Endogenous Communication and Tacit Coordination in Market Entry Games -An explorative experimental study *

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Abstract. This paper explores the effects of communication in market entry games experimentally. It is shown that communication increases coordination success substantially and generate inferior outcomes for consumers when market entry costs are symmetric. Such effects are not observed when costs are asymmetric, since asymmetries provide a tacit coordination cue used by experienced players (as a substitute to communication). It is also shown that although communication is used both to achieve market domination equilibria and cooperative market separating equilibria, the latter type of communication is much more common and successful.

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1 Introduction

> "One cannot, without empirical evidence, deduce what understandings can be perceived in a non-zero sum game of maneuver any more than one can prove, by purely formal deduction, that a particular joke is bound to be funny." (Schelling 1960, p. 164)

Market entry decisions have important implications for how resources are allocated in the economy. However, these decisions involve coordination problems that pose analytical difficulties in terms of equilibrium selection. This has motivated researchers to conduct experiments to better understand such problems (Ochs 1995, Camerer 2003). One obvious way to achieve coordination suggested in Farrell and Rabin (1996) is by communication, which also seem to work in various experiments, see e.g. Cooper, Dejong, Forsythe, and Ross (1992). In what follows we will argue that there are a number of interesting questions regarding communication in market entry games that still need to be addressed. The purpose of this paper is to explore these questions by conducting experiments.

The first question concerns which coordination principle will be applied when communication is available. Two fundamental coordination principles in market entry problems are those of cooperation and domination. Whereas cooperation is motivated by a mutual non-rival interest to increase total industry profit and share it, domination is motivated by the interest to get the largest possible proportion of it. Communication is a highly reasonable vehicle to achieve coordination according to both principles. In the case of cooperation, communication may primarily break symmetry and work as reassurance (Crawford 1998). To obtain domination, messages can be used to communicate threats. Despite this, no experiment has hitherto studied the effects of communication in situations that fully allow for the possibility to separate between the two principles as equilibrium outcomes.

Farrell (1987) noted early that cheap-talk in Battle-of-the-Sexes games (BOS) can provide insights to the role of communication in market entry games and Cooper et al (1989) showed thereafter experimentally that the coordination problem in a BOS can be overcome by (one-way) communication. However, a BOS does not fully capture the strategic trade-off between domination and cooperation since coordination naturally induces domination in this game. Moreover, it does not realistically capture the market entry problem unless some complementarity between the firms is assumed (i.e., that a firm that does not enter the market for some reason prefers that the other firm does). This complementarity has implications for the meaning of the messages in the game.[1] If this assumption is removed the (non-trivial) market entry game changes into a "Chicken" game in which, contrary to both messages in a BOS, no message is self-signaling in the sense of Farrell and Rabin (1996).[2] It is not the purpose of this paper to explore the effects of communication in "Chicken" games since the expected outcomes of such communication appear relatively uninteresting for our purposes.[3] Instead we study a market entry game without complementarities, where two firms can enter market X, market Y, both markets, or none of the markets. We demonstrate that this game has a rich structure that involves both pure non-rival market-separating equilibria, representing the principle of cooperation, and pure market-domination equilibria, representing domination. This structure allows us to separate between these principles and study how communication affects the outcome.

A second question of importance concerns the ambiguous welfare implications of communication in market entry situations. One positive consequence of improved coordination is that markets not previously served may be so after firms have coordinated. Another effect is that firms may coordinate to divide markets between themselves in order to reduce supply and thus affecting consumer welfare negatively.[4] If the intent is to restrict competition by dividing the market, the latter effect may be regarded as an economic rationale to make communication between firms' illegal. However, communication possibilities may also entice firms into uncoordinated dominating strategies leading to over-entry, which benefit consumers. The ambiguous consumer effects of communication in market entry games imply that it is not sufficient to study if communication solves the coordination problem but how it is solved. To our knowledge this observation has largely been ignored hitherto in the literature.[5] Hence, an additional objective

[1] Farrell (1987, p. 35) was aware of this and assumed complementarity to make his cheap-talk announcements work.

[2] This is likely to have negative impact on the credibility of the messages in the "Chicken" game.

[3] As noted by Farrell (1987) if messages have any credibility at all the dominant strategy will be to announce the intent of choosing the "hawkish" strategy.

[4] See e.g., L.Cabral (2004) for an analysis of welfare effects in market entry situations.

[5] Note, that this problem requires information about contra-factual outcomes, namely

of this paper is to study the consumer effects of allowing communication in market entry games. This question is of some importance, because if, for instance, communication has no or positive effects for consumers, one might question the rationale of competition laws that make communication between firms in these contexts illegal.[6]

A third question of importance concerns the extent and circumstances in which communication will take place in market entry situations. This is interesting for one general reason and one more specific. Results have already been established concerning behavior in market entry problems (see e.g., Rapoport and Winter (2000), for a study on a two-market entry game without communication). It is known that communication may help (Meyer, Huyck, Battalio, and Saving 1992) in some coordination situations, but not all (Cooper, Dejong, Forsythe, and Ross 1992). However, little is known about the extent of communication when it is costly and an endogenous choice.[7] The present study will add insights about this since the cost of communication will be varied at the same time as the players have the option not to communicate.[8] The more specific reason is that communication between firms is illegal when the intent is to coordinate market entry decisions. Such communication may be detected by a third party, implying that it can be used in a trial as incriminating evidence.[9] Knowledge about where incriminating communication is likely to take place may therefore be

what would the outcome be had there not been any communication. Such information is virtually impossible to obtain in the field but relatively easy to generate in the lab. It is therefore a problem that is suitable to address by experiments.

[6]Consumer welfare is one of the explicitly mentioned objectives in the EU competition legislation (Motta 2004, p. 19-20). Moreover The Economic Advisory Group for Competition Policy advocates a consumer welfare perspective when assessing issues of competitive harm in reference to Article 82 (J.Gual, Hellwig, Perrot, Polo, Rey, Schmidt, and Stenbacka 2006).

[7]There is some interesting literature on costly communication (Ben-Porath and Dekel 1992, Hurkens 1996). However, these models are not directly applicable to the games studied in this paper.

[8]Chapter **??** is a study with endogenous costly communication. However, this study tests the theory of Renegotiation Proofness in a repeated Bertrand game and is therefore peripheral to the present study.

[9]It is common that messages sent between firms are used as evidence of agreements or intent of illegal concerted behavior. In the so called "Gas-Cartel" in Sweden e-mails detected in some of the involved firms' computers were regarded by the Swedish Competition Authority as evidence of illegal coordination. The e-mails were detected after a raid by dawn.

		Firm 2	
		X	Y
Firm 1	X	0,0	2,2
	Y	2,2	0,0

Figure 1: A pure coordination game with symmetric cost.

valuable in the detection and fighting of cartels.

The next section introduces the two main environments that will be studied, namely markets with symmetric and asymmetric entry cost. The games are presented in section 3 with their respective parameterizations in the experiment. Section 4 contains the experimental design and section 5 presents the results. A discussion of policy implications is provided in section 6. Finally, section 7 contains concluding remarks.

2 Coordination: Symmetric and Asymmetric Entry Cost

In this section we briefly introduce market entry problems with symmetric and asymmetric entry cost to demonstrate that the cost structure may have implications for the willingness to communicate. Consider the following market entry problem. Two firms are located in the same town on the border between two countries. The firms are to decide whether to enter country X's or country Y's market. It is assumed that they can only enter one market. If the firms enter the same market they earn only normal profits, but if they enter different markets, each firm makes monopoly profit. Payoffs are illustrated in Figure 1. This game has two pure Nash equilibria, (X,Y) and (Y,X), where both firms earn 2 and a mixed strategy equilibrium where firms earn 1. Both firms realize that they have a mutual interest in coordinating on either pure Nash equilibria. However, there is no obvious way to do this without communication, which means that the likely outcome is the mixed strategy Nash equilibrium. Risk-neutral firms might therefore be willing to pay up to 1 for a communication channel.

Now consider a market where firms differ so that firm 1 and 2 are located in the middle of country X and Y, respectively. These, locations give the

		Firm 2	
		X	Y
Firm 1	X	0,0	3,3
	Y	1,1	0,0

Figure 2: A coordination game with asymmetric cost.

firms entry cost advantages in their respective home markets as indicated in Figure 2. In this game the structure of the equilibria is the same in the sense that there are still two pure Nash equilibria (X, Y) and (Y, X) and a mixed strategy equilibrium. However, in this case the entry cost asymmetry will provide the firms with coordination cues. The firms may choose (X, Y) since this is the only efficient equilibrium. It has been argued by e.g., Raiffa (1957) and by Schelling (1960) that efficiency may serve as a natural coordination device.[10] Clearly, such coordination is entirely tacit. No communication is needed and thus no evidence of intent to coordinate is generated.

