bids that won the contracts in question. However, we have not been able to establish whether the Road Administration actually made any financial saving from the trial.

Throughout the trials, the agency feared that the possibility to submit combinatorial bids would make it easier for a large firm to win a large number of contracts, thereby jeopardizing the industry's long run competitive pressure. Our data in combination with theoretical results by Krishna & Rosenthal (1996) confirm that this may be a risk, at least if there is only a small number of 'large' bidders. Even with modest scale economies, it takes a certain competitive pressure amongst the large firms to avoid this pitfall, at least when the number of contracts is

[11] For a discussion on how individuals' beliefs about costs and characteristics may be related to elicitation

large.

One way around the problem could be to require bidders to submit both package and stand-alone bids, a restriction imposed by the Road Administration officials. The chance that bids from small firms can be combined with the stand-alone bids of large operators would then be greater. This could indeed be countered if large firms submit stand-alone bids that are very large, precisely in order to avoid this obvious threat. A possible complementary restriction would then be to put an upper limit on the discount, i.e. that it could not exceed, say, 5-10% of the stand-alone bid. If anything, this demonstrates the importance of being careful in designing the details of any new method for handling age-old problems.

---

institutions, see Harrison *et al.* (2000)

References

Bykowsky, M., Cull, R and Ledyard, J. (1998). Mutually Destructive Bidding: The FCC Auction Design Problem. *Social Science Working Paper 916*, California Institute of Technology

Cybernomics, Inc. (2000a). Theory, Experiment and the FCC Spectrum Auctions Mimeo submitted to the Federal Communications Commission

Cybernomics, Inc. (2000b). An Experimental Comparison of the Simultaneous Multi-Round Auction and the CRA Combinatorial Auction Mimeo submitted to the Federal Communications Commission

Cramton, Peter. (1997). "The FCC Spectrum Auctions: An Early Assessment". *Journal of Economics and Management Strategy*, Vol. 6, No.3, 431-495

Eklöf, M. and Lunander, A. (1999). Contract Bidding under a First-Price Sealed Bid Auction - An Empirical Analysis of Competition in Procurement of Road Markings in Sweden *in* Lunander, A. Bids and Values. Ph.D. Dissertation, Department of Economics, Uppsala University

Engelbrecht-Wiggans, R., Weber, R. J. (1979). An Example of Multi-Object Auction Game. *Management Science*, Vol. 25, No.12, 1272-1277

Harrison, Glenn W., Harstad, Ronald M., Rutström, Elisabet E., (2000). Experimental Methods and Elicitation of Values, Mimeo, Department of Economics, The Darla Moore School of Business, University of South Carolina

Krishna, V. and Rosenthal, R.W. (1996a). Simultaneous Auctions with Synergies. *Games and Economic Behavior*, 17, 1-31.

Ledyard, J., Porter, D. and Rangel, A. (1997). Experiments Testing Multiobject Allocation Mechanisms. *Journal of Economics & Management Strategy*, Vol. 6, No. 3, 639-675.

Ledyard, J., Olson, M., Porter, D., Swanson, J., Torma, T. (2000) "First Use of Combined Value Auctions for Transportation Services" Net Exchange, Inc.

Milgrom, P. (1998). Game Theory and the Spectrum Auctions. *European Economic Review*, 42, 771-778.

Trade Extensions (2001). Business Case: Saving money for Volvo with a Combinatorial Auction. *www.tradeextensions.com*

Von Ungern-Sternberg, T. (1991). Swiss Auction. *Economica*, Vol. 58, 341-357

Appendix

Analysis of individual bidding behavior

Conjectures under Simultaneous Bidding

The average bid of *type 1* (*type 2*) bidders is below (above) the induced cost in order to increase the chance of winning all projects (reduce the risk of winning all projects at too low bids). There is no systematic difference between bids on projects *A*, *B* and *C*. To test the conjectures, we estimate equation (A1)

$$BID_{i,k} = \beta_1 COST_i + \beta_2 D_i^B + \beta_3 D_i^C + \varepsilon_i \qquad \text{(A1)}$$

where $i = 1,2$ (*type 1*), $i = 3,4,5$ (*type 2*) and $k = A, B, C$. The dependent variable, BID_i, is the bid on a specific contract, *COST* denotes the induced cost of winning a single contract and the two dummies D^B and D^C take the value 1 if the dependent variable reflects a bid on contract *B* and contract *C*, respectively. The regression results summarized in table A1 confirm these conjectures. On average, large bidders place bids five percent below the cost while small bidders add 18 percent to the cost on an average bid. Neither dummy variable coefficient is significant, indicating that bidders, given their type, placed identical bids on the three contracts.

