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Author

Farrell, Joseph

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UNIVERSITY OF CALIFORNIA, BERKELEY

Department of Economics

Berkeley, California 94720

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COMMUNICATION
BETWEEN POTENTIAL ENTRANTS

Joseph Farrell

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Abstract

The symmetric equilibrium of a game of announcements between two potential entrants, only one of whom can profitably enter, is analyzed. The ability to communicate (in a costless, non-verifiable, non-binding way) makes coordination failures (both enter or neither does) less likely than in the symmetric equilibrium of the entry game without communication. Even in the limit as there are very many rounds of communication, however, the probability of coordination failures does not go to zero. Equilibrium in early rounds involves both firms almost certainly announcing that they will enter; later, one is more likely to "drop out."

1. INTRODUCTION

When a number of firms contemplate entering an industry that can profitably accommodate only some of them, which of them enter? The traditional answer is simply that the "right" number of firms choose to enter and the rest stay out. Somehow they coordinate perfectly. But this answer is unsatisfactory. While that outcome would be self-enforcing if the potential entrants agreed or coordinated on it, we have no convincing story of how they achieve such perfect coordination: in other words, how they move so smoothly from symmetry ex-ante to coordinated asymmetry ex-post.

One possibility is that the firms come to an agreement. Agreement might be reached through side-payments; but this would probably be illegal, at least in the United States, under antitrust laws. Another possibility is suggested by the fact that the efficient outcomes are Nash equilibria: agree in advance to use some publicly observable random event to determine who enters and who does not. In game-theoretic terms, the firms could use a correlated equilibrium that would divide the full gains equally. However, potential entrants meeting to flip a coin to decide who enters would also (though possibly with less reason) be seen as suspect by antitrust authorities; and the idea of one firm announcing, say, that it will open a supermarket in a small town "if and only if it rains next Thursday" is not a convincing model. If such an announcement would be passively accepted by other potential entrants, then the announcing firm has an incentive to make the random event a very likely one; and if the other firms play a more active role, then we should model it. Thus, we reject the answer that firms simply "will play a correlated equilibrium," and ask how they correlate. If they cannot meet to toss a coin, then their main tool for coordination is talk. This is what we analyze.

Dixit and Shapiro (1986) analyze what happens if potential entrants play the symmetric mixed-strategy Nash equilibrium of the entry game. In this solution, the potential entrants do not coordinate their choices at all. As a result, the number of entrants may be greater or less than the "equilibrium" number. Dixit and Shapiro then consider the dynamic process of continued entry or of withdrawal that ensues if the wrong number of firms entered. They focus on direct costs of being in an overcrowded market, or opportunity costs

of missing out on an underpopulated market. In this paper, we analyze a related dynamic in which firms achieve coordination (some of the time) through talking about it: partial convergence to coordination is achieved without costs.

When antitrust laws or other problems prevent potential entrants from making binding agreements about who will enter, and when the kind of preemption studied by Fudenberg and Tirole (1983) and others is impossible, firms may try to coordinate their choices through non-binding communication. Firms often declare their intentions of entering, or of not entering, markets. For example, many firms announced plans to construct fiber-optic telecommunications networks in the United States, and there followed considerable discussion of whether there were "too many" declared participants, and if so who would most likely drop out. In due course, some firms announced that they would, after all, not construct networks.

In this paper, we analyze the extent to which verbal communication can solve this "nomination problem" (Richardson (1960)). We model a symmetric mixed-strategy equilibrium of a sequential "announce your intentions" game. In the last stage, each (of two, for simplicity) potential entrant must choose "In" or "Out." By hypothesis, the market is such that either one could make positive profits (M) if alone in the market, but each would incur losses (L) if both entered.

We suppose, as is often the case, that both firms value the provision of the good. This is plausible because potential entrants are often established in a complementary industry: for instance, telephone companies consider producing a new generation of telephone switches, or computer makers consider developing new microprocessors or high-quality printers. Thus it is preferable to have the other firm choose "In" if one chooses "Out."¹

¹ In our model with no reputational or other costs of bluffing or lying, that assumption is necessary for costless communication to matter. Realistically, however, continuing to announce entry plans until the last possible moment and then backing out would also damage one's credibility; incorporating this into our model would also yield a role for communication.

In each of T "rounds" before the actual In/Out decision, each firm non-bindingly states either that it does or that it does not plan to enter. We assume that if at any stage one firm declares "In" and the other declares "Out," then those strategies will (although there is no compulsion) be followed. In other words, once they reach a (non-binding but self-enforcing) agreement, they follow it. If both declare "In" or both "Out," then (unless it was the last communication round) the firms may revise their declarations, which they do symmetrically using mixed strategies. If at the end of T rounds, the firms have not "agreed" who is to enter, then they play the symmetric mixed-strategy equilibrium as analyzed by Dixit and Shapiro.

We show that such non-binding communication (cheap talk) mitigates, but does not eliminate, the failures of coordination in symmetric equilibrium. As the number of rounds of communication (T) increases, the probability of a failure of coordination declines, but not to zero. Thus, the firms do not always manage to coordinate on an asymmetric pure-strategy Nash equilibrium.

Thus, the opportunity for informal and non-binding communication partially, but not wholly, mitigates the problems of coordinating on an outcome. The role for cheap talk is created by the fact that the firms have a common interest in coordination, and limited by the fact that their preferences over the coordinated outcomes are in conflict. This is similar in spirit to the work of Crawford and Sobel (1982). There are many possible applications of these ideas. Farrell (1982) considered such communication in some mixed-motive games. Farrell and Saloner (1985) showed how communication can either mitigate or worsen problems of excess inertia in moving from one compatibility standard to another in an industry where there are compatibility benefits. Farrell and Gibbons (1986) discuss costless communication in bargaining.