It is empirically well established that in the type of simple coordination games described in Figure 2 subjects will, to a relatively large extent, be able to coordinate. Since we are to explore different aspects of communication in market entry situations we will do this in both symmetric and asymmetric cost environments.

3 Market Entry Games

This section presents the games that will be studied in the experiment. All games are different versions of market entry games with symmetric or asymmetric entry cost. Furthermore, each game is played with or without a pre-play communication stage. The presentation starts with the game

[10]In the equilibrium notion suggested by Raiffa (1957) Pareto dominated Nash-equilibria are even excluded from the equilibrium set as "jointly inadmissible". It should be noted that Schelling's reasoning in this respect (see Appendix C, in Schelling, 1960) is partly distinct from the standard notion of focal points or salience, which refers to circumstances outside the pure mathematical structure of the game (for instance, conspicuous strategy labels and so forth). See e.g., Huyck, Gillette, and Battalio (1992). However, it is also demonstrated that in more complicated coordination games issues relating to e.g., risk, history, and even payoffs in dominated strategies may affect the selection of strategies. For reviews see Ochs (1995) and Camerer (2003).

without communication and ends with the one with communication.

3.1 Market entry games without communication

In these games two firms, 1 and 2, can choose between four alternatives: enter market X, enter market Y, enter both markets (B) or do not enter any market (N). Formally, $s_i \in S_i = \{X, Y, B, N\},\ i = 1, 2$. The firms' revenue on a market depends on the number of firms that enter the market. The revenue for firm i on market $j \in \{X, Y\}$ will be $R_i^j = x_i^j K / \sum_{i=1}^{2} x_i^j$, where $x_i^j \in \{0, 1\}$ if and only if firm i enters market j and K is a constant reflecting the size of the market.[11] Furthermore, the cost for firm i to enter (and serve) market j is given by the parameter C_i^j. The class of games can be formally represented by $G = \{S_1, S_2; \pi_1, \pi_2\}$, where $\pi_i = F + x_i^x(R_i^x - C_i^x) + x_i^y(R_i^y - C_i^y)$ for $i = 1, 2$, and F is a constant.[12]

In reality, decisions about market entry have important consequences for consumers. Because the demand function is implicit in the game above, the welfare consequences for consumers are not obvious. However, using that consumers will have preferences over the different outcomes, we can with some relatively mild assumptions create preference orderings over the set of outcomes. From standard oligopoly theory it is reasonable to assume that consumers prefer as many firms as possible on each market. Because of a positive consumer surplus under monopoly, it is also natural to assume that consumers prefer that a market is served by a single firm than not served at all. Given these assumptions consumer preferences over the most preferred outcomes can be summarized as follows: $(B, B) \succ (B, X) \approx (X, B) \approx (Y, B) \approx (B, Y)$.[13] For the least preferred outcomes we can conclude that $(N, X) \approx (X, N) \approx (N, Y) \approx (Y, N) \succ (N, N)$. However, it is not possible to, a priori, determine whether consumers are

[11] We implicitly assume that after entry firms act using some strategic variable (e.g., price or quantities) in the market which they have entered. Their choice will depend on, among other things, the size of the market and if it is a monopoly or a duopoly. However, this stage is not explicitly modelled here, instead we just assume that firm i earns R_i^j. If $\sum_{i=1}^{2} x_i^j = 0$ we define $R_i^j = 0$.

[12] This is an arbitrary constant that is convenient when payoff matrices in the experiment are determined. An economic interpretation of the constant is what the firm would earn (e.g., on royalties etc) if it was inactive.

[13] In this paper consumer preferences are assumed to be generated from a representative consumer. Furthermore, it is assumed that consumers are indifferent concerning whether firm 1 or 2 serves a given market.

Table 1: Consumer Ranking

Ind. set	Ranking V	Ranking C
1	(B,B)	(B,B)
2	(B,X), (X,B), (B,Y), (Y,B)	(B,X), (X,B), (B,Y), (Y,B)
3	(X,Y), (Y,X), (B,N), (N,B)	(X,X), (Y,Y)
4	(X,X), (Y,Y)	(X,Y), (Y,X), (B,N), (N,B)
5	(X,N), (N,X), (Y,N), (N,Y)	(X,N), (N,X), (Y,N), (N,Y)
6	(N,N)	(N,N)

Note: Orderings of indifference sets representing consumer preferences in the games. Most preferred indifference set is 1 and least preferred is 6. Ranking V is the ordering with preferences for product variety and Ranking C is the corresponding ordering with preferences for competition.

better off with two firms serving one market each or with one market not served and one market served by two firms. Among other things, this will depend on preferences for product variety and the intensity of competition on the markets.[14] The ordering of the indifference sets with dominating preferences for product variety results in Ranking V in Table 1. The corresponding ordering with dominating preferences for competition generates Ranking C. Hence, independent of consumer preferences there are six indifference sets altogether that can be ranked in two different ways. By studying how communication affects the distribution of outcomes over these sets we get information about the consumer welfare effects of communication.

We will now introduce the parametrization of the games used in the experiments and start by presenting the game with symmetric entry cost, i.e., $C_1^j = C_2^j$ for all markets j. In the experiment the following parameters were used, $C_i^j = 20$ for $j = X, Y$ and $i = 1, 2$, $F = 12$, and finally $K = 32$. The resulting game matrix of the symmetric cost game (S) is presented in Figure 3.

There are four pure Nash equilibria (PNE) in this game, (X, Y), (Y, X), (B, N) and (N, B). The two first outcomes characterize non-rival cooperative Nash equilibria (CPNE), where both markets are served by one monopoly firm. The latter two represent market domination equilibria

[14] L.Cabral (2004) shows in a (single) market entry model that the intensity or toughness of competition is an important factor in determining the welfare effects of market entry in equilibrium.

Firm 2

		N	X	Y	B
Firm 1	N	12,12	12,24	12,24	12,36
	X	24,12	8,8	24,24	8,20
	Y	24,12	24,24	8,8	8,20
	B	36,12	20,8	20,8	4,4

Figure 3: The symmetric entry cost game (S).

Firm 2

		N	X	Y	B
Firm 1	N	12,12	12,22	12,26	12,36
	X	26,12	10,6	26,26	10,20
	Y	22,12	22,22	6,10	6,20
	B	36,12	20,6	20,10	4,4

Figure 4: The asymmetric entry cost game (A).

(DPNE), where one firm serves both markets as a monopoly. There is also a continuum of symmetric mixed strategy Nash equilibria (MNE) characterized by the probabilities firm 1 and 2 choose strategies N, X, Y, and B, respectively. The MNE is represented by a set of distributions of probabilities for the players, that is $((1/4-a,a,a,3/4-a),(1/4-a,a,a,3/4-a))$ where $a \in [0,1/4]$.

Without communication possibilities there is no obvious way for players to arrive at any PNE, MNE therefore provides the most reasonable prediction in S. We now consider the game above with entry cost asymmetry, that is, for some market j, $C_1^j \neq C_2^j$. Differences in costs to enter a given market can depend on factors like geographic locations, culture, technical compatibility in distribution systems etc. The parameters of the entry game with cost asymmetry (henceforth denoted as A) are the same as in S with the following differences: $C_1^x = C_2^y = 18$, $C_1^y = C_2^x = 22$. This means that firms 1 and 2 have cost advantages in market X and Y, respectively. The game matrix is given in Figure 4.

The game above has the same PNE as S. The corresponding continuum of MNE is now $((a,1/8-a,3/8-a,1/2+a),(a,3/8-a,1/8-a,1/2+a)$

where $a \in [0, \frac{1}{4}]$.

The Nash equilibrium concept does not provide an obvious selection principle. However, by the tacit coordination principles mentioned earlier it can be held that (X, Y) is more likely to be selected in this treatment than in S. One question of some interest is to what extent cost asymmetries can be used in market entry games as coordination devices.

3.1.1 Communication

Introducing communication simply means to add a pre-communication stage to the games presented above. In these games of complete information, pre-play communication naturally concerns a player's intentions. The impact of such communication most likely depends on how it relates to the payoff structure in the game. Following Farrell and Rabin (1996) two properties of a message may affect its credibility; if it is self-signaling and if it is self-committing. To structure the discussion of the messages' credibility (without going into formal details) we use these concepts to analyze messages suggesting a given PNE.[15]

A self-committing message is one that the sender prefers to conform to if the receiver believes in it (Farrell and Rabin 1996). In the games both message $(X, *)$ and $(Y, *)$ are therefore self-committing.[16] A self-signaling message is one that the sender wants to be believed if and only if it is true (Farrell and Rabin 1996). As a consequence, self-signaling messages have a higher degree of credibility. It follows from the reasoning that, $(X, *)$ and $(Y, *)$ are both self-signaling when communication is costly. To see this, note that if Player 1 plans to play B it is not preferable that Player 2 believes that he will play, say X. Furthermore, it makes no sense for Player 1 to take any costly action to induce any belief if his intention is to play N. Sending message $(B, *)$ in this game is self-committing but not self-signaling.[17] It is

[15] The reasoning by Farrell and Rabin (1996) concerns the case of costless communication (i.e., cheap-talk). However, there is no obvious reason for why this reasoning could not be extended to situations with costly communication given that the communication cost is kept in mind.

