

NAKED EXCLUSION IN THE LAB: THE CASE OF SEQUENTIAL CONTRACTING*

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In the context of the naked exclusion model of Rasmusen, Ramseyer and Wiley [1991] and Segal and Whinston [2000b], we examine whether sequential contracting is more conducive to exclusion in the lab, and whether it is cheaper for the incumbent than simultaneous contracting. We find that an incumbent who proposes contracts to buyers sequentially, excludes significantly more often than an incumbent who proposes contracts simultaneously. In contrast to theory, this comes at a substantial cost for the incumbent. Accounting for the observation that buyers are more likely to accept an exclusive contract the higher the payment, substantially improves the fit between theoretical predictions and observed behavior.

I. INTRODUCTION

SINCE THE BEGINNING OF THE 20TH CENTURY, courts have treated firms using exclusive contracts harshly for fear such contracts could be used to exclude

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rivals and, thus, hamper competition.¹ Starting in the 1950's, scholars belonging to the Chicago school (see, e.g., Director and Levi [1956]; Posner [1976]; Bork [1978]) argued that such fears are not warranted since using exclusive contracts for the sole purpose of anti-competitively excluding rivals would not be in the interest of rational profit-maximizing firms. Recently, this view on exclusive dealing has been challenged by various theorists who describe circumstances under which anti-competitive exclusion of rivals can be profitably used by dominant firms. One prominent contribution to this literature is the naked exclusion model put forward by Rasmusen, Ramseyer and Wiley [1991] and Segal and Whinston [2000b] (henceforth RRW-SW).²

Consider an incumbent seller, a more efficient entrant and two buyers with independent demand. Due to economies of scale caused by, for instance, fixed entry costs, the entrant needs both buyers to be 'free' (i.e., not bound by exclusive contracts with the incumbent) to enter the market profitably. An exclusive contract in this framework takes the form of a payment from the incumbent to a buyer in exchange for the buyer's promise to buy exclusively from the incumbent. RRW-SW show that, under mild assumptions, the incumbent needs to 'convince' only one buyer in the market to sign an exclusive contract to deter entry and extract monopoly profits from both buyers. Indeed, compensating one buyer for the forgone consumer surplus that results from dealing with the incumbent—sometimes referred to as a 'divide-and-conquer' strategy—is sufficient to obtain exclusion in the case different contracts can be proposed to the two buyers. Moreover, if buyers are approached sequentially, exclusion is achieved at negligible costs. The idea is that the first buyer anticipates that, if he rejects a contract, the incumbent can surely convince the second buyer to accept by making him an offer he cannot refuse. Hence, the first buyer will accept any, even a 'lousy,' offer that deters entry. This stands in contrast to the case in which it is impossible for the incumbent to

¹ Early cases include *Standard Fashion Company v. Margrane-Houston Company* (258 U.S. 346 [1922]) and *United States v. Aluminum Co. of America* (148 F.2d 416 [1945]). More recent cases include *Microsoft* (253 F.3d 34 [2001]), *U.S. v. Dentsply* (399 F.3d [2001]), *Comwood v. United States Tobacco* (290 f.3d 758 [2002]) in the U.S. and the *Intel* case (C227 [2009]) in Europe.

² The term 'naked' refers to the sole purpose of an exclusive deal to exclude a rival without offering any efficiency justification. Other models study exclusive dealing in a related context. Aghion and Bolton [1987], for example, include damage penalty provisions in their model. Innes and Sexton [1994] allow for buyers to vertically integrate. Bernheim and Whinston [1998] model exclusive dealing in a multi-market case. Fumagalli and Motta [2006], Fumagalli and Motta [2008], Simpson and Wickelgren [2007], Abito and Wright [2008] and Wright [2009] take into account that buyers might be firms that compete in a downstream consumer market. In the same context, Johnson [2012] analyzes exclusive dealing in the presence of adverse selection. Finally, DeGraba [2010] shows how exclusive deals in the presence of demand asymmetries allow a dominant supplier to charge the monopoly price for its input, even though a smaller rival manages to stay in the market.

discriminate between the buyers. In this case, exclusion is not guaranteed: the monopoly profit the incumbent would earn under exclusion is not sufficiently high to compensate both buyers for their forgone surplus. The buyers' subgame is then a symmetric coordination game with multiple equilibria and exclusion occurs only if the buyers fail to coordinate on the (more efficient) rejection equilibrium.

In this paper we examine whether sequential contracting is more conducive to exclusion in the lab than simultaneous contracting. Moreover, we study whether exclusion costs under sequential contracting are negligible as suggested by theory. For comparison purposes, we include treatments with simultaneous non-discriminatory and discriminatory contracting. While predictions in the case of simultaneous contracting are notoriously vague—there is a continuum of equilibria—the prediction is, as outlined above, quite strong in the case of sequential contracting: exclusion is guaranteed at negligible cost to the incumbent. Regarding the latter and in the light of the experimental literature on bargaining games, in particular the ultimatum game (Güth [1995]; Roth [1995]), it is questionable whether the first buyer will accept any offered payment, even a very small one—an assumption on which the result of exclusion at negligible costs rests. Furthermore, the predictions of the various versions of the naked-exclusion model, which we test in this paper, depend not only on whether contracting proceeds simultaneously or sequentially, but also on whether offers are (non)discriminatory or publicly known or not. These conditions can easily be controlled in the lab and much less so in the field.³

Our paper is the first to study exclusive dealing in an experiment with sequential contracting. Landeo and Spier [2009] report experimental evidence showing that the theoretical difference in exclusion rates between simultaneous discriminatory and simultaneous non-discriminatory regimes is not that important from a behavioral perspective. In fact, when the buyers cannot communicate, the exclusion rate is not higher in a discriminatory than in a non-discriminatory regime.⁴ When the buyers

³ The issue of generalizability of results from experiments where student subjects, as in our experiments, take the role of firms remains. We argue that it might be less of a concern in the present experiment than for typical market experiments. True, other-regarding preferences might matter in our experiment (and more so than in real markets). But the main issue tested here is that of coordination, which is beneficial for buyers both in the laboratory and in the market, and the issue of whether or not a 'principal' (the incumbent) can take advantage of an externality among 'agents' (the buyers). There is *a priori* no reason why it should work better or worse for experienced managers than for students. Testing the issue of coordination and the use of exclusive deals in lab markets thus potentially allows us to infer possible behaviors in non-experimental markets. Nevertheless, we acknowledge that despite the fact that we give subjects ample opportunity to learn, our use of a standard student subject pool may miss some important issues that matter for coordination of firms in the field.

⁴ When the buyers are able to communicate, the predicted difference in exclusion rates between both regimes occurs because the buyers coordinate better on the rejection equilibrium in the no-discriminatory case.

can communicate, they succeed reasonably well in coordinating to reject their offered contracts such that no exclusion occurs. Another experimental study on simultaneous exclusive dealing is Smith [2011]. Smith focuses on the case in which an incumbent cannot discriminate between buyers, and finds that the likelihood of exclusion increases when the incumbent needs fewer buyers to sign exclusive contracts for entry to be deterred.

In our paper, we show that if the discriminatory regime is one of sequential contracting, exclusion rates *do* increase above the level obtained under no discrimination. We also show that, in contrast to theory, exclusion costs are substantial under sequential contracting and do not differ much from those under the simultaneous regimes. The main driving force behind the results is that buyers are more likely to accept an exclusive contract as the payment proposed by the incumbent increases. Since such behavior is intuitive, plausible, and a robust phenomenon in our data, we adjust the naked exclusion model by modeling the buyers' acceptance probability with a logit response function. We show that such an adjustment improves the correspondence between theory and behavior and generates comparative-static predictions that are largely in line with observed behavior.

A few empirical studies analyze the effects of exclusive contracts; most of them deal with analyzing their effect on prices and welfare in the beer industry. Results are mixed. For instance, whereas Slade [2000] finds a negative effect of exclusive contracts on consumer welfare, Sass [2005], Asker [2004], and Asker [2005] report a positive effect. Furthermore, Heide, Dutta and Bergen [1998] conducted survey research in the machinery and electronic equipment sector and find that 'business efficiency factors play a significant role in firms' decisions regarding exclusive dealing' (p. 387). Whinston [2006] and Lafontaine and Slade [2008] have lamented the paucity of field studies analyzing the effect of exclusive contracts on competition. This report from the lab adds to the ongoing discussion on the effects of exclusive dealing.

The remainder of the paper is organized as follows. In Section II, we introduce the naked exclusion model. Section III contains the experimental design and procedures, and the hypotheses. In Section IV, we report the results. Section V concludes.

II. THEORY

The RRW-SW model features an incumbent seller, a more efficient entrant, and, in our implementation, two buyers with independent demand who are final consumers. Due to, for instance, fixed entry costs, the entrant needs to sell to both buyers to make entry profitable. Therefore, if the incumbent

TABLE I
PAYOFFS

		<i>Buyers' payoffs</i>			
		Decision of Buyer 2			
		Accept		Reject	
Decision of Buyer 1	Accept	$165 + x_1,$	$165 + x_2$	$165 + x_1,$	165
	Reject	165,	$165 + x_2$	500,	500
<i>Incumbent's payoffs</i>					
If no buyer accepts		If only buyer i accepts		If both buyers accept	
50		$500 - x_i$		$500 - x_1 - x_2$	

can induce at least one of the two buyers to sign an exclusive contract, entry is deterred.⁵

The model has four stages. In a first stage, the incumbent offers to pay x_1 , $x_2 \in \{0, 1, 2, \dots\}$ to buyer 1 and 2, respectively, and, in a second stage, the buyers either accept or reject the proposed amount. By accepting, a buyer signs a contract with the incumbent in which he promises to buy exclusively from the incumbent. In a third stage, the decisions of the two buyers become publicly known and the entrant decides about entry. In a fourth stage, all active firms set prices and payoffs ensue.⁶

In the case where both buyers reject the incumbent's offer and entry occurs, the entrant will set a price slightly below or equal to the incumbent's unit production cost. The entrant will thus sell to both free buyers. This leaves the incumbent with zero profit and generates a 'high' surplus for each buyer. If entry does not occur, the incumbent has monopoly power and monopoly pricing leads to higher prices and thus 'low' buyer surplus.