Table A1: Bidding behavior across types – simultaneous auction

	Type 1		Type 2	
Variable	All periods	Period >5	All periods	Period >5
COST	0,95*	0,95*	1,18*	1,18*
	(0,009)	(0,009)	(0,019)	(0,025)
D^B	-3,25	-0,72	5,78	5,34
	(3,14)	(3,25)	(5,18)	(6,88)
D^C	-1,44	-0,65	2,14	-0,20
	(3,19)	(3,32)	(5,17)	(6,88)
N	228	140	350	216

Standard error in parentheses, *significant at the (at least) 5 % level

Conjectures under Sequential Bidding

The average bid of *type 1* (*type 2*) is below (above) the induced cost in order to increase (reduce) the chance of winning all contracts. *Type 1* bidders then reduce their bids after having won a contract and without a win they increase their bids. *Type 2* bidders increase their bids after having won a contract, and without a win, they do not change their bidding behavior. To test the conjectures, we estimate equation (A2). The five dummy variables are used to represent the outcomes as given below and the regression results are summarized in table A2.

$$BID_{i,k} = \beta_1 COST_i + \beta_2 D_i^1 + \beta_3 D_i^2 + \beta_4 D_i^3 + \beta_5 D_i^4 + \beta_6 D_i^5 + \varepsilon_i \qquad \text{(A2)}$$

D^1 = 1 if bid on *B* when *A* is won
D^2 = 1 if bid on *B* when *A* is NOT won
D^3 = 1 if bid on *C* when *A* OR *B* is won
D^4 = 1 if bid on *C* when *A* AND *B* is won
D^5 = 1 if bid on C when neither A nor B is won

Table A2: Bidding behavior across types – sequential auction

	Type 1		Type 2	
Variable	All periods	Period >5	All periods	Period >5
COST	0,91*	0,93*	1,04*	1,04*
	(0,008)	(0,006)	(0,004)	(0,004)
D^1	-9,74	-10,37*	22,63*	24,63*
	(6,73)	(4,56)	(1,60)	(1,63)
D^2	3,79	7,28*	-2,32*	-1,73
	(3,03)	(2,24)	(1,17)	(1,16)
D^3	-6,66	-1,38	23,90*	28,31*
	(6,17)	(4,56)	(1,51)	(1,5)
D^4	-13,87	-15,33*	54,15*	55,62*
	(8,90)	(5,93)	(2,52)	(2,62)
D^5	17,71*	18,21*	-4,49*	-3,87*
	(3,20)	(2,39)	(1,27)	(1,28)
N	258	168	405	270

Standard error in parentheses, *significant at the (at least) 5 % level

Considering the behavior of *type 2* it is clear that the conjecture regarding D^5 is not confirmed by data. If these bidders have not won any item before, they seem to change their bidding behavior in the last round. This could possibly be a result of subjects not being informed about whether *a type 1* or *type 2* bidder had been awarded previous contracts. In other respects, our conjectures are not contradicted by observed behavior, however.

Conjectures under Combinatorial Bidding

Under this mechanism, up to seven bids from each bidder were received. For our purpose, this is partially redundant information since a bid on the single project *A* in all respects provides the same information as a bid on the single project *B*, which once more is the same as the bid on a single project *C*; no bidder will be awarded more than one contract based on the singleton-bids. The same argument is relevant for bids on two-pairs. The seven observations have therefore been boiled down to three: (i) the bidder's lowest bid on singletons *A*, *B* and *C*; (ii) the bidder's lowest bid on two-pairs *AB*, *AC* and *BC* (divided by two to allow for comparison with the induced cost); (iii) the bidder's bid on *ABC* (divided by three).

We conjecture that the average *type 1* bidder does not submit a singleton bid below his induced cost, and that his two combination and three combinations bids reflect the decreasing average cost of winning two and three contracts. The three bids of the average *type 2* bidder on varying numbers of contracts will exhibit his increasing average cost. The following equation is estimated for the two types of bidders, within the combinatorial mechanism

$$BID_{i,k} = \beta_1 COST_i + \beta_2 D_i^1 + \beta_3 D_i^2 + \varepsilon_i \quad . \qquad \text{(A3)}$$

The subscript *k* indicates whether *BID* is the bidder's (lowest) singleton bid, his (lowest) combinatorial bid on two contracts or his three-contract combinatorial bid. $COST_i$ is the bidder's induced cost of winning a single contract. The dummy variables D^1 and D^2 take on the value 1 if *BID* is a two-contract combinatorial bid and the three-contract combinatorial bid, respectively. The regression results are presented in table A3.