[16] Note, since the sender only has control over (and therefore also intentions concerning) his own action, beliefs are about this part of the message. Messages are denoted as if Player 1 is the sender.

[17] At first sight, one might argue that N weakly obstructs that the $(X, *)$ and $(Y, *)$ message is self-signaling, since if Player 1 plans to play N it does not matter what the other player believes since the payoffs will be the same. However, it is not consistent with

not self-signaling since irrespectively of what Player 1 plans to choose it is always (weakly) preferable for him to have Player 2 believe that he will play B.

To sum up, according to this reasoning there is room for credible communication in these games. In addition, communication opens up for both "friendly" intentions with emphasis on mutually beneficial CPNE (i.e., market separation) and "aggressive" intentions (of market domination) by "threats" of playing the DPNE. Furthermore, since communication is costly and may in addition compete with tacit coordination principles it is not obvious, a priori, what to expect from the players. In regards to the mode of communication, Crawford (1998) notes that previous experiments found one-sided communication to be much more effective in resolving symmetry than two-sided communication. It is therefore also interesting to study how efficiently a more natural free communication form (allowing multiple messages from both sides) resolves the coordination problem.

4 Experimental Design

Two experiments were conducted, one (Experiment 1) focusing on one-sided communication and the second studying free-form communication (Experiment 2). We start by presenting the former.

Experiment 1: The organization and denotation of the different sessions in the experiment is given in the upper part of Table 2.[18] Before, the subjects played these games, they played two subsessions of somewhat simpler games, in which they learned the structure of the strategic situation and gained experience.[19] The design makes it possible to compare behavior in the symmetric session with behavior in the asymmetric session through time.[20] In every subsession, each game was played ten rounds where subjects

equilibrium behavior for Player 1 (to have the intention) to play N and at the same time send a costly message. From this reasoning it also follows that if communication is free $(X, *)$ are $(Y, *)$ are not strictly self-signaling.

[18]The games were presented in payoff tables that differed somewhat from the conventional game matrices. The reason for this was that subjects were not assumed to be familiar with game matrices and that such matrices would make the efficient outcome somewhat salient. (See appendix for instructions to the subjects).

[19]These games were identical to the ones described earlier with the exception that strategy N was unavailable. Subjects, playing S (A) played a three-strategy version of S (A), first without communication and then with (one-way) communication.

[20]Conceivable spillover effects from earlier subsessions on behavior in latter subsessions

were re-matched to an anonymous subject not played against before (i.e., a strangers matching protocol was used). Subjects were informed about the outcome after each round. In each session the subjects played one subsession without communication and then a subsession with one-sided costly communication. In subsessions with communication Player 1 in each pair had the possibility to send a message before the game was played. The cost of the message, c, was set to 3, not an insignificant sum, but smaller than the potential gains from communication.[21] The message sent consisted of the strategy combination Player 1 suggested they should play.[22] That is, the message space consisted of the 16 possible strategy combinations.[23] The players were not committed to play according to the message(s) sent in the pre-play communication. After the pre-play communication was finished, each player chose simultaneously a strategy in the game.

Experiment 2: This experiment consisted of six sessions that were arranged according to the lower part of Table 2. The design allows for studies of treatment effects between sessions, but also within sessions over time. In particular, this experiment allows us to check if the results obtained in Experiment 1 holds in a more natural free-form communication context. In this experiment the cost of communication was varied so that communication was either costless ($c = 0$) or costly ($c = 3$ or $c = 5$). The treatments without communication can be interpreted as a situation where communication is prohibitively costly or impossible. In this experiment, subjects did not play any games before the sessions in Table 2 started.[24] In other respects the design was similar to the one in Experiment 1. The implementation

can of course not be excluded, but such effects can be attributed to experience effects from a specific environment.

[21]The potential gain from communication is not an unambiguous concept. In this paper it is considered to be the difference between a player's best pure strategy Nash-equilibrium payoff and his MNE payoff.

[22]Note, this design has similarities to the experiment conducted by (Huyck, Gillette, and Battalio 1992) and (Brandts and McLeod 1995). However, in these experiments the suggestions to play a strategy combination were exogenously given by the experimenter. It can also be noted that the games studied in those experiments were not market entry games.

[23]Also, note that one might say that there is an additional message, namely the "message" not to send a message. Since this message is free it is not included in the message space.

[24]One reason for this was that we wanted to have one subsession where we did not have to worry about "spill over" effects from earlier subsessions.

Table 2: Design

Experiment	Session(♯ subj)	subsession 1	subsession 2	subsession 3
1	1 (n = 20)	S(N,11)	S(O3,12)	-
	2 (n = 24)	A(N,21)	A(O3,22)	-
2	3 (n = 18)	S(N,31)	S(F0,32)	S(F5,33)
	4 (n = 24)	S(F0,41)	S(F3,42)	S(N,43)
	5 (n = 20)	S(F3,51)	S(F0,52)	S(N,53)
	6 (n = 16)	A(N,61)	A(F0,62)	A(F5,63)
	7 (n = 24)	A(F0,71)	A(F3,72)	A(N,73)
	8 (n = 20)	A(F3,81)	A(F0,82)	A(N,83)

Note: Experimental design. Each subsession consisted of 10 rounds of each treatment. S and A denote symmetric and asymmetric entry cost respectively. N denotes no communication, Oc denotes one-way communication at cost c and Fc indicates free-form at cost c, where $c \in \{0, 3, 5\}$. The two numbers, ij, after the comma in brackets indicate session and subsession, where $i = 1, 2, ..., 8$ and $j = 1, 2, 3$, respectively.

of free-form communication needs some further explanation. Both players were instructed that they, during 90 seconds, could send messages to the other player through a "chat" function.[25] They could send any message they wanted, except for messages that allowed them to identify themselves. In subsessions with $c > 0$, the cost of communication was incurred to each player the first time (in each round) he sent a message. Hence, the cost of communication for a player was at most c in each round.

Subjects were recruited to both experiments from introductory and intermediate Economics courses at the School of Economics and Management at Lund University.[26] Upon arrival subjects were seated in the School's computer lab.[27] Before the first game was played, subjects received verbal and written information about the experiment. The numbers of subjects in Experiment 1 and 2 were 44 and 122, respectively. The numbers of subjects in the various sessions are given in Table 2. Because, each subsession consisted

[25]See Appendix A for instructions to the subjects. The duration of the communication round was chosen as a compromise between letting subjects get enough time to express their intentions and to avoid letting subjects get bored in waiting for the game to start.

[26]Subjects were asked to sign up before the experiments took place. Experiment 1 took place on May 9, 2005 and Experiment 2 was conducted between September 27 and October 1, 2007.

[27]The experiment was programmed and conducted with the software z-Tree (Fischbacher 2007).

of ten rounds, observations of outcomes were obtained in each subsession, where n denotes the number of subjects in a session. A session took between 75 and 90 minutes. The subjects' total average earning was SEK291 in Experiment 1 and SEK373 in Experiment 2.[28] The earning consisted of a participation fee (of SEK100) plus what they earned in the experiment.

5 Results

In this section the results from the experiments will be presented. The treatments can be divided into the categories symmetric and asymmetric entry cost, respectively. We start to present the results within each category and then move on to compare the two.

5.1 The Consequences of Communication Possibilities: Symmetric Cost

We start to describe the results from session 1 in Experiment 1. Table 3 contains the average proportion of actions, equilibria and messages in the subsessions. In S(N,11) the proportions of the different strategy choices are consistent with MNE.[29] When communication is possible in S(O3,12) X and Y are played much more frequently, which suggests that communication is primarily used to cooperate. In Table 3 it can be verified that messages were sent in 87 percent of the games and from Table 4 it can be derived that 79 percent out of these were suggestions to play a CPNE.[30] Since Player 2s to a large extent complied with the suggestions, this resulted in a dramatic increase in coordination success as measured by the proportion of PNE (see Table 3 and Figure 5). However, a notable fraction of the messages (20 percent) contained suggestions to achieve domination and play the DPNE.[31] The overall proportion of PNE in S(O3,12) was 66 percent. Most of these (88 percent) were CPNE and the rest (12 percent) were DPNE. The fraction of

[28]The total average earnings corresponded to USD42 (Experiment 1) and USD57 (Experiment 2) at the time the experiments were conducted. The hourly earning in this experiment was substantially higher than the hourly salary for this group.