In our experiment, the monopoly profit is equal to 500 such that the incumbent earns 500 minus the sum of the accepted payments in the case of exclusion. In the case of entry, the incumbent earns 50 (see lower part of Table I). The payoff matrix of the buyers is as shown in the upper part of Table I.⁷ If at least one buyer i accepts payment x_i offered by the

⁵ RRW-SW analyze the general case with $N \geq 2$ buyers, where the entrant enters the market if and only if the number of buyers that sign exclusive contracts is smaller than N^* with $1 \leq N^* \leq N$.

⁶ In our experiment, we focus on the interaction between the incumbent and the buyers. Hence, we will collapse the four-stage game into a two-stage game assuming subgame-perfect behavior in stages 3 and 4 (just like Landeo and Spier [2009]; Smith [2011]). See Section 3 for more details on the design.

⁷ In the parametric example underlying our experiment, the incumbent has unit production costs of $c_I = 20$ and the entrant has unit production costs of $c_E = 0$. A buyer's demand is given by $D(p) = 50 - p$. The consumer surplus for each buyer is $CS^E = 450$ under entry and

incumbent, entry is deterred and the accepting buyers earn $165 + x_i$. A buyer who rejects, earns 165 in the case of entry deterrence. If both buyers reject, the more efficient entrant enters the market, and the buyers earn 500 each. The extra consumer surplus of entry for a single buyer is thus equal to 335.

In our experiment we focus on the case where the incumbent can offer payments to buyers sequentially. Since we are interested in comparative statics, we study whether sequential contracting leads to different exclusion rates than simultaneous contracting. In particular, we compare outcomes under sequential contracting to three benchmark cases: one with simultaneous non-discriminatory contracting and two with simultaneous discriminatory contracting. Hence, we first discuss these three cases of simultaneous contracting.

If the incumbent approaches both buyers simultaneously and cannot discriminate between buyers, such that $x_1 = x_2 = x$, both exclusionary and non-exclusionary equilibria exist. To ensure exclusion, the incumbent would have to offer $x > 335$ such that both buyers are sure to accept. However, the incumbent is not in the position to offer an amount that high since it would lead to a loss on his side ($2 \times 335 > 500 - 50$). Therefore, given that $x \leq 335$, the buyers play a symmetric coordination game. In particular, there are two classes of subgame-perfect equilibria: exclusion equilibria where $x \in [0, 225]$ and both buyers accept and no-exclusion equilibria where $x \in [0, 335]$ and both buyers reject.⁸ Successful exclusion is thus obtained if buyers fail to coordinate on rejecting the incumbent's payment.⁹ We refer to the game in which the incumbent makes offers simultaneously and cannot discriminate between buyers as *SIMNON*.¹⁰

Let us now turn to the case in which the incumbent can discriminate between the buyers but still makes offers simultaneously. We consider two

$CS^I = 112.5$ (rounded at 115) under exclusion. The incumbent's profit is zero under entry and 450 minus the sum of the accepted offers under exclusion. In order to avoid zero earnings for the incumbent in the case entry occurs, and thus potential frustration on the part of subjects acting in the role of an incumbent in the experiment, we add 50 to the payoffs of *all* active players (so also to CS^I and CS^E). This generates payoffs as mentioned in the text and in Table I.

⁸ The upper bound on offers in exclusion equilibria is due to the fact that for $x > 225$ incumbents would make losses, and the upper bound on offers in no-exclusion equilibria is due to the fact that for $x > 335$ it becomes a dominant strategy for buyers to accept.

⁹ In the buyers' subgame, risk dominance predicts that both buyers reject if $x < 167.5$ and both buyers accept if $x > 167.5$. Buyers are indifferent for $x = 167.5$ (Harsanyi and Selten [1988]). Note also that only non-exclusionary equilibria are perfectly coalition-proof (see Segal and Whinston [2000b]).

¹⁰ We focus on pure strategy equilibria. There also exist mixed strategy equilibria in the buyers' subgame. These have the property that the probability of acceptance *decreases* with the offer in order to keep the other buyer indifferent between accepting and rejecting. However, as can be seen in Table VI, in the experiment the probability of acceptance is an *increasing* function of the offer. Therefore, we do not consider equilibria in mixed strategies here.

versions, one with public and one with secret offers. In the first version, the two simultaneous offers made by the incumbent are observable by the buyers before they make their decision. We refer to this game as *SIMDIS-P*, where ‘P’ stands for public. Given that the monopoly profit is sufficiently high to convince one buyer to sign an exclusionary contract ($450 > 335$), the entrant can be excluded with certainty (see case A of Proposition 3 in Segal and Whinston [2000b]) and only exclusionary equilibria exist. The costs of exclusion (i.e., the sum of *accepted* offers) lie anywhere between zero and 336. In one subgame-perfect Nash equilibrium, the incumbent offers a payment of 335 or 336 to one buyer, who accepts, and zero to the other buyer, who rejects. In other subgame-perfect Nash equilibria, offers to both buyers are positive and sum up to an amount smaller than or equal to 336 and both buyers accept.¹¹

In the second version of simultaneous discriminatory offers, a buyer observes his own offer but not the offer made to the other buyer. We refer to this game as *SIMDIS-S*, where ‘S’ stands for secret. In this game, the incumbent obtains exclusion for free. In fact, under passive beliefs, the unique (perfect Bayesian) Nash equilibrium predicts the incumbent to offer $(x_1, x_2) = (0, 0)$ and both buyers accept.¹²

In the case of sequential contracting, which is the main focus of our experiment, the incumbent first makes an offer to one buyer (‘buyer 1’) who decides whether to accept or reject. Then—knowing the decision of buyer 1—the incumbent makes an offer to the other buyer (‘buyer 2’) who—after being informed about buyer 1’s decision—also decides whether to accept or reject. In this game, exclusion again arises for sure and (almost) for free. Indeed, in the subgame-perfect Nash equilibrium the incumbent offers zero or one to buyer 1, who accepts, and zero to buyer 2, who rejects or accepts. The reason that buyer 1 accepts a payment of zero or one is that he knows that if he would reject, the incumbent would make buyer 2 an offer he cannot refuse (> 335). Given that buyer 1 accepts (which already deters entry), buyer 2 is offered zero along the subgame-perfect equilibrium path.

¹¹ In the buyers’ subgame, risk dominance predicts that both buyers accept if $x_1 x_2 > (335 - x_1)(x_2 - 335)$, or equivalently, $x_1 + x_2 > 335$. If $x_1 + x_2 < 335$ both buyers reject and if $x_1 + x_2 = 335$ they are indifferent (Harsanyi and Selten [1988]).

¹² Under passive beliefs, a buyer receiving an out-of equilibrium offer, believes that the other buyer received the equilibrium offer (see McAfee and Schwartz [1994]). To see that the equilibrium is unique under passive beliefs, consider an offer (x_1, x_2) which is rejected by both buyers. This cannot be an equilibrium as the seller can deviate from this by offering 335 (or 336) to one buyer and get acceptance. Next, consider as candidate equilibrium the offer (x_1, x_2) with $x_2 \in [1, 335]$. If buyer 1 accepts, this cannot be an equilibrium as buyer 2 should accept as well in this case and the seller could have saved money by setting $x_2 = 0$. If buyer 1 rejects, buyer 2 should reject as well, which cannot be an equilibrium, as we just explained. Note that this reasoning holds for any $x_1 < 335$ and in particular for $x_1 = 0$. Hence offers of 0 to both buyers and both buyers accepting is the only equilibrium outcome (see Segal and Whinston [2000b]). Note also that wary beliefs (see McAfee and Schwartz [1994]) deliver the same result.

TABLE II
THEORETICAL PREDICTIONS

	Exclusion rate	Exclusion costs
SIMNon	∈ [0,100%]	∈ [0, 450]
SIMDIS-P	100%	∈ [0, 336]
SIMDIS-S	100%	0
SEQ-P	100%	∈ [0, 1]
SEQ-S	100%	∈ [0, 1]

Note: The predictions are derived from subgame-perfect Nash equilibrium.

In our experiment, we have two versions of the sequential contracting game. In both versions, buyer 2 observes the *decision* of buyer 1. But whereas in one version buyer 2 observes the offer made to buyer 1, in the other version buyer 2 does not observe the offer made to buyer 1. We refer to the first as SEQ-P and to the second as SEQ-S, where, ‘P’ stands for a public offer 1 and ‘S’ stands for a secret offer 1. Keeping secret offer 1 for buyer 2 is inconsequential for the subgame-perfect equilibrium outcome. However, we include SEQ-S in our experiment in order to bring the laboratory setting closer to a real-life setting as it is not likely that payments offered by incumbents are publicly observable.

Table II summarizes the theoretical predictions. Exclusion costs are defined as the sum of accepted offers given exclusion.