For both types, the singleton bids are very close to their induced cost. The option to submit combinatorial bids on packages of two and three enables the *type 1* bidder to bid a lower average price for two and three contracts. The average *type 2* bidder exhibits the inverse behavior, that is, bidding a higher average price for the two- and three-contract combinations in order to compensate for his increasing average cost of winning more than one contract.

Table A3: Bidding behavior across types – combinatorial auction

	Type 1		*Type 2*	
Variable	All periods	Period >5	All periods	Period >5
Cost	1,00*	1,00*	1,03*	1,02*
	(0,005)	(0,005)	(0,004)	(0,003)
D^1	-21,02*	-20,09*	17,94*	18,31*
	(1,69)	(1,72)	(1,07)	(0,98)
D^2	-45,55*	-43,07*	36,27*	37,99*
	(1,66)	(1,68)	(1,12)	(1,02)
N	205	131	327	207

Standard error in parentheses, *significant at the (at least) 5 % level

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI
Fondazione Eni Enrico Mattei Working Paper Series
Our working papers are available on the Internet at the following addresses:
http://www.feem.it/web/activ/_wp.html
http://papers.ssrn.com

SUST	1.2002	*K. TANO, M.D. FAMINOW, M. KAMUANGA and B. SWALLOW*: Using Conjoint Analysis to Estimate Farmers' Preferences for Cattle Traits in West Africa
ETA	2.2002	*Efrem CASTELNUOVO and Paolo SURICO*: What Does Monetary Policy Reveal about Central Bank's Preferences?
WAT	3.2002	*Duncan KNOWLER and Edward BARBIER*: The Economics of a "Mixed Blessing" Effect: A Case Study of the Black Sea
CLIM	4.2002	*Andreas LÖSCHEL*: Technological Change in Economic Models of Environmental Policy: A Survey
VOL	5.2002	*Carlo CARRARO and Carmen MARCHIORI*: Stable Coalitions
CLIM	6.2002	*Marzio GALEOTTI, Alessandro LANZA and Matteo MANERA*: Rockets and Feathers Revisited: An International Comparison on European Gasoline Markets
ETA	7.2002	*Effrosyni DIAMANTOUDI and Eftichios S. SARTZETAKIS*: Stable International Environmental Agreements: An Analytical Approach
KNOW	8.2002	*Alain DESDOIGTS*: Neoclassical Convergence Versus Technological Catch-up: A Contribution for Reaching a Consensus
NRM	9.2002	*Giuseppe DI VITA:* Renewable Resources and Waste Recycling
KNOW	10.2002	*Giorgio BRUNELLO*: Is Training More Frequent when Wage Compression is Higher? Evidence from 11 European Countries
ETA	11.2002	*Mordecai KURZ, Hehui JIN and Maurizio MOTOLESE*: Endogenous Fluctuations and the Role of Monetary Policy
KNOW	12.2002	*Reyer GERLAGH and Marjan W. HOFKES:* Escaping Lock-in: The Scope for a Transition towards Sustainable Growth?
NRM	13.2002	*Michele MORETTO and Paolo ROSATO*: The Use of Common Property Resources: A Dynamic Model
CLIM	14.2002	*Philippe QUIRION*: Macroeconomic Effects of an Energy Saving Policy in the Public Sector
CLIM	15.2002	*Roberto ROSON*: Dynamic and Distributional Effects of Environmental Revenue Recycling Schemes: Simulations with a General Equilibrium Model of the Italian Economy
CLIM	16.2002	*Francesco RICCI* (l): Environmental Policy Growth when Inputs are Differentiated in Pollution Intensity
ETA	17.2002	*Alberto PETRUCCI*: Devaluation (Levels versus Rates) and Balance of Payments in a Cash-in-Advance Economy
Coalition Theory Network	18.2002	*László Á. KÓCZY* (liv*):* The Core in the Presence of Externalities
Coalition Theory Network	19.2002	*Steven J. BRAMS, Michael A. JONES and D. Marc KILGOUR* (liv): Single-Peakedness and Disconnected Coalitions
Coalition Theory Network	20.2002	*Guillaume HAERINGER* (liv): On the Stability of Cooperation Structures
NRM	21.2002	*Fausto CAVALLARO and Luigi CIRAOLO:* Economic and Environmental Sustainability: A Dynamic Approach in Insular Systems
CLIM	22.2002	*Barbara BUCHNER, Carlo CARRARO, Igor CERSOSIMO and Carmen MARCHIORI*: Back to Kyoto? US Participation and the Linkage between R&D and Climate Cooperation
CLIM	23.2002	*Andreas LÖSCHEL and ZhongXIANG ZHANG:* The Economic and Environmental Implications of the US Repudiation of the Kyoto Protocol and the Subsequent Deals in Bonn and Marrakech
ETA	24.2002	*Marzio GALEOTTI, Louis J. MACCINI and Fabio SCHIANTARELLI*: Inventories, Employment and Hours
CLIM	25.2002	*Hannes EGLI:* Are Cross-Country Studies of the Environmental Kuznets Curve Misleading? New Evidence from Time Series Data for Germany
ETA	26.2002	*Adam B. JAFFE, Richard G. NEWELL and Robert N. STAVINS*: Environmental Policy and Technological Change
SUST	27.2002	*Joseph C. COOPER and Giovanni SIGNORELLO*: Farmer Premiums for the Voluntary Adoption of Conservation Plans
SUST	28.2002	*The ANSEA Network*: Towards An Analytical Strategic Environmental Assessment
KNOW	29.2002	*Paolo SURICO*: Geographic Concentration and Increasing Returns: a Survey of Evidence
ETA	30.2002	*Robert N. STAVINS:* Lessons from the American Experiment with Market-Based Environmental Policies