[29]In S(N,11) it seems that X, Y and N are played with equal probability. This would correspond to the MNE where $a = 1/8$.

[30]The proportion of CPNE suggestions was 0.69 in all games. The proportion of messages suggesting a CPNE was thus $0.69/0.87 = 0.79$.

[31]The proportion of DPNE is obtained by the difference between PNE and CPNE in Table 3.

Table 3: Proportions

		N	X	Y	B	PNE	CPNE	Message
Experiment 1	S(N,11)	0.13	0.13	0.13	0.62	0.18	0.04	-
	S(O3,12)	0.05	0.38	0.32	0.25	0.66	0.58	0.87
	A(N,21)	0.00	0.49	0.45	0.06	0.86	0.86	-
	A(O3,22)	0.02	0.45	0.41	0.12	0.80	0.77	0.23
Experiment 2	S(N,31)	0.11	0.08	0.17	0.64	0.18	0.02	-
	S(F0,32)	0.01	0.48	0.48	0.03	0.94	0.93	0.99
	S(F5,33)	0.01	0.43	0.47	0.09	0.82	0.81	0.67
	S(F0,41)	0.00	0.50	0.49	0.00	0.97	0.97	1.00
	S(F3,42)	0.01	0.42	0.47	0.10	0.81	0.80	0.68
	S(N,43)	0.12	0.15	0.18	0.55	0.22	0.09	-
	S(F3,51)	0.02	0.42	0.45	0.11	0.83	0.79	0.73
	S(F0,52)	0.03	0.41	0.42	0.15	0.82	0.76	0.99
	S(N,53)	0.11	0.17	0.16	0.57	0.15	0.06	-
	A(N,61)	0.01	0.38	0.36	0.24	0.44	0.44	-
	A(F0,62)	0.01	0.48	0.48	0.04	0.91	0.91	1.00
	A(F5,63)	0.03	0.43	0.42	0.13	0.81	0.78	0.27
	A(F0,71)	0.01	0.45	0.49	0.05	0.87	0.85	1.00
	A(F3,72)	0.00	0.43	0.55	0.03	0.86	0.86	0.54
	A(N,73)	0.00	0.42	0.53	0.05	0.82	0.82	-
	A(F3,81)	0.02	0.39	0.43	0.16	0.67	0.66	0.54
	A(F0,82)	0.01	0.39	0.46	0.16	0.74	0.73	0.98
	A(N,83)	0.01	0.40	0.40	0.20	0.63	0.63	-

Note: Average proportion of actions, PNE, CPNE and messages.

DPNE actually decreased with communication possibilities. Hence, CPNE but not DPNE was easily attainable by communication, which suggests that the success of communication in market entry situations is highly dependent on the content of the message. The fact that DPNE was not effectively communicated although it is a self-committing one-sided message and an efficient Nash-equilibrium probably partly depends on the fact that it is not self-signaling, but also that the DPNE can be considered as unfair, motivating Player 2 to avoid it.

The consequences of introducing communication possibilities for consumers can be obtained in Table 5 by comparing S(N,11) with S(O3,12).

Table 4: Types of messages in Experiment 1

	S(O3,12)	A(O3,22)
N,N	0.01	0
N,X	0	0
N,Y	0	0
N,B	0	0
X,N	0	0
X,X	0	0
X,Y	0.49	0.13
X,B	0	0
Y,N	0	0
Y,X	0.2	0
Y,Y	0	0
Y,B	0	0
B,N	0.17	0.1
B,X	0	0
B,Y	0	0
B,B	0	0
No Message	0.13	0.77

Note: Average proportion of different types of messages in Experiment 1.

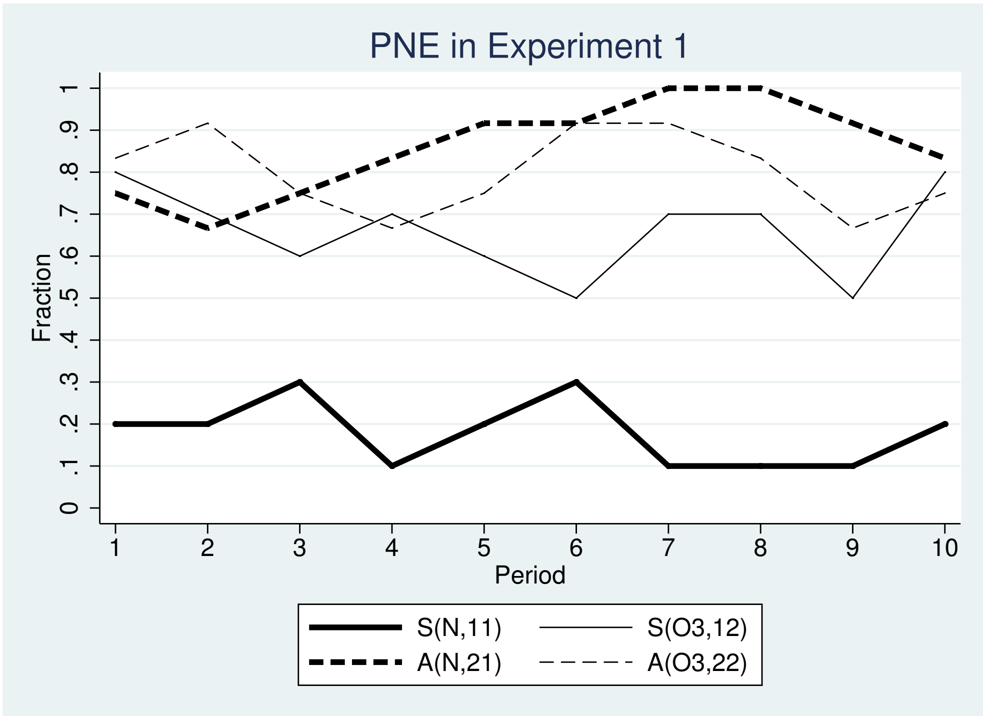


Figure 5: Fraction of pure Nash equilibrium outcomes in Experiment 1

The opportunity to communicate drastically affects the frequency of outcomes in the various indifference sets by making the distribution more centered on the third and fourth indifference sets in Ranking (V) and Ranking (C), respectively. These sets contain the CPNE. In fact, the introduction of communication reduces the outcomes in all other indifference sets, but primarily from higher ranked sets. This suggests that outcomes are likely to be ranked lower in the communication treatment.

To test statistically whether the probability that a randomly selected outcome from S(N,11) is ranked equally to a randomly selected outcome from S(O3,12), we perform a Wilcoxon-Mann-Whitney test (henceforth, a WMW-test).[32] The null-hypothesis that the ranks are stochastically equally large in the two treatments is strongly rejected ($p = 0.000$) and this is so independently of the chosen consumer ranking.[33] The reason is that the medium consumer rank of the outcomes in S(N,11) is significantly higher than in S(O3,12).

Experiment 2 confirms that the results obtained in Experiment also holds for free-form communication. As before, Table 3 reveals that the actions in subsessions without communication (i.e., S(N,31), S(N,43), and S(N,53)) are roughly consistent with MNE.[34] Introducing costly communication drastically increases the proportion of PNE (primarily through CPNE). This can be verified both between subjects (i.e., compare S(N,31) with S(F3,51)) and within the same session (compare S(N,31) vs. S(F5,33), S(F3,42) vs. S(N,43), S(F3,51) vs. S(N,53)). Furthermore, statistical WMN-tests con-

[32]To do this each outcome is assigned its rank according to which indifference set they belong to (i.e., 1 to 6). A WMW-test is then applied to the two samples of rank distributions. The null-hypothesis in this test is then that $P[R^i > R^j] = 1/2$, where R^i and R^j is a random observation of the rank from the distribution of outcomes of session i and j, respectively (S.Siegel and N.´Castellan 1988, p. 128-129). The WMW-test tells us if the "bulk" of the outcomes in one sample are ranked higher than outcomes from another sample, but it does not tell us if one shape of a sample distribution is preferred to another. If its limitations are realized, we think this is a reasonable test for distributions of ordinal rankings like the present ones.

[33]It should be noted that in this test observations are assumed to be independent. This commonly made assumption can always be debated. For instance, using 10 observations from each individual in each treatment can be argued to violate this assumption. However, the use of a strangers' matching ought to mitigate the worst dependencies between observations.

[34]For readers interested in outcomes per round in each session of Experiment 2 we provide figures illustrating this in Appendix B.