III. EXPERIMENTAL PROCEDURES AND HYPOTHESES

The experiment was run in June, 2010, in the CEE lab at the University of Copenhagen with 234 students from different fields of study.¹³ Sessions took about 90 minutes and participants earned EUR 19 on average.

As mentioned before, in our experiment we focus on the interaction between the incumbent and the buyers (like Landeo and Spier [2009]; Smith [2011]), which in our view is the crux of the naked-exclusion model. Therefore, there is no entrant present in our experiment and we collapse the multiple-stage game into a two-stage game, assuming subgame-perfect behavior of the entrant (and the incumbent) with respect to both entry and pricing decisions.¹⁴ This allows the construction of a payoff table for buyers

¹³ We used the z-Tree toolbox (Fischbacher [2007]) to program and run the software used in this experiment.

¹⁴ We think it is the coordination problem of the buyers and the (in)ability of the incumbent to take advantage of the externality buyers exert on each other that are the most interesting aspects of the naked-exclusion model. Moreover, Boone *et al.* [2012] conduct experimental Bertrand markets with asymmetric unit costs. They show that these markets work as theory predicts right from the start, in the sense that the most efficient firm sets a price slightly below the unit cost of the second most efficient firm. Given these results, the only question left in the context of the naked-exclusion model is whether entry happens when it is profitable. We thought this is of lesser interest. For a similar approach, see, e.g., the limit-pricing experiments by Cooper, Gravin and Kagel [1997], Landeo and Spier [2009] or Smith [2011].

TABLE III
OVERVIEW OF TREATMENTS AND NUMBERS OF OBSERVATIONS

	Treatment	Sequential	Full info	# Subjects	# Matching groups
1	SIMNON	no	yes	45	5
2	SIMDIS-P	no	yes	54	6
3	SIMDIS-S	no	no	36	4
4	SEQ-P	yes	yes	45	5
5	SEQ-S	yes	no	54	6
Total				234	26

as shown in Table I, which we also used in the experiment. All participants in a session received the same instructions, containing the payoff function of the incumbent and the buyers.¹⁵ Subjects were informed that monetary earnings would depend on the cumulative earnings made throughout the experiment. In the instructions, payoffs were denoted in points and, in order to cover potential losses of participants acting in the role of an incumbent, all participants were initially endowed with 1600 points. The conversion rate of points into DKK was 500 points = DKK 10. After reading the instructions, subjects were randomly assigned a role, which was fixed throughout the experiment.¹⁶

The experiment has five treatments that correspond to each of the five games described in Section II, and each subject participated in one of the five treatments only. Table III provides an overview of our treatments. In all treatments, the same game was repeated twenty times in order to allow for learning. After each repetition, feedback was provided to incumbents and buyers about acceptance decisions and own payoffs, and participants were randomly rematched within matching groups of nine subjects each (three incumbents and six buyers). Whereas in SIMDIS-P, buyers were informed about both offers before they made their decision, in SIMDIS-S a buyer was only informed about his own offer but not about the one received by the other buyer. In SEQ-P, buyer 2 was informed about buyer 1's decision before he made his decision, and about the offer buyer 1 received. In SEQ-S, buyer 2 was informed about buyer 1's decision before he made his decision, but *not* about the offer buyer 1 received.¹⁷ In both of these sequential treatments, the incumbent made an offer to buyer 2 after having learned about the decision of buyer 1.

¹⁵ Instructions are available on the Journal's editorial Web site.

¹⁶ In the experiment we used neutral wording and did not mention the existence of an entrant. An incumbent was called an A-participant and buyers were called B-participants.

¹⁷ Participants acting in the role of a buyer in the four discriminatory treatments alternated between being buyer 1 ('B1') and buyer 2 ('B2') and were informed about this. This switching was implemented in order to avoid the possibility that an incumbent always discriminated the same buyer subject.

The RRW-SW model predicts that under SIMNON , there is a multiplicity of equilibria where either both buyers reject or both buyers accept the offer made by the incumbent. The average exclusion rate can thus lie anywhere between 0 and 1. Under a discriminatory regime, however, both buyers rejecting cannot be part of a subgame-perfect or perfect Bayesian Nash equilibrium. Nor does it matter whether within the sequential regimes buyer 2 observes the amount offered to buyer 1. Knowing that the incumbent can always offer an amount such that it is a dominant choice for buyer 2 to accept, buyer 1 should accept any offer, irrespective of whether the information about the size of the offer is communicated to buyer 2. Therefore, in the discriminatory treatments the exclusion rate should be 100%. Hypothesis 1 is thus formulated as follows.

Hypothesis 1. Exclusion rates in SIMDIS-P , SIMDIS-S , SEQ-P and SEQ-S are higher than in SIM-Non , as long as the exclusion rate is strictly below 100% in the latter treatment.

With respect to the costs of exclusion for incumbents, the predictions of the RRW-SW model are clear-cut for three of the four discriminatory games (SIMDIS-S , SEQ-P and SEQ-S): they are predicted to be either 0 or 1. For the case of SIMNON and SIMDIS-P , exclusion costs can be substantially above 0 (see Table II). This leads to our second hypothesis.

Hypothesis 2. Exclusion costs are lower in SIMDIS-S , SEQ-P and SEQ-S compared to SIMNON and SIMDIS-P , as long as they are strictly above one in the latter two treatments.

IV. RESULTS

In Section IV(i) we present the aggregate results and focus on differences across treatments with respect to exclusion rates and exclusion costs. In Section IV(ii) we take a closer look at behavior of incumbents and buyers in each of the different treatments. In Section IV(iii) we propose a ‘behavioral’ modification of the naked exclusion model that substantially increases the fit between predictions and observed data.

IV(i). *Exclusion Rates and Costs: Aggregate Results*

In this section we present the aggregate results and focus on differences between treatments. Table IV gives an overview of aggregate exclusion rates and costs and profits averaged by treatment across all data points. Table V reports p -values from Mann-Whitney-U (MWU) tests that compare exclusion rates and costs between treatments, where the units of observation are averages of independent matching groups.

Exclusion rates in SIMNON , SIMDIS-P , and SIMDIS-S are 53%, 59%, and 57%, respectively (differences not significant). In line with results reported

TABLE IV
AVERAGE EXCLUSION RATES AND COSTS

	Exclusion rate	Exclusion costs	Profit incumbent	Total Profit buyers
SIMNON	0.53 (0.50)	273 (117)	143 (123)	791 (216)
SIMDIS-P	0.59 (0.49)	254 (112)	166 (129)	755 (222)
SIMDIS-S	0.57 (0.50)	245 (108)	166 (130)	759 (226)
SEQ-P	0.81 (0.40)	247 (88)	214 (113)	658 (185)
SEQ-S	0.74 (0.44)	256 (86)	194 (112)	693 (196)

Notes: The table reports averages across all data points and standard deviations (in parentheses). Exclusion costs are conditional on acceptance.

TABLE V
NON-PARAMETRIC TEST RESULTS

(a) Exclusion rate					
	SIMDIS-P	SIMDIS-S	SEQ-P	SEQ-S	SEQ
SIMNON	.855	.902	.028	.100	.027
SIMDIS-P		.915	.006	.055	
SIMDIS-S			.014	.088	
SEQ-P				.715	
SIMDIS					.002
SIM					.001
(b) Exclusion costs					
	SIMDIS-P	SIMDIS-S	SEQ-P	SEQ-S	SEQ
SIMNON	.273	.086	.251	.273	.193
SIMDIS-P		.286	.855	.749	
SIMDIS-S			.624	.136	
SEQ-P				.465	
SIMDIS					.398
SIM					.979

Notes: The table reports p -values from Mann-Whitney-U tests based on independent observations. SEQ refers to merged data from SEQ-P and SEQ-S, SIMDIS to merged data from SIMDIS-P and SIMDIS-S, and SIM to merged data from SIMNON and SIMDIS.

in Landeo and Spier [2009], we neither find that discrimination significantly increases the likelihood of exclusion.¹⁸ The 53% exclusion rate in SIMNON implies that in 47% of the cases buyers succeed in coordinating on the more efficient rejection outcome. This corresponds to the standard result from

¹⁸ Our treatment SIMNON corresponds to their treatment 'EN/ND/NC' while our treatment SIMDIS-P corresponds to their treatment 'EN/D/NC'. The exclusion rates found in our treatments are substantially lower than those found in Landeo and Spier [2009]. A potential explanation might be a possible subject-pool effect. Engelmann and Normann [2010] report that in their Danish sample, subjects coordinated on the Pareto-optimal equilibrium in minimum-effort games more often than subjects in other countries (holding other design features constant). As we recruited our subjects from the same Danish subject pool, the lower exclusion rates found in our paper in comparison to those in Landeo and Spier [2009] could hence be explained by the higher propensity to successfully coordinate by the Danish subject pool. Clearly, a potential fixed subject pool effect has no bearing on between-treatment comparisons, which are the main purpose of analysis in our paper.

experiments on coordination games, that players often succeed in overcoming coordination problems (for example, Cooper *et al.* [1990]; Battalio, Samuelson and Huyck [2001]; Schmidt *et al.* [2003]).

Exclusion rates in SEQ-P and SEQ-S are 81% and 74% (difference not significant). Under a sequential regime exclusion rates are thus overall at least 15 percentage points higher than in both (non-discriminatory and discriminatory) simultaneous regimes (pooled 'SEQ' versus pooled 'SIMDIS' and pooled 'SEQ' versus pooled 'SIM' both significantly different at the 1% level, and pooled 'SEQ' versus pooled 'SIMNON' significantly different at the 5% level).