NRM	31.2002	*Carlo GIUPPONI and Paolo ROSATO:* Multi-Criteria Analysis and Decision-Support for Water Management at the Catchment Scale: An Application to Diffuse Pollution Control in the Venice Lagoon
NRM	32.2002	*Robert N. STAVINS*: National Environmental Policy During the Clinton Years
KNOW	33.2002	*A. SOUBEYRAN and H. STAHN* : Do Investments in Specialized Knowledge Lead to Composite Good Industries?
KNOW	34.2002	*G. BRUNELLO, M.L. PARISI and Daniela SONEDDA:* Labor Taxes, Wage Setting and the Relative Wage Effect
CLIM	35.2002	*C. BOEMARE and P. QUIRION* (lv): Implementing Greenhouse Gas Trading in Europe: Lessons from Economic Theory and International Experiences
CLIM	36.2002	*T.TIETENBERG* (lv): The Tradable Permits Approach to Protecting the Commons: What Have We Learned?
CLIM	37.2002	*K. REHDANZ and R.J.S. TOL* (lv): On National and International Trade in Greenhouse Gas Emission Permits
CLIM	38.2002	*C. FISCHER* (lv): Multinational Taxation and International Emissions Trading
SUST	39.2002	*G. SIGNORELLO and G. PAPPALARDO:* Farm Animal Biodiversity Conservation Activities in Europe under the Framework of Agenda 2000
NRM	40.2002	*S .M. CAVANAGH, W. M. HANEMANN and R. N. STAVINS:* Muffled Price Signals: Household Water Demand under Increasing-Block Prices
NRM	41.2002	*A. J. PLANTINGA, R. N. LUBOWSKI and R. N. STAVINS:* The Effects of Potential Land Development on Agricultural Land Prices
CLIM	42.2002	*C. OHL* (lvi): Inducing Environmental Co-operation by the Design of Emission Permits
CLIM	43.2002	*J. EYCKMANS, D. VAN REGEMORTER and V. VAN STEENBERGHE* (lvi): Is Kyoto Fatally Flawed? An Analysis with MacGEM
CLIM	44.2002	*A. ANTOCI and S. BORGHESI* (lvi): Working Too Much in a Polluted World: A North-South Evolutionary Model
ETA	45.2002	*P. G. FREDRIKSSON, Johan A. LIST and Daniel MILLIMET* (lvi): Chasing the Smokestack: Strategic Policymaking with Multiple Instruments
ETA	46.2002	*Z. YU* (lvi): A Theory of Strategic Vertical DFI and the Missing Pollution-Haven Effect
SUST	47.2002	*Y. H. FARZIN*: Can an Exhaustible Resource Economy Be Sustainable?
SUST	48.2002	*Y. H. FARZIN*: Sustainability and Hamiltonian Value
KNOW	49.2002	*C. PIGA and M. VIVARELLI*: Cooperation in R&D and Sample Selection
Coalition Theory Network	50.2002	*M. SERTEL and A. SLINKO* (liv): Ranking Committees, Words or Multisets
Coalition Theory Network	51.2002	*Sergio CURRARINI* (liv): Stable Organizations with Externalities
ETA	52.2002	*Robert N. STAVINS*: Experience with Market-Based Policy Instruments
ETA	53.2002	*C.C. JAEGER, M. LEIMBACH, C. CARRARO, K. HASSELMANN, J.C. HOURCADE, A. KEELER and R. KLEIN* (liii): Integrated Assessment Modeling: Modules for Cooperation
CLIM	54.2002	*Scott BARRETT* (liii)*:* Towards a Better Climate Treaty
ETA	55.2002	*Richard G. NEWELL and Robert N. STAVINS*: Cost Heterogeneity and the Potential Savings from Market-Based Policies
SUST	56.2002	*Paolo ROSATO and Edi DEFRANCESCO*: Individual Travel Cost Method and Flow Fixed Costs
SUST	57.2002	*Vladimir KOTOV and Elena NIKITINA* (lvii): Reorganisation of Environmental Policy in Russia: The Decade of Success and Failures in Implementation of Perspective Quests
SUST	58.2002	*Vladimir KOTOV* (lvii): Policy in Transition: New Framework for Russia's Climate Policy
SUST	59.2002	*Fanny MISSFELDT and Arturo VILLAVICENCO* (lvii): How Can Economies in Transition Pursue Emissions Trading or Joint Implementation?
VOL	60.2002	*Giovanni DI BARTOLOMEO, Jacob ENGWERDA, Joseph PLASMANS and Bas VAN AARLE:* Staying Together or Breaking Apart: Policy-Makers' Endogenous Coalitions Formation in the European Economic and Monetary Union
ETA	61.2002	*Robert N. STAVINS, Alexander F.WAGNER and Gernot WAGNER*: Interpreting Sustainability in Economic Terms: Dynamic Efficiency Plus Intergenerational Equity
PRIV	62.2002	*Carlo CAPUANO*: Demand Growth, Entry and Collusion Sustainability
PRIV	63.2002	*Federico MUNARI and Raffaele ORIANI*: Privatization and R&D Performance: An Empirical Analysis Based on Tobin's Q
PRIV	64.2002	*Federico MUNARI and Maurizio SOBRERO*: The Effects of Privatization on R&D Investments and Patent Productivity
SUST	65.2002	*Orley ASHENFELTER and Michael GREENSTONE*: Using Mandated Speed Limits to Measure the Value of a Statistical Life
ETA	66.2002	*Paolo SURICO:* US Monetary Policy Rules: the Case for Asymmetric Preferences
PRIV	67.2002	*Rinaldo BRAU and Massimo FLORIO*: Privatisations as Price Reforms: Evaluating Consumers' Welfare Changes in the U.K.
CLIM	68.2002	*Barbara K. BUCHNER and Roberto ROSON*: Conflicting Perspectives in Trade and Environmental Negotiations
CLIM	69.2002	*Philippe QUIRION*: Complying with the Kyoto Protocol under Uncertainty: Taxes or Tradable Permits?
SUST	70.2002	*Anna ALBERINI, Patrizia RIGANTI and Alberto LONGO*: Can People Value the Aesthetic and Use Services of Urban Sites? Evidence from a Survey of Belfast Residents
SUST	71.2002	*Marco PERCOCO:* Discounting Environmental Effects in Project Appraisal