Table 5: Number of outcomes in different indifference sets

Ranking V		1	2	3	4	5	6
Experiment 1	S(N,11)	43	24	18	4	10	1
	S(O3,12)	12	18	66	2	2	0
	A(N,21)	0	15	103	1	1	0
	A(O3,22)	2	21	96	0	1	0
Experiment 2	S(N,31)	38	26	16	5	5	0
	S(F0,32)	0	5	85	0	0	0
	S(F5,33)	3	10	74	2	1	0
	S(F0,41)	0	1	116	2	1	0
	S(F3,42)	6	12	97	3	2	0
	S(N,43)	39	40	26	2	12	1
	S(F3,51)	1	16	83	0	0	0
	S(F0,52)	6	11	82	1	0	0
	S(N,53)	33	38	15	3	9	2
	A(N,61)	5	29	35	9	2	0
	A(F0,62)	2	3	73	1	1	0
	A(F5,63)	3	11	65	0	1	0
	A(F0,71)	0	10	104	5	1	0
	A(F3,72)	0	6	103	11	0	0
	A(N,73)	0	11	98	11	0	0
	A(F3,81)	4	23	67	3	3	0
	A(F0,82)	4	22	74	0	0	0
	A(N,83)	4	32	63	0	1	0
Ranking C		1	2	3	4	5	6
Experiment 1	S(N,11)	43	24	4	18	10	1
	S(O3,12)	12	18	2	66	2	0
	A(N,21)	0	15	1	103	1	0
	A(O3,22)	2	21	0	96	1	0
Experiment 2	S(N,31)	38	26	5	16	5	0
	S(F0,32)	0	5	0	85	0	0
	S(F5,33)	3	10	2	74	1	0
	S(F0,41)	0	1	2	116	1	0
	S(F3,42)	6	12	3	97	2	0
	S(N,43)	39	40	2	26	12	1
	S(F3,51)	1	16	0	83	0	0
	S(F0,52)	6	11	1	82	0	0
	S(N,53)	33	38	3	15	9	2
	A(N,61)	5	29	9	35	2	0
	A(F0,62)	2	3	1	73	1	0
	A(F5,63)	3	11	0	65	1	0
	A(F0,71)	0	10	5	104	1	0
	A(F3,72)	0	6	11	103	0	0
	A(N,73)	0	11	11	98	0	0
	A(F3,81)	4	23	3	67	3	0
	A(F0,82)	4	22	0	74	0	0
	A(N,83)	4	32	0	63	1	0

firm (p = 0.000) the earlier conclusion that costly communication generates outcome distributions that are inferior to consumers.

As the cost of communication was varied in Experiment 2, the effect of this can also be studied. A tendency towards less PNE (and CPNE) is detected when communication is costly compared to when it is costless. Hence, if we compare S(F0,41) with S(F3,51), we find a significantly higher fraction of PNE in the former subsession ($p = 0.001$, Chi-square-test).[35] The reason for this is quite logical, when communication gets costly fewer subjects send messages (see Table 3), which decreases coordination and thus PNE (and CPNE) outcomes. This can be verified by comparing the fraction of subjects that sends messages in S(F0,41) with S(F3,51). In free-form communication it is not entirely trivial to classify and count messages of different types. However, a quick inspection reveals that the vast majority of messages concern suggestions and acceptance to coordinate on CPNE, which is consistent with the fact that 87 percent of the games with communication result in a CPNE. A typical exchange of messages is the following:

Player 1	"I choose Y and you choose X"
Player 2	"Ok"

Like in Experiment 1 there are also some subjects that try to use communication as a threat strategy to attain domination. However, such threats are rare and often rejected by the opponent player already in the communication phase, like the following conversion reveals:

Player 1	"I intend to enter both. We will not meet again hence you cannot "punish" me. It is best for your to stay outside and get twelve instead of four."
Player 2	"Then it will be a pleasure for me to give you (and me) 4." "The best you can do is to choose y..."
Player 1	"ok lets do that..."
Player 2	"good"

[35]This picture is also to a large extent confirmed if we compare coordination successes within the two first sessions (i.e, S(F0,32) vs. S(F5,33)13, S(F0,41) vs S(F3,42)), but not in the third were the difference between PNE in S(F3,51) and S(F0,52) is insignificant. However, for random reasons, one should not expect that an effect should be detected in all sessions.

In general, one should be careful when comparing subsessions from different experiments. However, without drawing any far-fetched conclusions it is worth noting that the fraction of DPNE is smaller with free-from communication than with one-sided communication. This can be verified by comparing the difference between PNE and CPNE in S(O3,12) and S(F3,42) in Table 3. A tentative explanation to this is that threats can be more effectively communicated when communication is one-sided, since both players know that Player 2 cannot respond (as in the conversation example above). This is also consistent with Crawford's (1998) reasoning that in the case of one-sided communication symmetry issues are often resolved in favor of the sender's most preferred equilibrium outcome.

Let us summarize the main findings concerning the consequences of introducing possibilities of communication in market entry games with symmetric entry cost:

I. Communication substantially increased the proportion of PNE, primarily by coordination on CPNE.

II. Messages revealed intentions of both cooperation and domination, but the former intention were much more common (and observed in four out of five messages in Experiment 1).

III. Communication led to a substantial reduction in the most preferred outcomes for consumers. Outcomes generated with communication are therefore likely to be less preferred by the consumers than outcomes generated without communication.

IV. The fraction of PNE outcomes and fraction of players sending messages were higher when communication was free compared to when it was costly.

5.2 The Consequences of Communication Possibilities: Asymmetric Cost

We will now explore the consequences of communication possibilities in market entry games with asymmetric entry cost. We start by Experiment 1. Without communication it can be verified in Table 3 that X and Y are the standard choices and since these choices are coordinated, the proportion of CPNE in A(N,21) is high. Recall that before the subjects played this game, they played a simpler asymmetric cost game where they appear to have learned to coordinate. Hence, in this experiment the players can be considered experienced.[36]

When communication was allowed the choices of actions were relatively similar, which can be verified by a comparison of A(N,21) and A(O3,22). The only noteworthy difference is that B was played somewhat more often in the latter treatment. The likely explanation for this is that some Player 1s tried to use messages to implement the DPNE. This is also confirmed by the data on the messages. Here, 40 percent of all messages sent were suggestions to play (B, N). However, only four Player 2s out of twelve acted according to the message, which suggest that these messages often resulted in coordination failures. As a consequence, the PNE frequency dropped from 86 percent in A(N,21) to 80 percent in A(O3,22). This somewhat remarkable result implies that communication possibilities do not necessarily lead to an increase in PNE in coordination games of this type.[37] A chi-square test does not reject equality of proportions of PNE in the two treatments ($p = 0.23$).

In both treatments 80 percent or more of the outcomes belong to the third (Ranking V) or fourth (Ranking C) indifference set (see Table 5). The number of outcomes in the two highest ranked indifference sets is somewhat larger in A(O3,22) than in A(N,21), suggesting that consumers are somewhat better off with communication possibilities. Although, the difference is not statistically significant ($p = 0.125$ for Ranking V and $p = 0.411$ for Ranking C), the result is in stark contrast to the case with symmetric cost, where communication substantially reduced the outcomes in the highest ranked indifference sets.

Let us now analyze the results of Experiment 2. The first thing to note

[36]A similar learning effect could not be observed in the symmetric environment. This is not strange, since there is not much to be learned in the symmetric game, without communication.

[37]This observation is somewhat similar to the findings in Cooper et al. (1992). The present observation differs, however, in two important respects. First, the coordination games used in this paper have a clear economic interpretation and differ from the ones studied in Cooper, Dejong, Forsythe, and Ross (1992). Furthermore, Cooper, Dejong, Forsythe, and Ross (1992) demonstrated that one-way communication, but not two-way communication, increased coordination success. In this game we show that not even one-way communication may lead to increases in coordination success.

is that there seems to be learning involved in the asymmetric entry cost game without communication. This can be seen in Table 3 by comparing the PNE of A(N,61), where subjects are inexperienced with A(N,73) and A(N,83), where they are experienced. The rate of PNE is much higher in the latter subsessions. The learning among inexperienced subjects is similar to what was observed in the simpler "exercise" games (with asymmetric cost and without communication) in Experiment 1.[38] To evaluate the effects of communication it is therefore important to separate between inexperienced and experienced subjects. We regard the subjects in the first subsession as inexperienced, and subjects in the second and third subsessions as experienced.[39]

To study the effect of communication on inexperienced subjects we compare A(N,61) with A(F0,71) and A(F3,81) in Table 3. Communication increases the proportion of PNE substantially, which is confirmed by a chi-square test that strongly rejects equal proportions ($p = 0.000$ for A(N,61) vs. A(F0,71) and $p = 0.002$ for A(N,61) vs. A(F3,81)). Almost all PNE are CPNE, which suggest that domination is not attainable in this environment. Furthermore, as in the symmetric sessions the cost of communication significantly affects PNE outcomes among inexperienced players.[40] Rather expectedly, the improved coordination due to communication also resulted in significantly lower consumer rankings.[41] Comparing, costly communication (A(F3,81)) with no communication (A(N,61)) gave more ambiguous effects for consumers. Communication lead to significantly less preferred outcomes for ranking C ($p = 0.0034$, WMW), but not for ranking V ($p = 0.2369$,WMW).[42]

[38] It is also interesting to note that there is no obvious learning effect when communication is allowed. It appears that communication makes subjects able to "get it" directly.