Exclusion costs for incumbents, calculated as the sum of accepted offers conditional on exclusion, are on average between 245 and 256 in the discriminatory treatments (SIMDIS-P, SIMDIS-S, SEQ-P, and SEQ-S) and somewhat higher (273) in SIMNON. In all cases, exclusion costs are significantly higher than zero ($p < .001$ in one-sample t-test). And, as Table V shows, with only one exception, pair-wise treatment differences are statistically indistinguishable. Moreover, the null hypotheses that average exclusion costs come from different populations depending on the treatment is not rejected in a Kruskal-Wallis test ($p = .371$).

How do our results translate into earnings of incumbent and buyers? The incumbent's earnings are significantly higher under a sequential regime than under a simultaneous regime ($p = .016$ in MWU-test comparing SIM to SEQ) whereas buyers are worse off under sequentiality ($p = .007$ in MWU-test comparing SIM to SEQ).

Our first result can be summarized as follows:

Result 1.

- (i) Exclusion rates in simultaneous discriminatory and non-discriminatory regimes are not significantly different from one another.
- (ii) Exclusion rates in sequential regimes are significantly higher than in the non-discriminatory regime.
- (iii) Exclusion rates in sequential regimes are significantly higher than in the simultaneous discriminatory regimes.
- (iv) Exclusion costs for the incumbent are significantly higher than zero in all treatments. Moreover, exclusion costs are not significantly different between treatments.

Result 1(i) basically confirms an earlier result in Landeo and Spier [2009] that discrimination *per se* does not increase the exclusion rate. Results 1(ii) to 1(iv) are new. Result 1(ii) is in line with the theoretical prediction. Results 1(iii) and 1(iv), on the contrary, are not. Indeed, whereas theory does not predict exclusion to be sensitive to the type of discriminatory regime, the experiment reveals that a necessary condition for discrimination to facili-

tate exclusion is that contracts are offered sequentially. Moreover, in contrast to the predictions, exclusion costs in treatment SIMDIS-S and the two sequential treatments are as substantial as in the other treatments.

Why doesn't the possibility of discrimination between buyers *alone* significantly increase the incidence of exclusion, but, rather, does it also take sequentiality of offers to do so? A possible reason is that without sequentiality, buyers still have the possibility of coordinating on the more efficient entry outcome in the buyers' subgame. Indeed, when the incumbent's offers are both below 336, the buyers' subgame is a coordination game. In the sequential treatments, the buyers never play a coordination game. In Section IV(ii) we not only show that the buyers' subgame is often a coordination game in SIMDIS, but also that, on average, incumbents make higher profits when proposing offers that turn the buyers' subgame into a coordination game than when proposing divide-and-conquer offers.¹⁹

IV(ii). *Description of Behavior of Incumbents and Buyers*

In this section we study behavior of incumbents and buyers in the different treatments in more detail. In particular, we study the distribution of amounts offered by incumbents and acceptance rates of buyers. Figure 1 shows the distribution of offers made by incumbents (depicted by the size of the bubbles) and acceptance rates of buyers for the four treatments.²⁰ For the sequential treatments, we distinguish between offers made to buyer 1, to buyer 2 after buyer 1 rejected, and to buyer 2 after buyer 1 accepted.

Panel (a) of Figure 1 shows that in SIMNON, the majority of offered payments are between 150 and 250, in particular around 200. Also, the acceptance rate increases as the offered payment increases. This finding is parallel to behavior in experimental coordination (stag hunt) games. Players in such games take *ceteris paribus* less risk in coordinating on the efficient equilibrium when the 'risky' payoff is lower or the payoff corresponding to the safe alternative is higher (see e.g., Battalio, Samuelson and

¹⁹ In an older set of sessions we implemented the naked exclusion games in a within-subject design. Here, all subjects first play the non-discriminatory regime before playing (with the player roles kept fixed) one of the three discriminatory regimes. The comparative statics are the same as in this study, except that sequential contracting alone is not sufficient to obtain a higher exclusion rate. Instead, it only increases exclusion rates over those in simultaneous regimes if the contract terms offered to the first buyer are unknown to the second buyer (cf. SEQ-S). The fact that in this other experiment subjects first play the non-discriminatory game, where exclusion is not guaranteed, may make behavior in subsequently played discriminatory games more 'sticky.' Indeed, the relatively favorable outcomes for buyers obtained in the non-discriminatory game may form an aspiration for outcomes in games played thereafter, such that more than sequentiality alone is needed to break coordination between buyers. The data of the current between-subject design supersedes the one of the earlier within-subject design. We report on the latter in Boone, Müller and Suetens [2009].

²⁰ For a tabular version, see Table A1 in Appendix A(i).

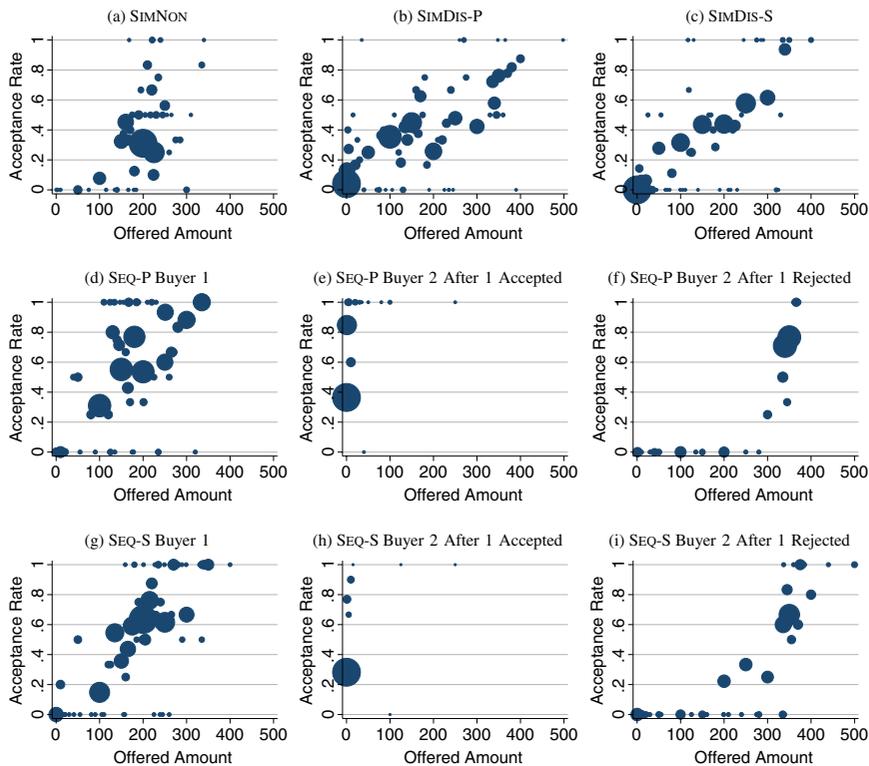


Figure 1

Acceptance Rate as a Function of Offered Amount

Notes: The figure shows acceptance rates as a function of offered amounts by treatment. The size of the bubbles is proportional to observed frequencies.

Huyck [2001]; Schmidt *et al.* [2003]). Translated to the naked exclusion context: buyers are less likely to take the risk of rejecting an offer made by the incumbent if the offer, and thus the payoff from accepting, is higher (see also Smith [2011]; Landeo and Spier [2009]). This behavior is most likely driven by individuals using threshold strategies. If one views the buyers' subgame as a game where the buyers have heterogeneous risk preferences and are uncertain about each other's risk preferences (as discussed in Heinemann, Nagel and Ockenfels [2009]), buyers are predicted to switch at different thresholds from rejecting to accepting, which results in an aggregate visual pattern as in panel (a) of Figure 1.

Panels (b) and (c) of Figure 1 show that in SIMDIS-P and SIMDIS-S offered amounts are more dispersed as compared to SIMNON. The modal offer is now close to zero. In SIMDIS-P this peak partly stems from a divide-and-conquer strategy on the part of the incumbent where one buyer is offered an amount close to zero (measured as an offer in the range $[0,35]$),

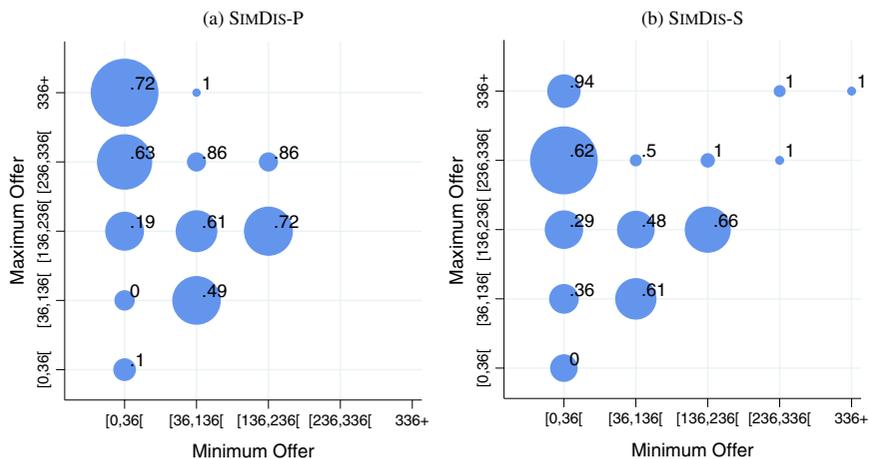


Figure 2

Exclusion Rate by Minimum and Maximum Offer in SIMDIS

Notes: The figure shows exclusion rates for different combinations of minimum and maximum offers in SIMDIS-P and SIMDIS-S (divided into five intervals each). The size of the bubbles is proportional to observed frequencies for each combination of intervals.

and the other buyer an amount slightly higher than 335 (measured as an offer of 336 or higher). Such strategy makes it a dominant strategy for the buyer with the high offer to accept in the subgame. Panel (a) of Figure 2 gives an overview of pairs of offered amounts and exclusion rates in SIMDIS-P. The graph shows that from all offer combinations, more than one quarter correspond to a combination of a minimum offer in interval [0,35] and a maximum offer above 335.²¹ The figure also shows that the exclusion rate for such divide-and-conquer strategies is among the highest.²² Other observed offer combinations (with the exception of one observation) transform the buyers' subgame into a coordination game. These are pairs of offers where the maximum offer is below 335. About 70% of combined payments are such that the buyers' subgame is a coordination game, of which about 40% are nearly symmetric.²³

It thus seems that rather than inducing acceptance as a dominant strategy for one of the buyers, incumbents prefer to induce strategic uncertainty among buyers. Interestingly, this strategy is successful in the sense that

²¹ For a tabular version, see Table A2 in Appendix A(i).