NRM	72.2002	*Philippe BONTEMS and Pascal FAVARD*: Input Use and Capacity Constraint under Uncertainty: The Case of Irrigation
PRIV	73.2002	*Mohammed OMRAN:* The Performance of State-Owned Enterprises and Newly Privatized Firms: Empirical Evidence from Egypt
PRIV	74.2002	*Mike BURKART, Fausto PANUNZI and Andrei SHLEIFER:* Family Firms
PRIV	75.2002	*Emmanuelle AURIOL, Pierre M. PICARD:* Privatizations in Developing Countries and the Government Budget Constraint
PRIV	76.2002	*Nichole M. CASTATER*: Privatization as a Means to Societal Transformation: An Empirical Study of Privatization in Central and Eastern Europe and the Former Soviet Union
PRIV	77.2002	*Christoph LÜLSFESMANN*: Benevolent Government, Managerial Incentives, and the Virtues of Privatization
PRIV	78.2002	*Kate BISHOP, Igor FILATOTCHEV and Tomasz MICKIEWICZ*: Endogenous Ownership Structure: Factors Affecting the Post-Privatisation Equity in Largest Hungarian Firms
PRIV	79.2002	*Theodora WELCH and Rick MOLZ*: How Does Trade Sale Privatization Work? Evidence from the Fixed-Line Telecommunications Sector in Developing Economies
PRIV	80.2002	*Alberto R. PETRUCCI*: Government Debt, Agent Heterogeneity and Wealth Displacement in a Small Open Economy
CLIM	81.2002	*Timothy SWANSON and Robin MASON* (lvi): The Impact of International Environmental Agreements: The Case of the Montreal Protocol
PRIV	82.2002	*George R.G. CLARKE and Lixin Colin XU:* Privatization, Competition and Corruption: How Characteristics of Bribe Takers and Payers Affect Bribe Payments to Utilities
PRIV	83.2002	*Massimo FLORIO and Katiuscia MANZONI*: The Abnormal Returns of UK Privatisations: From Underpricing to Outperformance
NRM	84.2002	*Nelson LOURENÇO, Carlos RUSSO MACHADO, Maria do ROSÁRIO JORGE and Luís RODRIGUES*: An Integrated Approach to Understand Territory Dynamics. The Coastal Alentejo (Portugal)
CLIM	85.2002	*Peter ZAPFEL and Matti VAINIO* (lv): Pathways to European Greenhouse Gas Emissions Trading History and Misconceptions
CLIM	86.2002	*Pierre COURTOIS*: Influence Processes in Climate Change Negotiations: Modelling the Rounds
ETA	87.2002	*Vito FRAGNELLI and Maria Erminia MARINA* (lviii): Environmental Pollution Risk and Insurance
ETA	88.2002	*Laurent FRANCKX* (lviii): Environmental Enforcement with Endogenous Ambient Monitoring
ETA	89.2002	*Timo GOESCHL and Timothy M. SWANSON* (lviii): Lost Horizons. The noncooperative management of an evolutionary biological system.
ETA	90.2002	*Hans KEIDING* (lviii): Environmental Effects of Consumption: An Approach Using DEA and Cost Sharing