[39] Obviously, this restricts the possibility of within-subjects comparisons between the first and the following two subsessions.

[40] Equality of proportions of PNE between A(F0,71) and A(F3,81) is rejected ($p = 0.000$). However, we advise the reader to be careful regarding results relying on between session comparisons involving session 8, since this session contained two subjects consistently playing B in all rounds. Given the play of other subjects this non-standard behavior decreases the proportion of PNE (and of course CPNE as well) in session 8.

[41] Similarities of ranking V and C of A (N,61) and A(F0,71) were strongly rejected ($p = 0.002$ and $p = 0.002$, respectively).

[42] The logic behind the different results is that communication mainly increases the number of CPNE and thus guarantees product variety, which is higher ranked in V than in C. Thus, the loss for consumers due to communication is therefore less severe if they

Let us now study communication effects among experienced players. Here it is relevant to compare the results to the findings in Experiment 1, where all subjects can be considered experienced. When we compare no communication with costly communication between subjects we find no significant difference in proportions of PNE when comparing A(F5,63) with A(N,73) ($p = 0.941$), but a significantly higher PNE proportion in A(F5,63) compared to A(N,83). However, we believe that the latter finding is an artifact, since there is a generally low level of PNE in throughout session 8. Furthermore, if we look within the sessions we do not find that communication significantly increases PNE proportions. Thus, if we compare A(F3,72) with A(N,73) the PNE proportion is somewhat higher in the former treatment, but not significantly so ($p = 0.382$). Similarly, if we compare A(F3,81) with A(N,83), PNE proportions are very similar. Furthermore, no significant consistent effects on PNE proportions were detected when comparing costly and costless communication.

Like in Experiment 1, we did not detect any unambiguously negative consumer effect from communication possibilities in the asymmetric game. If we compare costly communication in session A(F5,63) with no communication in A(N,73) (and leave out session 8 in the between session comparisons for the reasons indicated above) communication significantly improves the outcomes for consumers with Ranking V and make no difference with Ranking C. Within the same session, we find no significant effect when we compare costly communication to no communication (subsession A(F3,72) vs. A(N,73)) or costless communication to no communication (subsession A(F0,82) vs. A(N,83)), and this is so for both rankings. To sum up, in most respects the results for experienced players in Experiment 2 is consistent with the earlier findings in Experiment 1; communication has possibly small, but mostly insignificant effects on coordination and consumer welfare in asymmetric entry cost games.

Let us now comment on the fraction of players that sent messages. From Table 3 it is obvious that almost all subjects sent messages when communication was costless. These messages appear somewhat redundant for experienced subjects, who are able to coordinate without communication. When communication was costly, 27 and 54 percent sent messages when and , respectively. Hence, introducing a cost of communication reduces the number

have preferences for product variety.

of players sending messages for both experienced and inexperienced subjects. The second conclusion is that the relative cost of the message appears to matter for experienced players also when costs are asymmetric.[43]

The following main observations are made concerning communication in market entry games with asymmetric cost:

I. Coordination success is improved by experience when communication is unavailable.

II. Experienced subjects exploit the tacit coordination device that cost asymmetries offer, which means that although communication possibilities had somewhat different effects on consumers and coordination success depending on communication form, none of the effects were unambiguous and substantial.

III. Inexperienced subjects significantly increase the proportion PNE outcomes by communication (almost exclusively by increases in CPNE), which is detrimental to consumers.

IV. Irrespective of experience, the proportion of players that send messages decreases when communication gets costly.

5.3 The Effects of Communication: Symmetric vs. Asymmetric Cost

This section focuses on comparisons between the two main treatment groups. As in the previous sections we present the results from the experiments sequentially.

In Experiment 1, without communication, the PNE proportion is significantly ($p = 0.000$) lower in the symmetric cost treatment than in the asymmetric one. The reasonable explanation for this is that the cost asymmetry provides a coordination cue that points out the efficient equilibrium. Such a cue is unavailable in the symmetric game.[44] The difference in PNE proportions between the asymmetric and the symmetric cost treatment decreases when communication is possible (see Table 3). This suggests that

[43] A chi-square test strongly rejects ($p = 0.000$) that the fractions of subjects that send messages in A(F5,63) and A(F3,72) are drawn from the same distribution.

[44] Consistent with this reasoning the majority of PNE in the symmetric game are DPNE (which is consistent with MNE) whereas all PNE in the asymmetric game are CPNE (which indicates a coordination device).

communication is more effective in the symmetric game, which is reasonable since there are no alternative means of coordination. However, the possibility to communicate does not entirely even out the differences in PNE.[45]

A substantially smaller fraction of subjects in the asymmetric treatment sent messages than subjects in the symmetric treatment (see Table 3). In S(O3,12) and A(O3,22) messages were sent in 87 and 23 percent of the games, respectively.[46] This suggests that tacit coordination crowds out explicit communication, which probably is due to the fact that tacit coordination is free while communication is costly.

For the same reason as have been explained above, without communication PNE proportions are highest in games with asymmetric cost in Experiment 2. The difference is most marked for experienced subjects (compare S(N,43) and S(N,53) with session A(N,73)), but also significant for inexperienced subjects.[47] When communication is introduced behavior between asymmetric and symmetric cost becomes more similar. However, the PNE proportion is significantly higher in the symmetric treatment for inexperienced subjects.[48] As subjects gain experience, this significant difference disappears for both costly and costless communication. A conceivable explanation for this is that the asymmetric game is somewhat more cognitive demanding which results in some coordination mistakes even if subjects can communicate. As subjects get more experienced they learn the more complicated asymmetric game and the difference disappears.

Interestingly, with costly communication there is a significantly higher proportion of PNE in the asymmetric treatment compared to the symmetric one in Experiment 1 but not in Experiment 2. This may be explained by the form of communication. In the symmetric (but not the asymmetric) treatment subjects have to send messages to arrive at a PNE. When they do this, the one-way communication form in Experiment 1 probably makes it more

[45]Equality of PNE proportions between the subsessions is also rejected at a statistically significant level ($p = 0.019$).

[46]Needless, to say the null hypothesis of equality of proportion messages sent in these treatments can strongly be rejected ($p = 0.000$).

[47]Equal proportions of CPE (of session S(N,31) and A(N,51) can be rejected at $p = 0.000$.

[48]This result holds for both costly and non-costly communication. The null hypotheses of equal proportions of coordination success (of S(F0,41) vs. A(F0,71) and session S(F3,51) vs. A(F3,81)) are rejected at $p = 0.005$ and $p = 0.009$, respectively. However, one should be careful with the latter result due idiosyncrasies mentioned earlier regarding session 8.

tempting for the players to use the message to suggest the DPNE, which often lead to a coordination failure. With free-form communication the opponent can always reject such a suggestion in the pre-play communication, which makes efforts to achieve the DPNE less tempting.

When communication is free virtually all subjects send messages in all rounds irrespective of treatment. However, consistent with our result in Experiment 1, significantly smaller fractions of subjects send costly messages in the asymmetric games compared to the symmetric ones.[49] The largest difference between the fraction of subjects sending messages occurred in the sessions where and subjects were experienced. Here, on average 67 percent of the subjects sent messages in the symmetric treatment and only 27 percent in the asymmetric treatment.

It is also interesting to compare how the possibility to communicate affected profits when communication cost is taken into account. Table 6 reports average final profits for subjects in the different subsessions.

In symmetric subsessions without communication profits are slightly below the theoretical MSE profit of 120. Moreover, in symmetric sessions, profits increase when costless communication possibilities are introduced and are fairly close to the efficiency frontier (see S(F0,32) and S(F0,41)). When communication gets costly profits naturally decline since subjects then have to pay in order to coordinate. Furthermore, since fewer subjects chose to communicate when it was costly, part of this decline in profits might also be due to the decrease in PNE outcomes observed in the previous analysis.

When entry cost is asymmetric communication possibilities appear to have a positive effect on profits for inexperienced subjects. For experienced subjects there are no large differences in profits between the treatments. Profits are highest in subsessions with costless communication. At the same time, profits are lower in subsessions with costly communication compared to subsessions without communication. Hence, although communication possibilities appear profitable to the players in most cases, there are exceptions to this.