²² Landeo and Spier [2009] observe these divide-and-conquer offers more frequently than we do, which is, arguably, not surprising given that in their design the action space for the incumbent is restricted to four possible payments.

²³ As long as the sum of these offers is below 336, they could be part of a subgame-perfect Nash equilibrium. However, since the corresponding exclusion rates are well below 1, most of these cases are *not* part of a subgame-perfect Nash equilibrium.

incumbents who use divide-and-conquer offers earn on average much less than incumbents who do not use them, particularly compared to incumbents who propose combinations of (sufficiently high) offers that create a coordination game in the buyers' decision stage. To illustrate, in treatment SIMDIS-P the average profit calculated across all divide-and-conquer offers is 119, whereas it is 183 across all other offers, and 208 across 'nearly symmetric' offers in intervals [36-135) or [136-235).²⁴ This suggests that it might be a clever strategy for incumbents in SIMDIS-P to avoid divide-and-conquer offers, and, particularly, to offer roughly symmetric amounts.

Although in both SIMDIS-P and SIMDIS-S there is a positive relation between offered amount and acceptance rate, it can be seen in panel (b) of Figure 2 that the distribution of minimum and maximum offers in SIMDIS-S is different from the one in SIMDIS-P. Specifically, SIMDIS-S has much fewer divide-and-conquer offers than SIMDIS-P (specifically 7.5% versus about 27%, see Table A3). However, just like in SIMDIS-P, quite a substantial part (more than a quarter) of the offer combinations is roughly symmetric. And also like in SIMDIS-P, average profit calculated across the divide-and-conquer offers is lower as compared to other offers, particularly as compared to 'nearly symmetric' offers in intervals [36-135) or [136-235). Average payoffs are 149 for divide-and-conquer offers as compared to 168 and 215, for all other offers and all roughly symmetric offers respectively.²⁵

With respect to the sequential games SEQ-P and SEQ-S, panels (d) and (g) of Figure 1 show that the majority of amounts offered to buyer 1 lie far above the theoretical prediction of zero or one. Amounts offered to buyer 2, however, are more in line with theoretical predictions: panels (e) and (h) show that mostly very low amounts are offered when buyer 1 has accepted, and panels (f) and (i) show that mostly amounts above 335 are offered when buyer 1 has rejected. The reason why incumbents offer relatively large amounts to buyers 1 is most likely that the latter (almost) never accept 'low' offers. Indeed, in SEQ-P and SEQ-S, buyers 1 almost never accept offers below 35. And once buyer 1 has rejected, it takes a large offer to convince buyer 2 to accept; as shown in panels (f) and (i), offers below 300 are rarely accepted after rejection by buyer 1. An incumbent who anticipates such buyers' behavior will prefer to have buyer 1 accept a relatively high amount in order to avoid an even higher payment that would be needed to convince buyer 2 to accept.

²⁴ These differences are statistically significant ($p < .001$) in linear regressions where the incumbents' profit is regressed on a divide-and-conquer dummy (including random effects for individuals and matching groups, and standard errors adjusted for potential dependency within matching groups).

²⁵ The difference between average payoffs for divide-and-conquer offers and all other offers is statistically insignificant ($p = .381$). However, the difference between average payoffs for divide-and-conquer offers and roughly symmetric offers is significant ($p < .001$), where we used the same test method as described in footnote 24.

Perhaps surprisingly at first sight is the observation that up to 30% of buyers 2 reject dominant offers larger than 335 after buyer 1 rejected his offer (cf. Table A1 in Appendix A(i)). However, buyer 2 might reject dominant offers out of reciprocity with respect to buyer 1 who rejected a (possibly high) offer. After all, only rejection on the part of buyer 1 may bring buyer 2 into the position of being approached with a substantial offer, as the meager offers to buyer 2 show after buyer 1 accepted.²⁶

Summarizing, subgame-perfect Nash equilibrium does not organize behavior well in the experiment. As shown by Gale, Binmore and Samuelson [1995] for the ultimatum game, if one allows for noise that is correlated with the cost of making a mistake, other Nash equilibria than subgame-perfect Nash equilibrium can be supported. In the next section we re-calculate theoretical predictions along these lines.

IV(iii). *Behavioral Approach to Naked Exclusion*

The descriptive analysis in the previous section suggests that the buyers' acceptance probability is positively related to the incumbents' proposed payments. We formally show this below by estimating the acceptance probability as a function of the proposed payments by means of a logistic response function (see, e.g., Slonim and Roth [1998] in the context of an ultimatum game). The regression results confirm that, generally, the buyers' acceptance probability depends positively and significantly on the incumbents' proposed payments. Then, instead of assuming subgame-perfect behavior by buyers, we use buyers' estimated response functions in the subgames as an input into the incumbent's maximization problem. That is, we recompute an incumbent's optimal offers (and implied exclusion rates and costs) under the assumption he is correctly anticipating the effect his offers have on the acceptance probability of an average buyer observed in the experiment.

We model buyers' acceptance behavior with a logit function. As shown in Section A(ii) in the Appendix, quantal-response equilibrium (see McKelvey and Palfrey [1995]; Goeree, Holt and Palfrey [2005]) yields an acceptance function that can be approximated by a logit function. Alternatively, the combination of heterogeneous risk preferences and uncertainty about each

²⁶ One can also view the SEQ treatments as bargaining games where players share surplus from 'trade.' Assume for simplicity that players have equal bargaining power. Using backward induction, in the case buyer 1 rejects, the incumbent and buyer 2 are bargaining partners and the Nash product $(165 + x_2 - 500)(500 - x_2 - 50)$ is maximized at $x_2 = 392.5$, which results in a surplus for the incumbent of 107.5. Knowing this, in bargaining between the incumbent and buyer 1, maximizing the Nash product $(165 + x_1 - 165)(500 - x_1 + 107.5)$ gives $x_1 = 196.25$. Average observed x_1 are not too far off this solution (182 in SEQ-P and 186 in SEQ-S). Average observed x_2 are substantially below 392.5, though (278 in SEQ-P and 276 in SEQ-S) suggesting buyer 2 has less bargaining power than the 50:50 we assumed.

TABLE VI
ESTIMATION RESULTS FOR BUYERS' PROBABILITY OF ACCEPTANCE

	Constant	Own Offer	Other Offer	<i>N</i>	<i>LL</i>
SIMNon	-7.49*** (1.02)	0.034*** (0.005)	—	600	-262.06
SIMDIS-P	-3.28*** (0.73)	0.013*** (0.002)	0.004 (0.003)	720	-348.82
SIMDIS-S	-3.01*** (0.73)	0.014*** (0.002)	— (0.003)	480	-215.52
SEQ-P					
buyer 1	-2.59*** (0.55)	0.017*** (0.001)	—	300	-148.26
buyer 2 (1 accepts)	2.22** (6.06)	0.177*** (0.586)	-0.008* (0.028)	182	-83.98
buyer 2 (1 rejects)	-28.64*** (10.31)	0.087*** (0.030)	0.000 (0.004)	118	-44.97
SEQ-S					
buyer 1	-2.79*** (0.47)	0.016*** (0.002)	—	360	-194.84
buyer 2 (1 accepts)	-0.70 (0.63)	0.013 (0.014)	—	196	-110.37
buyer 2 (1 rejects)	-9.05*** (2.51)	0.028*** (0.007)	—	164	-69.68

Notes: The regression equation is either $P(\text{Accept})_{ijt} = F(\alpha + \beta \text{OwnOffer}_{ijt} + v_i + v_{jt} + \varepsilon_{ijt})$ or $P(\text{Accept})_{ijt} = F(\alpha + \beta \text{OwnOffer}_{ijt} + \gamma \text{OtherOffer}_{ijt} + v_i + v_{jt} + \varepsilon_{ijt})$ for matching group $i = 1$ to 20, buyer $j = 1$ to 6 and period $t = 1$ to 20. F is the logit function and nested random effects (v_i and v_{jt}) are included. The table reports $\hat{\alpha}$ and $\hat{\beta}$, and $\hat{\gamma}$ whenever possible. Standard errors (in brackets) are robust to possible dependency within matching groups. Two-tailed significance levels of 1%, 5%, and 10% are indicated by *, ** and ***, respectively.

other's risk preferences (for the simultaneous games) also gives rise to a logit relation between offered amount and acceptance probability (see Section A(iii) in Appendix).