ETA	91.2002	*Wietze LISE* (lviii): A Game Model of People's Participation in Forest Management in Northern India
CLIM	92.2002	*Jens HORBACH*: Structural Change and Environmental Kuznets Curves
ETA	93.2002	*Martin P. GROSSKOPF:* Towards a More Appropriate Method for Determining the Optimal Scale of Production Units
VOL	94.2002	*Scott BARRETT and Robert STAVINS*: Increasing Participation and Compliance in International Climate Change Agreements
CLIM	95.2002	*Banu BAYRAMOGLU LISE and Wietze LISE:* Climate Change, Environmental NGOs and Public Awareness in the Netherlands: Perceptions and Reality
CLIM	96.2002	*Matthieu GLACHANT*: The Political Economy of Emission Tax Design in Environmental Policy
KNOW	97.2002	*Kenn ARIGA and Giorgio BRUNELLO*: Are the More Educated Receiving More Training? Evidence from Thailand
ETA	98.2002	*Gianfranco FORTE and Matteo MANERA*: Forecasting Volatility in European Stock Markets with Non-linear GARCH Models
ETA	99.2002	*Geoffrey HEAL*: Bundling Biodiversity
ETA	100.2002	*Geoffrey HEAL, Brian WALKER, Simon LEVIN, Kenneth ARROW, Partha DASGUPTA, Gretchen DAILY, Paul EHRLICH, Karl-Goran MALER, Nils KAUTSKY, Jane LUBCHENCO, Steve SCHNEIDER and David STARRETT*: Genetic Diversity and Interdependent Crop Choices in Agriculture
ETA	101.2002	*Geoffrey HEAL:* Biodiversity and Globalization
VOL	102.2002	*Andreas LANGE*: Heterogeneous International Agreements – If per capita emission levels matter
ETA	103.2002	*Pierre-André JOUVET and Walid OUESLATI*: Tax Reform and Public Spending Trade-offs in an Endogenous Growth Model with Environmental Externality
ETA	104.2002	*Anna BOTTASSO and Alessandro SEMBENELLI*: Does Ownership Affect Firms' Efficiency? Panel Data Evidence on Italy
PRIV	105.2002	*Bernardo BORTOLOTTI, Frank DE JONG, Giovanna NICODANO and Ibolya SCHINDELE*: Privatization and Stock Market Liquidity
ETA	106.2002	*Haruo IMAI and Mayumi HORIE* (lviii): Pre-Negotiation for an International Emission Reduction Game
PRIV	107.2002	*Sudeshna GHOSH BANERJEE and Michael C. MUNGER*: Move to Markets? An Empirical Analysis of Privatisation in Developing Countries
PRIV	108.2002	*Guillaume GIRMENS and Michel GUILLARD*: Privatization and Investment: Crowding-Out Effect vs Financial Diversification
PRIV	109.2002	*Alberto CHONG and Florencio LÓPEZ-DE-SILANES*: Privatization and Labor Force Restructuring Around the World
PRIV	110.2002	*Nandini GUPTA*: Partial Privatization and Firm Performance
PRIV	111.2002	*François DEGEORGE, Dirk JENTER, Alberto MOEL and Peter TUFANO*: Selling Company Shares to Reluctant Employees: France Telecom's Experience