Our main findings in this section are:

I. Without communication entry cost asymmetries substantially increase

[49] The null hypotheses of equal fractions subjects sending messages (of session S(F5,33) vs. A(F5,63), S(F3,42) vs. A(F3,72), and S(F3,51) vs. A(F3,81)) are strongly rejected (at $p = 0.000$, $p = 0.001$ and $p = 0.009$, respectively).

Table 6: Average Final Profit (SEK)

		Average profit
Experiment 1	S(N,11)	116
	S(O3,12)	181
	A(N,21)	244
	A(O3,22)	232
Experiment 2	S(N,31)	114
	S(F0,32)	234
	S(F5,33)	184
	S(F0,41)	236
	S(F3,42)	195
	S(N,43)	132
	S(F3,51)	200
	S(F0,52)	215
	S(N,53)	123
	A(N,61)	183
	A(F0,62)	246
	A(F5,63)	221
	A(F0,71)	240
	A(F3,72)	222
	A(N,73)	233
	A(F3,81)	200
	A(F0,82)	227
	A(N,83)	215

PNE outcomes in market entry games.

II. Communication substantially reduces the difference in PNE proportions between the symmetric and asymmetric games.

III. The fraction of players that send costly messages in games with symmetric entry cost is substantially higher than the corresponding fraction in games with asymmetric cost. This suggests that tacit coordination partly crowds out costly communication.

6 Implications for Competition Policies and Tactics

The effects of communication in entry decisions are not only of academic interest. To see this let us refer to two cases where the European Commission has acted against suspected collusion in market entry situations. The first case concerns the two firms ICI and Solvay that operated in the market for soda ash.[50] ICI had traditionally served the market in UK and Ireland, and Solvay had been the dominant supplier of soda ash in continental Europe. As evidence of market separation and thus collusion, the Commission used the observation that although substantial price differences between the markets (in UK/Ireland and continental Europe) neither ICI nor Solvay did enter the other company's home markets in the 70s and 80s. Hence, the Commission used the fact that a company did not enter another market as (indirect) evidence for tacit collusion. This decision has been challenged on the grounds that sufficient information about cost and demand parameters to rule out that the observed behavior was consistent with non-cooperative competitive behavior, was not presented (Phillips 1995). Clearly, had there been incriminating evidence of explicit communication between the two firms indicating intent of market separation, then few would probably challenge the Commission's decision.[51] The point is that without any explicit evidence of intent of coordination through some sort of communication it is very difficult to prove that the outcome is necessarily the result of concerted action. An important aspect in this case is that there were obvious cost asymmetries in that each company had a substantial cost advantage at their respective home market. It is therefore possible and fully consistent with our results that no explicit co-ordination was necessary.

The other case we shall refer to involved two Scandinavian airlines, Maersk Air and SAS. This case involved (among other things) a market separation agreement that lead to a withdrawal by Maersk Air from the

[50]For a more thorough presentation of this case see Phillips (1995, chapter 8) and the ECC Commission decision (EEC 1991).

[51]In the decision the European Commission also refers to documentary evidence and some evidence of meetings between the two firms (EEC 1991). However, the documentary evidence mainly concerned old agreements that were annulled according to the firms and the evidence of meetings did not unambiguously show the intent of the meetings was to concert market sharing.

Copenhagen-Stockholm route and a withdrawal by SAS from the Copenhagen-Venice route. In contrast to the previous case, here the Commission could rely on explicitly written incriminating information that was obtained by the Commission's inspections at the companies' headquarters. This made the legal grounds for actions against the two companies relatively clear. Furthermore, in this case the presence of cost asymmetries was less obvious than in the previous case.[52] It is not impossible that this partly explained why explicit communication was necessary here in the same way it was needed in the symmetrical games in the experiment. Hence, collusion in market entry situations actually takes place and competition authorities like the European Commission do not hesitate to impose heavy fines on violators.[53] Furthermore, the presence or absence of cost asymmetries may have played a role in explaining how co-ordination was achieved.

One question to address in this context is if communication between firms concerning market entry should be illegal. In the beginning of the paper we noted that allowing communication in market entry situations may have positive as well as negative consequences for consumers. Our results point out that without any other means of coordination, the negative effect dominates. Hence, the illegality of means to achieve market entry co-ordination seems perfectly reasonable from this perspective.[54] However, this result does not seem to hold for market entry situations characterized by cost asymmetries. Hence, in situations like the ICI-Solvay case communication may not be harmful, primarily for the reason that it is not needed to the same extent as in the symmetric cost case. In addition, communication makes it possible to communicate threats, something that may destabilize co-ordination and potentially improve consumer welfare.

A second question concerns the tactics used by competition authorities to detect cartels. Many officers of competition authorities would testify that it is one thing to find a probable cartel and another thing to prove to a court that it actually existed. Hence, it is not sufficient for the authorities to get guidance of the likely markets to detect cartels, it is also important to find the likely contexts where proofs of such cartels are being generated. Hence,

[52]For instance, both companies operated from Copenhagen.

[53]Maersk and SAS were fined more than 50 million euro (see press release, IP/01/1009, Brussels, 18 July, 2001).

[54]Note, this evidence is based on just one parameterization. Clearly, more research is needed to have a firm basis for policy conclusions.

the question of where collusion is likely to emerge is clearly related but somewhat different from the questions of where evidence of such collusion is generated. Important evidence is generated when communication takes place, but not when coordination is tacit. Our results indicate that the probability of detecting incriminating evidence on communication (e.g., in a "dawn raid") can be much higher in market entry situations with symmetric cost compared to asymmetric cost. Considering that efforts to detect such communication are costly, it may be unwise of the competition authorities to complement its material by conducting such inspections in cases with cost asymmetries (e.g., in cases similar to the ICI-Solvay case).

7 Concluding Remarks

This paper experimentally explores the effects of allowing communication in market entry situations where tacit coordination cues may or may not be present. The two fundamental coordination principles in market entry problems are those of cooperation and domination. Whereas cooperation is motivated by a mutual non-rival interest, domination is motivated by the interest to get the largest possible share of the industry profit. In the spirit of the quote by Thomas Schelling in the introduction, we emphasize that it is not trivial to predict the outcomes in such situations without exploring them empirically. To our knowledge, this is the first paper that investigates the effect of introducing (costly) communication a market entry game which fully recognizes and separates between the principles of domination and co-operation. This means that we are able to generate new results. Some of our findings appear relatively convincing both from a statistical and theoretical point of view and hold in different experiments relying on different forms of communication. On top of this, some of the results confirm observations made in other but somewhat similar settings.

One important result is that communication was predominantly used to cooperate in order to achieve market separation. Messages to achieve domination were often rejected in action (but also in pre-play communication), resulting in disequilibrium outcomes in terms of over-entry, whereas communication intended to achieve cooperation was almost always accepted by the counter-part.

A second important result is that communication increased coordination success (in terms of pure equilibrium outcomes) substantially, but does so mainly in environments where tacit coordination cues were absent. This result resembles that of Van Huyck, Gillette, and Battalio (1992) and Brandts and McLeod (1995) who found that communication of assignments by the experimenter was most successful when it did not compete with strong tacit coordination principles. Hence, tacit and explicit communication appear to be substitutes. Furthermore, this study demonstrated that these substitution effects can be large and moreover hold for different forms of communication. With experienced players and one-way communication the probability that a message was sent was four times higher in the symmetric market entry game compared to the asymmetric one. This result may have an implication for competition authorities in search for evidence of illegal coordination; the probability of detecting proofs in terms of incriminating messages in raids by dawn may be quite sensitive to the presence of entry cost asymmetries.

In contrast to earlier studies we explicitly recognize that the outcomes in market entry games have implications for consumer welfare. To evaluate effects for consumers, outcomes were assigned to indifference sets that were ranked according to some standard assumptions on consumer preferences. These rankings were in turn used to statistically evaluate if communication leads to better or worse outcomes for consumers. In the games with symmetric entry cost, communication was likely to lead to inferior outcomes for consumers. In the case of asymmetric entry cost no such negative effect was detected when players were experienced. These results hold for both one-sided and free-form communication. Even if it can be argued that these results depend on the parametrization in the experiment, the results clearly demonstrate that the effects of communication can depend on a contextual factor often present in real markets, namely, entry cost asymmetries.

Appendix A: Instructions for the experiments

This is a translation of the instructions given to the subjects in the two experiments. We will only present instructions for the symmetric entry cost treatments. The instructions for asymmetric treatments only differed in the payoff matrix. Our comments are given in *italics*.

Experiment 1

General Information

You are going to participate in an economic experiment. You receive SEK 100 for your participation and you can earn additional money on the choices you make during the experiment. The amount you earn depends on your and your co-players' choices. In the experiment you earn experimental "daler", which will be converted to SEK when the experiment is finished according to the exchange rate 1 daler = SEK 0.25. We ask you to be silent during the experiment. If you have any questions, please raise your hand, so that the experimenters can come to you and answer your questions.