We show that this 'behavioral' approach to the naked exclusion model organizes observed incumbent behavior and game outcomes quite well. In particular, once buyer behavior is modeled more realistically, our exercise replicates the two main comparative static features of our experimental results: compared to the non-discriminatory regime, exclusion rates increase substantially with sequential contracts only, and exclusion costs are substantial in all (and not too different between) treatments.

Buyers' acceptance behavior. We estimate the buyers' acceptance probability as a logit function of the offered amounts. For the treatments where the amounts offered to both buyers are the same or where a buyer has no information about the offer made to the other buyer in the market, only a buyer's own offer is included in the regression (in SIMNon, SIMDIS-S, SEQ-S and for buyer 1 in SEQ-P). For the two other treatments, the offer made to the other buyer in the market is included as well (in SIMDIS-P and for buyer 2 in SEQ-P). Table VI presents the estimation results for the five games and confirms that, overall, the relation between the size of a buyer's own offer

and his acceptance probability is positive and significant.²⁷ Buyers are thus significantly more likely to accept an offer, the higher the offer.

Result 2. Not only under simultaneous contracting, but also under sequential contracting, buyers are more likely to accept an offer, the higher the offer.

Incumbents' behavior. We now re-solve the incumbents' maximization problem in each game using the buyers' observed response functions as estimated in Table VI, and re-compute exclusion rates and costs. More precisely, when deciding which amounts to offer to buyers, we assume that an incumbent maximizes his expected profit, taking into account that the probability that buyers accept offers is positively related to the size of the amount in the way described in Table VI.

As an example, we describe the new calculations for treatment SIMNON. The calculations for the other treatments are in Section A(v) of the Appendix. We assume that in SIMNON the probability a buyer accepts an offer of size x is described by the logistic function $F(x) = \frac{1}{1 + e^{-(\hat{\alpha} + \hat{\beta}x)}}$, with $\hat{\alpha}$ and $\hat{\beta}$ given in Table VI. Given that a buyer's response function is described by $F(x)$, the probability that two, exactly one, or none of the buyers accept the incumbent's offer x is given by $F(x)^2$, $2F(x)(1 - F(x))$, and $(1 - F(x))^2$, respectively. The payoffs for the incumbent in these cases are $500 - 2x$, $500 - x$, and 50 , respectively. Hence the incumbent maximizes expected profits by choosing to offer the amount x that solves

$$\max_x \{F(x)^2(500 - 2x) + 2F(x)(1 - F(x))(500 - x) + (1 - F(x))^2(50)\}.$$

In panel (a) of Table VII we report predicted offers under the behavioral approach, and for comparison, predictions based on subgame-perfect behavior, and observed averages. Panel (b) of Table VII reports exclusion rates and costs. For SIMNON, for example, the behavioral approach predicts an offer of 232, an exclusion rate of $1 - (1 - F(232))^2 \approx 0.6$, and exclusion costs conditional on exclusion of $[2 \cdot 232 \cdot F(232)^2 + 232 \cdot F(232)(1 - F(232))] / [1 - (1 - F(232))^2] \approx 284$ (i.e., expected exclusion costs divided by the probability of exclusion).

Looking at panel (a) of Table VII, we can see that, in line with observed offers, overall, the behavioral approach predicts higher offers by incumbents as compared to those under the assumption of subgame perfection.

²⁷ An exception is the estimated coefficient of the payment to buyer 2 in SEQ-S, given that buyer 1 has accepted. This estimate is statistically not significant, which, arguably, is not surprising given that almost all offers are just slightly above zero (see Table A1 in Appendix A(i)).

TABLE VII
 PREDICTED AND OBSERVED OFFERED PAYMENTS, EXCLUSION RATES,
 AND EXCLUSION COSTS

(a) Offered payments						
Predicted						
	SPN	Behavioral		Observed		
SIMNon	$x \geq 0$	232		194		
SIMDIS-P	$x_1 + x_2 \leq 336$	$x_1 = 194; x_2 = 194$		$x_1 = 53; x_2 = 233$		
SIMDIS-S	$x_1 \leq 1, x_2 = 0$	$x_1 = 197; x_2 = 197$		$x_1 = 36; x_2 = 181$		
SEQ-P	$x_1 \leq 1, x_2 = 0$	$x_1 = 176; x_2^a = 0; x_2^r = 343$		$x_1 = 182; x_2^a = 6; x_2^r = 278$		
SEQ-S	$x_1 \leq 1, x_2 = 0$	$x_1 = 193; x_2^a = 0; x_2^r = 332$		$x_1 = 186; x_2^a = 4; x_2^r = 276$		

(b) Exclusion rates and costs						
	Exclusion Rate			Exclusion Costs		
	Predicted			Predicted		
	SPN	Behavioral	Observed	SPN	Behavioral	Observed
SIMNon	≤ 1	0.60	0.53	≥ 0	284	273
SIMDIS-P	1	0.54	0.59	≤ 336	230	254
SIMDIS-S	1	0.45	0.58	≤ 1	227	226
SEQ-P	1	0.97	0.81	≤ 1	220	247
SEQ-S	1	0.92	0.74	≤ 1	225	256

Notes: The predictions in columns 'SPN' are based on the RRW-SW model assuming subgame perfection and the predictions in columns 'Behavioral' are based on the RRW-SW model assuming buyers behave according to Table VI and incumbents anticipate this. Data in columns 'Observed' are averages across all data points. In the case of SIMDIS-P and SIMDIS-S, x_1 refers to the average minimum and x_2 to the average maximum offer. In the case of SEQ-P and SEQ-S, x_2^a and x_2^r refer to average amounts offered to buyer 2, given that buyer 1 accepted or rejected, respectively. Exclusion costs are conditional on acceptance.

Particularly in the two SEQ treatments, the fit between behaviorally predicted and observed offers is quite accurate, especially for offers x_1 and x_2^a . In the two SIMDIS treatments, the fit is less accurate at first sight: the behavioral approach predicts incumbents' making the same offers to both of the buyers whereas average minimum and maximum offers are quite different. However, behaviorally predicted averages do correspond quite closely to observed *modal* behaviour in these treatments. As described in Section IV(ii), in both of these treatments incumbents make roughly symmetric offers in a substantial share of cases, and doing so implies larger profits to incumbents than offering highly asymmetric offers of the divide-and-conquer type.

Next, panel (b) of Table VII shows that by taking into account the positive relation between an offer made to a buyer and the latter's acceptance probability in the incumbent's maximization problem, comparative statics are largely in line with those observed. Specifically, the behavioral approach predicts the exclusion rate's increasing substantially only when buyers are approached sequentially, and it does not predict exclusion costs

to drop substantially under simultaneous and secret discriminatory or sequential offers.²⁸

We summarize our third result as follows:

Result 3. By assuming the incumbent takes into account the positive relation between an offer made to a buyer and the latter's acceptance probability when deciding about the size of the offer, we find that

- (i) compared to the non-discriminatory regime, exclusion rates increase substantially with sequential contracts only, and
- (ii) exclusion costs are substantial and of the same order of magnitude in all treatments.

V. DISCUSSION

In the context of the naked exclusion model of Rasmusen, Ramseyer and Wiley [1991] and Segal and Whinston [2000b], we find that an incumbent who proposes exclusive contracts to buyers sequentially, is able to deter entry significantly more often than an incumbent who proposes contracts simultaneously. Thus, in contrast to the theoretical predictions, it is not discrimination *per se* that increases the exclusion rate. Rather, it is the combination of discrimination and sequentiality of contracting that increases the exclusion rate. Furthermore, we also find that buyers generally reject low offers. This is the case even under sequential contracting, where they are predicted to accept even the smallest possible offer. The consequence is that the incumbent carries a substantial cost for excluding rivals under all types of discrimination regimes.²⁹

The main driving force behind these results is that there exists a positive relation between buyers' acceptance probability and the amount of the payment proposed by the incumbent. Incumbents appear to take this buyer behavior into account when proposing payments. In fact, we show that by replacing subgame-perfect behavior in the buyers' subgames by the more realistic assumption that the acceptance probability of buyers is an increasing function of the offered payment—which is predicted by, for example, quantal-response equilibrium—and keeping all other aspects of

²⁸ The behavioral predictions are not an artefact of the specific parameters estimated for the buyers' (logit) response function. This is illustrated in Appendix A(iv) where we show for treatment SEQ-P that the qualitative predictions are robust to changes in the estimated parameters of the response function of buyers. Also note that predicted profits of the incumbent based on optimal offers are equal to 150, 168, 151, 274 and 257 for treatments SIMNon, SIMDis-P, SIMDis-S, SEQ-P and SEQ-Q, respectively. Our prediction thus captures that incumbents' profits are roughly the same for the three simultaneous treatments and substantially higher for the two sequential treatments.

²⁹ In the same vein, Frechette, Kagel and Morelli [2005] find that a player who tries to assemble a minimal coalition needs to make larger concessions than predicted by theory due to the reluctance of other players to accept small shares.

the RRW-SW framework intact, replicates the two main features of our experimental results. Compared to the non-discriminatory regime, exclusion rates only increase substantially when offers are made sequentially, and exclusion costs are generally substantial and do not differ much across treatments.

The positive relation between buyers' acceptance probability and the amount of the payment proposed by the incumbent is comparable to behavior in experimental coordination games and ultimatum games. For one, in coordination games players typically succeed better in coordinating on the efficient equilibrium the lower the 'cost' of coordination. And in ultimatum games, the probability that responders will accept a proposer's offer is typically higher, the higher the offer.