PRIV	112.2002	*Isaac OTCHERE*: Intra-Industry Effects of Privatization Announcements: Evidence from Developed and Developing Countries
PRIV	113.2002	*Yannis KATSOULAKOS and Elissavet LIKOYANNI*: Fiscal and Other Macroeconomic Effects of Privatization
PRIV	114.2002	*Guillaume GIRMENS:* Privatization, International Asset Trade and Financial Markets
PRIV	115.2002	*D. Teja FLOTHO:* A Note on Consumption Correlations and European Financial Integration
PRIV	116.2002	*Ibolya SCHINDELE and Enrico C. PEROTTI*: Pricing Initial Public Offerings in Premature Capital Markets: The Case of Hungary
PRIV	1.2003	*Gabriella CHIESA and Giovanna NICODANO*: Privatization and Financial Market Development: Theoretical Issues
PRIV	2.2003	*Ibolya SCHINDELE*: Theory of Privatization in Eastern Europe: Literature Review
PRIV	3.2003	*Wietze LISE, Claudia KEMFERT and Richard S.J. TOL*: Strategic Action in the Liberalised German Electricity Market
CLIM	4.2003	*Laura MARSILIANI and Thomas I. RENSTRÖM*: Environmental Policy and Capital Movements: The Role of Government Commitment
KNOW	5.2003	*Reyer GERLAGH*: Induced Technological Change under Technological Competition
ETA	6.2003	*Efrem CASTELNUOVO*: Squeezing the Interest Rate Smoothing Weight with a Hybrid Expectations Model
SIEV	7.2003	*Anna ALBERINI, Alberto LONGO, Stefania TONIN, Francesco TROMBETTA and Margherita TURVANI:* The Role of Liability, Regulation and Economic Incentives in Brownfield Remediation and Redevelopment: Evidence from Surveys of Developers
NRM	8.2003	*Elissaios PAPYRAKIS and Reyer GERLAGH*: Natural Resources: A Blessing or a Curse?
CLIM	9.2003	*A. CAPARRÓS, J.-C. PEREAU and T. TAZDAÏT*: North-South Climate Change Negotiations: a Sequential Game with Asymmetric Information
KNOW	10.2003	*Giorgio BRUNELLO and Daniele CHECCHI*: School Quality and Family Background in Italy
CLIM	11.2003	*Efrem CASTELNUOVO and Marzio GALEOTTI*: Learning By Doing vs Learning By Researching in a Model of Climate Change Policy Analysis
KNOW	12.2003	*Carole MAIGNAN, Gianmarco OTTAVIANO and Dino PINELLI (eds.)*: Economic Growth, Innovation, Cultural Diversity: What are we all talking about? A critical survey of the state-of-the-art
KNOW	13.2003	*Carole MAIGNAN, Gianmarco OTTAVIANO, Dino PINELLI and Francesco RULLANI* (lvix): Bio-Ecological Diversity vs. Socio-Economic Diversity. A Comparison of Existing Measures
KNOW	14.2003	*Maddy JANSSENS and Chris STEYAERT* (lvix): Theories of Diversity within Organisation Studies: Debates and Future Trajectories
KNOW	15.2003	*Tuzin BAYCAN LEVENT, Enno MASUREL and Peter NIJKAMP* (lvix): Diversity in Entrepreneurship: Ethnic and Female Roles in Urban Economic Life
KNOW	16.2003	*Alexandra BITUSIKOVA* (lvix): Post-Communist City on its Way from Grey to Colourful: The Case Study from Slovakia
KNOW	17.2003	*Billy E. VAUGHN and Katarina MLEKOV* (lvix): A Stage Model of Developing an Inclusive Community
KNOW	18.2003	*Selma van LONDEN and Arie de RUIJTER* (lvix): Managing Diversity in a Glocalizing World
Coalition Theory Network	19.2003	*Sergio CURRARINI:* On the Stability of Hierarchies in Games with Externalities
PRIV	20.2003	*Giacomo CALZOLARI and Alessandro PAVAN* (lvx): Monopoly with Resale
PRIV	21.2003	*Claudio MEZZETTI* (lvx): Auction Design with Interdependent Valuations: The Generalized Revelation Principle, Efficiency, Full Surplus Extraction and Information Acquisition
PRIV	22.2003	*Marco LiCalzi and Alessandro PAVAN* (lvx): Tilting the Supply Schedule to Enhance Competition in Uniform-Price Auctions
PRIV	23.2003	*David ETTINGER* (lvx): Bidding among Friends and Enemies
PRIV	24.2003	*Hannu VARTIAINEN* (lvx): Auction Design without Commitment
PRIV	25.2003	*Matti KELOHARJU, Kjell G. NYBORG and Kristian RYDQVIST* (lvx): Strategic Behavior and Underpricing in Uniform Price Auctions: Evidence from Finnish Treasury Auctions
PRIV	26.2003	*Christine A. PARLOUR and Uday RAJAN* (lvx): Rationing in IPOs
PRIV	27.2003	*Kjell G. NYBORG and Ilya A. STREBULAEV* (lvx): Multiple Unit Auctions and Short Squeezes
PRIV	28.2003	*Anders LUNANDER and Jan-Eric NILSSON* (lvx): Taking the Lab to the Field: Experimental Tests of Alternative Mechanisms to Procure Multiple Contracts