You will make your choices by clicking on your computer screen. It is important that you understand the structure of the game, you are therefore asked to carefully read the instructions to make sure that you fully understand it before the experiment starts.

You will make choices in four different strategic situations. Each strategic situation will be repeated 10 times.[55]

Strategic Situation *S(N,–)*

The choice you are about to make concerns entry on two markets. This situation will be repeated 10 times. In each round you will be paired with a new co-player.[56] You will not receive any information about who you have been matched with. You are asked to choose one out of four possible strategies in this situation:

- Stay out
- Only enter market x
- Only enter market y

[55] *The two first situations were the simpler exercise games (see section 4).*

[56] *In the original written information subjects were informed that they would be randomly matched to a new co-player and that the probability that they would encounter the same co-player in two consecutive rounds was small. This wording was used should the number of participating pairs in a session be less than 10 (the number of rounds in each session). However, the number of pairs was 10 or above, which meant that we could use a matching protocol with new pairs in each repetition. The subjects were verbally informed that they met a new co-player in each round.*

- Enter both markets

Below you will find information on the amounts you will earn in this situation for different choices (the amount earned by your co-player is given in parenthesis):

		Your opponent's strategy			
		N	X	Y	B
	N	12(12)	12(24)	12(24)	12(36)
Your	X	24(12)	8(8)	24(24)	8(20)
strategy	Y	24(12)	24(24)	8(8)	8(20)
	B	36(12)	20(8)	20(8)	4(4)

The information above was given on a sheet of paper. The subjects then made choices for 10 rounds in this situation on the computer.

Strategic Situation *S(O3,–)*

The choice you are about to make concerns entry on two markets. This situation will be repeated 10 times. In each round you will be paired with a new co-player. You will not receive any information about who you have been matched with. You are asked to choose one out of four possible strategies in this situation:

- Stay out
- Only enter market x
- Only enter market y
- Enter both markets

Information given to Player 1: In this situation you have also the possibility of sending a message to your co-player before you make your strategy choices. You can you do this in each round. The message is a suggestion of what strategies you think you and your co-player should choose. However, neither you nor your co-player has to act according to your suggestion. If you decide to send a message, it will cost you 3 daler. This amount will be deducted from what you earn in the round. Your co-player cannot send you any message.

Information given to Player 2: In this situation your co-player has the possibility of sending you a message before you make your strategy choices. The message is a suggestion of what strategies you and your co-player should choose. Each time the co-player decides to send a message, it will cost her/him 3 daler. You do not have to pay anything, but has the possibility of reading the messages. However, neither you nor your co-player has to act according to the suggestion.

Below you will find information on the amounts you will earn in this situation for different choices (the amount earned by your co-player is given in parenthesis):

		Your opponent's strategy			
		N	X	Y	B
	N	12(12)	12(24)	12(24)	12(36)
Your	X	24(12)	8(8)	24(24)	8(20)
strategy	Y	24(12)	24(24)	8(8)	8(20)
	B	36(12)	20(8)	20(8)	4(4)

The information above was given on a sheet of paper. The subjects then made choices for 10 rounds in this situation on the computer. The information given to the subjects in the other treatments followed the same logic.

Experiment 2

The instructions for treatments without communication are identical in the two experiments and therefore left out here.

General Information

You are going to participate in an economic experiment. You receive SEK 100 for your participation and you can earn additional money on the choices you make during the experiment. The amount you earn depends on your and your co-players' choices. In the experiment you earn experimental ”daler”, which will be converted to SEK when the experiment is finished according to the exchange rate 1 daler = SEK 0.45. We ask you to be silent during the experiment. If you have any questions, please raise your hand, so that the experimenters can come to you and answer your questions.

You will make your choices by clicking on your computer screen. It is important that you understand the structure of the game, you are therefore asked to carefully read the instructions to make sure that you fully understand it before the experiment starts.

You will make choices in three different strategic situations. Each strategic situation will be repeated 10 times.

Strategic Situation *S(Fc,-)*

The choice you are about to make concerns entry on two markets. This situation will be repeated 10 times. In each round you will be paired with a new co-player. You will not receive any information about who you have been matched with. You are asked to choose one out of four possible strategies in this situation:

- Stay out
- Only enter market x
- Only enter market y
- Enter both markets

Below you will find information on the amounts you will earn in this situation for different choices (the amount earned by your co-player is given in parenthesis):

		Your opponent's strategy			
		N	X	Y	B
	N	12(12)	12(24)	12(24)	12(36)
Your	X	24(12)	8(8)	24(24)	8(20)
strategy	Y	24(12)	24(24)	8(8)	8(20)
	B	36(12)	20(8)	20(8)	4(4)

Before you choose strategy you and your co-player have the opportunity to communicate via the computer terminal. To open your side of the communication channel you will pay an initial fee of c daler.[57] When you send your first message the fee will be deducted automatically from what you earn. Neither you nor your co-player is however required to do what you

[57] *c was set to 0,3 or 5.*

may have said in your messages. In the following page there is a graphic illustration of how the communication procedure. **Note: It is forbidden to write messages where you identify yourself by for example name, sex, or appearance. Violation against this rule will lead to that the entire payment will be withdrawn.**

Message screen

Computer screen (above). Translation of the text in the boxes:

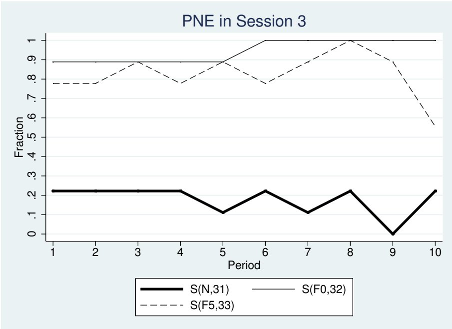
Top box: Here you are able to see those messages that you and your co-player sent. Note that it does not cost anything to look at your co-players messages.

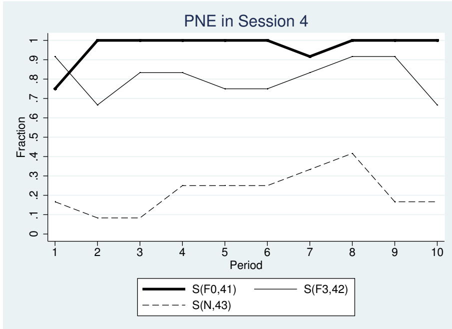
Middle box: You write the messages you want to write here. You send a message by pressing Return.

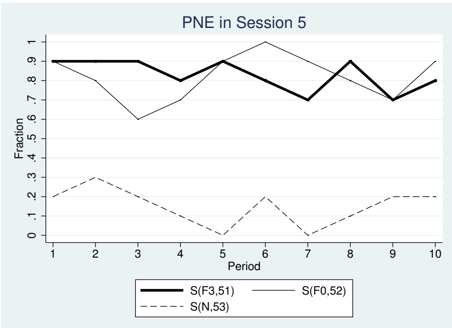
Bottom box: During 90 seconds you have the opportunity to communicate with the other group participant. It costs 0 daler to open your side of the communication channel.

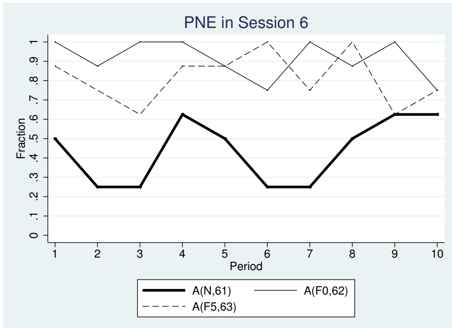
Appendix B: PNE figures

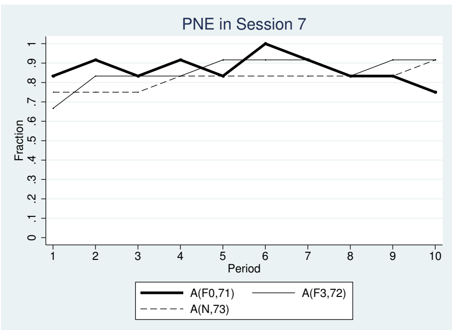
The following six figures illustrate the fraction of PNE outcomes in each period for Experiment 2.

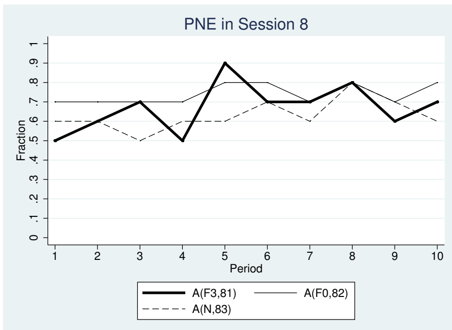












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