Not only are our results consistent with previous experimental results, competition authorities also recognize that buyers are more likely to accept exclusive deals, the higher the amount they are offered. Specifically, recent guidelines of the European Commission regarding the abuse of a dominant position state the following on the use of conditional rebates that incumbent firms may give to buyers, potentially in order to exclude rivals: 'The higher the rebate as a percentage of the total price (. . .), the stronger the likely foreclosure of actual or potential competitors' (EC [2008]).

Our results might also be relevant for antitrust policy. Indeed, exclusivity clauses are not necessarily aimed at foreclosure but can also have an efficiency rationale. Besanko and Perry [1993] and Segal and Whinston [2000a], for example, show that such clauses can enhance manufacturers' incentives to invest. Therefore, regulatory bodies and courts have to judge which of the two effects of exclusive contracts—the efficiency-enhancing or the foreclosure effect—outweighs the other.³⁰ This task is not straightforward and, in this respect, our results provide some insights.

In particular, we find that the most effective way for the seller to achieve exclusion is to approach buyers sequentially instead of simultaneously. From an efficiency point of view, it seems immaterial whether the contracts are offered either simultaneously or sequentially. Hence, an argument can be made that contracts offered sequentially should be interpreted as being more likely to aim at exclusion only compared to contracts that are offered simultaneously. For practical purposes, this would mean that an antitrust authority should be on high alert if the suspected company staggered its contracting with buyers over a certain period of time to get the required sequencing of offers (see also Whinston [2006], p. 147).

³⁰ See, for example, Segal and Whinston's [2000a] discussion of a DoJ investigation of Ticketmaster's contracting practice, or the recent Microsoft case in which Microsoft was accused of entering exclusive deals with original computer equipment manufacturers in an effort to exclude Microsoft's rivals.

APPENDIX

A(i). *Supplementary Tables*

TABLE A1
DISTRIBUTION OF OFFERS (IN %) AND ACCEPTANCE RATES

	0–35	36–135	136–235	236–335	> 335	total	#	avg. offer ^a
<i>SimNon</i>	1.0 [0.00]	7.3 [0.05]	81.3 [0.36]	10.0 [0.48]	0.3 [1.00]	100 [0.35]	600	194.1 (50.3)
<i>SimDis-P</i>	30.6 [0.09]	20.8 [0.31]	24.2 [0.40]	10.8 [0.54]	13.6 [0.71]	100 [0.34]	720	142.9 (124.2)
<i>SimDis-S</i>	32.7 [0.03]	19.8 [0.29]	25.0 [0.41]	17.9 [0.60]	4.5 [0.95]	100 [0.32]	480	130.7 (112.0)
<i>Seq-P</i> to buyer 1	5.0 [0.00]	22.7 [0.43]	43.7 [0.63]	27.3 [0.82]	1.3 [1.00]	100 [0.61]	300	182.3 (82.1)
to buyer 2 after 1 reject	8.5 [0.00]	11.0 [0.00]	6.8 [0.00]	10.2 [0.33]	63.5 [0.75]	100 [0.51]	118	274.0 (120.8)
to buyer 2 after 1 accept	96.7 [0.59]	2.7 [0.80]	0.0 —	0.6 [1.00]	0.0 —	100 [0.60]	182	5.5 (22.7)
<i>Seq-S</i> to buyer 1	7.2 [0.04]	18.1 [0.31]	50.0 [0.60]	19.7 [0.69]	5.0 [1.00]	100 [0.54]	360	186.1 (81.4)
to buyer 2 after 1 reject	14.6 [0.00]	5.5 [0.00]	9.8 [0.13]	14.6 [0.21]	55.5 [0.70]	100 [0.43]	164	263.3 (132.2)
to buyer 2 after 1 accept	98.5 [0.36]	1.0 [0.50]	0.0 —	0.5 [1.00]	0.0 —	100 [0.37]	196	3.2 (21.2)

Notes: The table reports observed relative frequencies of offered amounts and average acceptance rates by buyers in brackets. ^aStandard deviations in parentheses.

TABLE A2
DISTRIBUTION OF MINIMUM AND MAXIMUM OFFERS (IN %) AND EXCLUSION RATES
IN SIMDIS-P

min offer	max offer					total
	0–35	36–135	136–235	236–335	> 335	
0–35	2.8 [0.10]	2.2 [0.00]	8.6 [0.19]	17.8 [0.63]	26.9 [0.72]	58.3 [0.56]
36–135	—	13.6 [0.49]	10.0 [0.61]	1.9 [0.86]	0.3 [1.00]	25.8 [0.57]
136–235	—	—	13.9 [0.72]	1.9 [0.86]	0 —	15.8 [0.74]
total	2.8 [0.10]	15.8 [0.42]	32.5 [0.55]	21.7 [0.67]	27.2 [0.72]	100.0 [0.59]

Notes: Panel (a) and (b) report percentages of minimum and maximum offers and [in parentheses] average exclusion rates by buyers for SIMDIS-P.

TABLE A3
DISTRIBUTION OF MINIMUM AND MAXIMUM OFFERS (IN %) AND EXCLUSION RATES IN
SIMDIS-S

min offer	max offer					total
	0–35	36–135	136–235	236–335	> 335	
0–35	5.0 [0.00]	5.8 [0.36]	10.0 [0.29]	32.1 [0.62]	7.5 [0.94]	60.4 [0.53]
36–135	—	11.7 [0.61]	9.6 [0.48]	0.8 [0.50]	0 —	22.1 [0.55]
136–235	—	—	14.6 [0.66]	1.2 [1.00]	0 —	15.8 [0.68]
236–335	—	—	—	0.4 [1.00]	0.8 [1.00]	1.2 [1.00]
> 335	—	—	—	—	0.4 [1.00]	0.4 [1.00]
total	5.0 [0.00]	17.5 [0.52]	34.2 [0.50]	34.6 [0.64]	8.8 [0.95]	100.0 [0.57]

Notes: Panel (a) and (b) report percentages of minimum and maximum offers and [in parentheses] average exclusion rates by buyers for SIMDIS-S.

A(ii). *Quantal Response Equilibrium*

A justification for using the logit function to describe buyer behavior (e.g., buyers' acceptance probability as a function of the offer(s) made by the incumbent) is given by a quantal response equilibrium (see McKelvey and Palfrey [1995]; Goeree, Holt and Palfrey [2005]). The idea here is that players make mistakes (or that 'real' payoffs are perturbed) but are more likely to play strategies that yield higher expected payoffs. Let $\phi: \mathbb{R} \rightarrow \mathbb{R}_+$ be a strictly increasing and continuous function. Then we assume that the probability F_i that i accepts the offer x_i (while the other buyer has an offer x_j) is given by

$$F_i = \frac{\phi(165 + x_i)}{\phi(165 + x_i) + \phi(500 - 335F_j)}$$

where the probability that j accepts the offer x_j is given by

$$F_j = \frac{\phi(165 + x_j)}{\phi(165 + x_j) + \phi(500 - 335F_i)}$$

In words, the higher i 's payoff ($165 + x_i$) from accepting the incumbent's offer (compared to not accepting and getting expected payoff $(1 - F_j)500 + F_j165 = 500 - 335F_j$), the more likely i is to accept.

Figure A1 illustrates the quantal response approach for the case in which $\phi(x) = x^\lambda$ with $\lambda = 3.5$. This approach suggests that the probability of acceptance can be approximated by a logit function.

The significance of modeling buyer's behavior with a non-degenerate distribution function F can be illustrated as follows. When assuming subgame-perfect buyer behavior, an optimal strategy of the incumbent is to get exclusion for sure by offering (0,335) in SIMDIS-P. However, for buyer behavior as described by the example considered in Figure A1, the incumbent does better by offering the same to both buyers

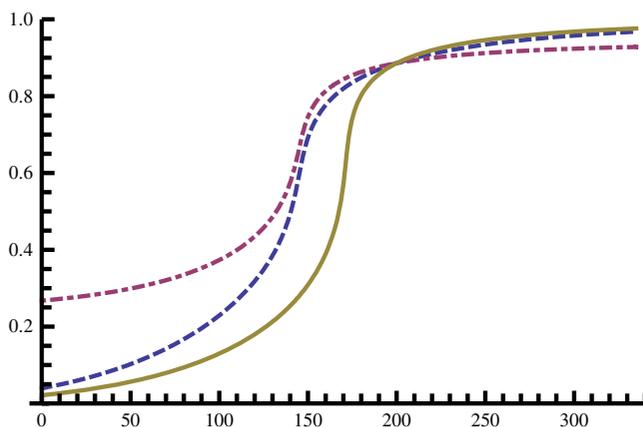


Figure A1

Acceptance Probabilities Using Quantal Response

Notes: Acceptance probability $F(x)$ for the symmetric case (solid line), $F(x,200)$ (dashed) as a function of the offer x to the buyer himself and $F(200,x)$ as a function of the offer to the other buyer (dot-dashed).

($x = 170$). In fact, expected profits for the incumbent equal 223 in this case, which are higher than profits assuming subgame-perfect buyer behavior ($500 - 335 = 165$). Clearly, the exact optimum depends on the parameters. Hence, we use the estimated logit functions in Table VI and then calculate the incumbent's optimal offers for this logit function.