(l) This paper was presented at the Workshop "Growth, Environmental Policies and Sustainability" organised by the Fondazione Eni Enrico Mattei, Venice, June 1, 2001

(li) This paper was presented at the Fourth Toulouse Conference on Environment and Resource Economics on "Property Rights, Institutions and Management of Environmental and Natural Resources", organised by Fondazione Eni Enrico Mattei, IDEI and INRA and sponsored by MATE, Toulouse, May 3-4, 2001

(lii) This paper was presented at the International Conference on "Economic Valuation of Environmental Goods", organised by Fondazione Eni Enrico Mattei in cooperation with CORILA, Venice, May 11, 2001

(liii) This paper was circulated at the International Conference on "Climate Policy – Do We Need a New Approach?", jointly organised by Fondazione Eni Enrico Mattei, Stanford University and Venice International University, Isola di San Servolo, Venice, September 6-8, 2001

(liv) This paper was presented at the Seventh Meeting of the Coalition Theory Network organised by the Fondazione Eni Enrico Mattei and the CORE, Université Catholique de Louvain, Venice, Italy, January 11-12, 2002

(lv) This paper was presented at the First Workshop of the Concerted Action on Tradable Emission Permits (CATEP) organised by the Fondazione Eni Enrico Mattei, Venice, Italy, December 3-4, 2001

(lvi) This paper was presented at the ESF EURESCO Conference on Environmental Policy in a Global Economy "The International Dimension of Environmental Policy", organised with the collaboration of the Fondazione Eni Enrico Mattei , Acquafredda di Maratea, October 6-11, 2001

(lvii) This paper was presented at the First Workshop of "CFEWE – Carbon Flows between Eastern and Western Europe", organised by the Fondazione Eni Enrico Mattei and Zentrum fur Europaische Integrationsforschung (ZEI), Milan, July 5-6, 2001

(lviii) This paper was presented at the Workshop on "Game Practice and the Environment", jointly organised by Università del Piemonte Orientale and Fondazione Eni Enrico Mattei, Alessandria, April 12-13, 2002

(lvix) This paper was presented at the ENGIME Workshop on "Mapping Diversity", Leuven, May 16-17, 2002

(lvx) This paper was presented at the EuroConference on "Auctions and Market Design: Theory, Evidence and Applications", organised by the Fondazione Eni Enrico Mattei, Milan, September 26-28, 2002

2002 SERIES

CLIM	*Climate Change Modelling and Policy* (Editor: Marzio Galeotti)
VOL	*Voluntary and International Agreements* (Editor: Carlo Carraro*)*
SUST	*Sustainability Indicators and Environmental Valuation* (Editor: Carlo Carraro)
NRM	*Natural Resources Management* (Editor: Carlo Giupponi)
KNOW	*Knowledge, Technology, Human Capital* (Editor: Dino Pinelli)
MGMT	*Corporate Sustainable Management* (Editor: Andrea Marsanich)
PRIV	*Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)

2003 SERIES

CLIM	*Climate Change Modelling and Policy* (Editor: Marzio Galeotti)
GG	*Global Governance* (Editor: Carlo Carraro*)*
SIEV	*Sustainability Indicators and Environmental Valuation* (Editor: Anna Alberini)
NRM	*Natural Resources Management* (Editor: Carlo Giupponi)
KNOW	*Knowledge, Technology, Human Capital* (Editor: Gianmarco Ottaviano)
IEM	*International Energy Markets* (Editor: Anil Markandya)
CSRM	*Corporate Social Responsibility and Management* (Editor: Sabina Ratti)
PRIV	*Privatisation, Regulation, Antitrust* (Editor: Bernardo Bortolotti)
ETA	*Economic Theory and Applications* (Editor: Carlo Carraro)
CTN	*Coalition Theory Network*