A(iii). Buyers' Acceptance Probability Predicted by Risk Dominance and an Estimated Logit Function

Another alternative delivering a positive relationship between incumbents' offers and buyers' acceptance probability is risk dominance combined with players' having heterogeneous risk preferences. Recall, for example, that in the buyers' subgame in SIMNon, risk dominance predicts that (both) buyers reject when the offer is low ($x < 167.5$), (both) accept when it is high ($x > 167.5$) and are indifferent when $x = 167.5$. If risk preferences are heterogeneous such that different players switch at different thresholds, one could argue that the buyer behavior observed in SIMNon is in line with risk dominance.³¹ This is illustrated in Figure A2, which plots the acceptance probability predicted by risk dominance and, additionally, an estimated logit function of the general form $P(\text{Accept}) = F(\alpha + \beta \text{Offer} + \varepsilon)$ (see also Subsection IV(iii)). For buyer behavior in game SIMDis-P, a similar argument can be made. Here,

³¹ Heinemann, Nagel and Ockenfels [2009] show that in symmetric stag hunt games, a majority of subjects uses threshold strategies. They suggest different models, some inspired by global games, to organize this behavior.

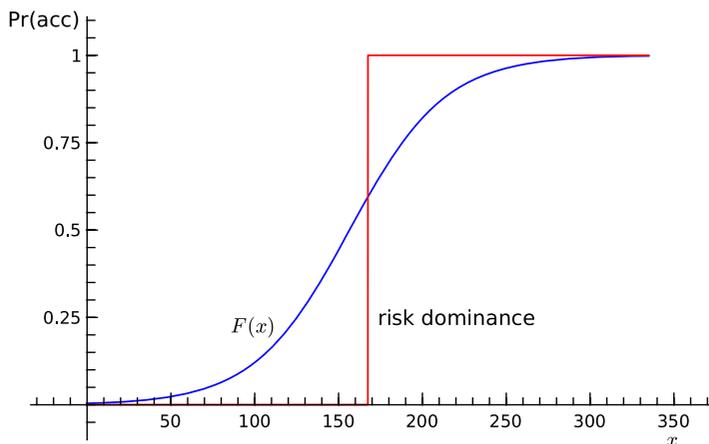


Figure A2

A Buyer's Acceptance Probability as a Function of the Offer in Treatment

Notes: SIMNON predicted by risk-dominance and by an estimated logit function.

an estimated logit function that regresses a buyer's acceptance probability on both offers can be argued to be in line with risk dominance, combined with heterogeneity of risk preferences.

A(iv) Robustness Analysis of 'Behavioral' Predictions for SEQ-P

Since our 'behavioral' predictions differ most starkly from the subgame perfect predictions in the case of SEQ-P (see, e.g., Tables IV and A1) we do the following robustness check. For buyer 1's probability of acceptance we define a multinormal distribution with expectations (see Table VI) -2.59 for $\hat{\alpha}$ and 0.02 for $\hat{\beta}$. The variance and covariance for $\hat{\alpha}$ and $\hat{\beta}$ equal resp. 0.30 , 0.000002 and -0.00007 (which we derived from our estimation). For buyer 2's acceptance probability we define a multinormal distribution with expectations -28.64 for $\hat{\alpha}$, 0.09 for $\hat{\beta}$ and -0.0002 for $\hat{\gamma}$. The resp. variances equal 106.33 , 0.001 and 0.00001 . Finally, the covariance between $\hat{\alpha}$ and $\hat{\beta}$, $\hat{\alpha}$ and $\hat{\gamma}$, $\hat{\beta}$ and $\hat{\gamma}$ equal resp. -0.31 , 0.01 and -0.00004 .

To get an idea of the robustness of our predictions in SEQ-P, we simulate 8,000 draws for buyer 1's $\hat{\alpha}$ and $\hat{\beta}$ and buyer 2's $\hat{\alpha}$, $\hat{\beta}$ and $\hat{\gamma}$ from the multinormal distributions defined above. For each draw we calculate the incumbent's optimal offer and derive the exclusion rate and exclusion costs. The histograms of the exclusion rate and costs are given in Figure A3. The figure shows that our prediction for SEQ-P that the exclusion rate is strictly below 1 and the exclusion cost clearly above 0 is robust.

A(v). The Incumbent's Maximization Problem in the Behavioral Approach

For SIMNON we assume the probability that a buyer accepts an offer of size x as described by the logistic function $F(x) = \frac{1}{1 + e^{-(\hat{\alpha} + \hat{\beta}x)}}$, with $\hat{\alpha}$ and $\hat{\beta}$ given in Table VI. Given that a buyer's response function is described by $F(x)$, the probability that two,

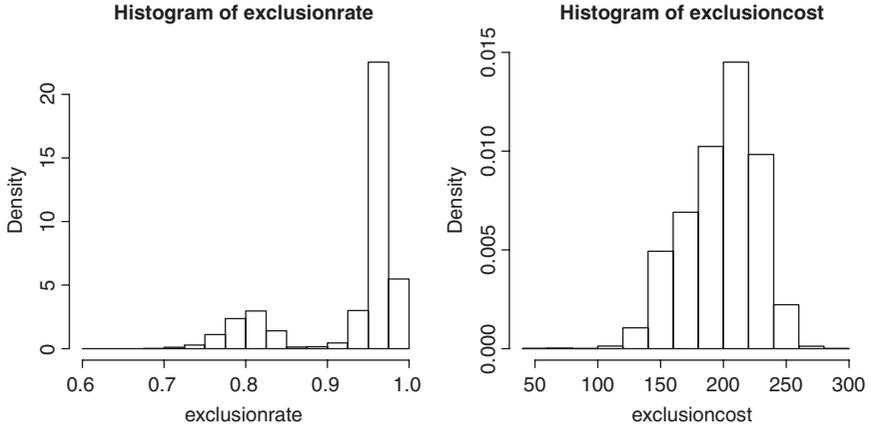


Figure A3

Histograms of Exclusion Rates and Exclusion Costs

Notes: For 8,000 draws of parameters for the buyers’ acceptance probability functions in SEQ-P.

exactly one, or none of the buyers accept the incumbent’s offer x is given by $F(x)^2$, $2F(x)(1 - F(x))$, and $(1 - F(x))^2$, respectively. The payoffs for the incumbent in these cases are $500 - 2x$, $500 - x$, and 50 , respectively. Hence the incumbent maximizes expected profits by choosing to offer the amount x that solves

$$\max_x \{F(x)^2(500 - 2x) + 2F(x)(1 - F(x))(500 - x) + (1 - F(x))^2(50)\}.$$

For SIMDIS-P we assume the probability a buyer accepts is described by the function $F(x_1, x_2) = \frac{1}{1 + e^{-(\hat{\alpha} + \hat{\beta}x_1 + \hat{\gamma}x_2)}}$, where x_1 and x_2 stand for the offer made to the buyer himself and the offer made to the other buyer in the market, respectively. Parameters $\hat{\alpha}$, $\hat{\beta}$, and $\hat{\gamma}$ are given in Table VI. An incumbent maximizes expected profits by offering (x_1, x_2) that solves

$$\max_{x_1, x_2} \left\{ \begin{aligned} &F(x_1, x_2)F(x_2, x_1)(500 - x_1 - x_2) + F(x_1, x_2)(1 - F(x_2, x_1))(500 - x_1) \\ &+ F(x_2, x_1)(1 - F(x_1, x_2))(500 - x_2) + (1 - F(x_1, x_2))(1 - F(x_2, x_1))(50) \end{aligned} \right\}.$$

In SIMDIS-S, a buyer’s acceptance decision can only depend on his own offer because the offer made to the other buyer in the market is not observed. The incumbent’s optimization problem is written as follows.

$$\max_{x_1, x_2} \left\{ \begin{aligned} &F(x_1)F(x_2)(500 - x_1 - x_2) + F(x_1)(1 - F(x_2))(500 - x_1) \\ &+ F(x_2)(1 - F(x_1))(500 - x_2) + (1 - F(x_1))(1 - F(x_2))(50) \end{aligned} \right\}$$

with $F(x) = \frac{1}{1 + e^{-(\hat{\alpha} + \hat{\beta}x)}}$, with $\hat{\alpha}$ and $\hat{\beta}$ given in Table VI.

For SEQ-P and SEQ-S we assume the probability that the buyer moving first accepts the offer made to him (x_1) is described by $F_1(x_1) = \frac{1}{1 + e^{-(\hat{\alpha} + \hat{\beta}x_1)}}$, with $\hat{\alpha}$ and $\hat{\beta}$ given in Table VI. If x_1 is accepted, it is optimal for the incumbent to offer 0 to the second-moving buyer ($x_2^d = 0$). If x_1 is rejected, the incumbent offers x_2^r to the second-moving

buyer. For SEQ-P we denote the probability that the second offer gets accepted as $F_2(x_2^r, x_1)$, since it is possibly conditional on x_1 (buyer 2 observes the amount offered to buyer 1). Hence, the incumbent solves

$$\max_{x_1, x_2^r} \{F_1(x_1)(500 - x_1) + (1 - F_1(x_1))F_2(x_2^r, x_1)(500 - x_2^r) + (1 - F_1(x_1))(1 - F_2(x_2^r, x_1))(50)\}.$$

For SEQ-S we denote the probability that the second offer gets accepted as $F_2(x_2^r)$, since it is not conditional on x_1 (buyer 2 does not observe the amount offered to buyer 1). Hence, the incumbent solves

$$\max_{x_1, x_2^r} \{F_1(x_1)(500 - x_1) + (1 - F_1(x_1))F_2(x_2^r)(500 - x_2^r) + (1 - F_1(x_1))(1 - F_2(x_2^r))50\}.$$

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