2. THE MODEL

First, we describe the last round, in which the directly payoff-relevant choices are made. Each of two firms, aiming to maximize expected profit, chooses either to enter ("In") or not to enter ("Out") a natural-monopoly market. If both enter, each loses L ; if neither enters, each gets zero (a normalization). If just one enters, it gets profits M , while the other gets a surplus B , which we take to be positive but less than M . We can summarize this information in a payoff matrix:

		In	Out
In	(-L, -L)	(M, B)	
Out	(B, M)	(0, 0)	

This entry game has three Nash equilibria. In one, firm 1 plays In and firm 2 plays Out. In the second, the roles are reversed. In the third, each plays a mixed strategy, in which the probability p of entry makes the other player indifferent between In and Out:

$$(1) \quad p(-L) + (1 - p)M = pB$$

or

$$(2) \quad p = \frac{M}{B + L + M}$$

We shall refer to this third equilibrium as "the Dixit-Shapiro equilibrium." If the players are identical, then (as Dixit and Shapiro argue) it is reasonable to think that, absent any coordination mechanism, they will play the symmetric equilibrium.

Next, we describe the game with one round of communication. Communication consists of each firm saying "In" or "Out." Then they play the entry game, and payoffs are just as described above - that is, the messages sent in communication do not themselves directly affect payoffs.

There are many equilibria of this game, but we focus on the (unique) equilibrium with the following properties:

- a) It is symmetric, in that both firms play the same (mixed) normal-form strategy in the two-stage game. (We are concerned with the problem of how initially symmetric firms achieve asymmetric coordination: it would be begging the question to have them use asymmetric strategies.)
- b) If one firm says "In" while the other says "Out," then the first firm will choose "In" in the subsequent entry game. (Because there are no payoff links between the two periods, this is an assumption. It seems a reasonable one: once an equilibrium of the original entry game becomes focal through being "agreed on," it will be followed.)
- c) If both firms say "In" or if both say "Out," then they play the Dixit-Shapiro equilibrium in the subsequent entry game.

We look for an equilibrium with properties (a) - (c), and in which each firm announces "In" with probability q_1 in the communication round. Since $q_1 = 1$ or $q_1 = 0$ cannot be an equilibrium if (a) - (c) hold, q_1 must be such that each player is indifferent between his messages:

$$(3) \quad q_1 u_1 + (1 - q_1) M = q_1 B + (1 - q_1) u_1$$

where u_1 is the expected payoff in the Dixit-Shapiro equilibrium. This yields

$$(4) \quad q_1 = \frac{M - u_1}{M - 2u_1 + B}$$

$$= \frac{M - pB}{M - 2pB + B} \quad (\text{substituting from (2)}),$$

whence

$$(5) \quad 1 - q_1 = \frac{B}{M - 2pB + B} (1 - p)$$

From (5), and since $M > B$, q_1 is closer to 1 than is p . If, as we might expect, $M \gg B$, then q_1 is very close to 1. In this sense, the outcome is "almost" that each firm claims that it will enter, and then randomizes. However, the probability of a failure of coordination (both enter or neither enter) has fallen, if only a little, from $[p^2 + (1-p)^2]$ to $[p^2 + (1-p)^2] [q_1^2 + (1-q_1)^2]$. This raises the question of what happens if we allow more rounds of communication. If each round reduced that probability by a constant factor, then many rounds of communication would essentially eliminate such failures. But that is not the case, as we now show.

Consider the $(T+1)$ -stage game in which, in each of the first T stages, the strategies available are merely to say "In" or to say "Out," while the last stage is the entry game itself. We seek a symmetric mixed-strategy equilibrium, such that if at any stage the firms make different announcements then they will in fact do what they have announced. If after $S \leq T$ stages they have not "reached an agreement," then they play the game with $(T-S)$ rounds of communication as if the first S rounds had not happened.²

Writing u_{T+1} for the expected payoff in that equilibrium, (so that u_2 for example describes the value given in (3)), we have recurrence equations:

$$(6) \quad u_{T+1} = q_T u_T + (1-q_T) M = q_T B + (1 - q_T) u_T$$

² In a complete information model such as this, it is natural to think of playing the subgame as if the first S periods had not occurred. In a related incomplete-information model, in which for example firms may differ in costs, we would find at each stage that the (lower-cost firms said "In" and the higher-cost firms said "Out." Then, each firm would (in equilibrium) have learned something about the other from their S -fold disagreement. Nevertheless, the equilibrium cutoffs in round $(S + 1)$ would be the same as if they were beginning a $(T - S)$ -round game, but one in which only those "types" that in equilibrium reach this subgame would be possible.

where q_T is the probability of saying "In" in the first round of the $(T+1)$ -stage game. Since $u_1 = pB < B$, and (6) tells us that u_{T+1} is a weighted average between u_T and B , we know by induction that $u_t \leq B$ for all t . Note that this shows that a firm that just said "Out" and whose opponent said "In" is not tempted to jump back in by unexpectedly saying "In" next round. This would give him u_{t-1} , compared to his equilibrium payoff B . This comparison (and other similar ones) show that our equilibrium is subgame-perfect.

From (6), since $u_t \leq B$, the sequence of u 's is increasing: $u_{t+1} \geq u_t$. In fact, $u_t \rightarrow B$. To see this, note that the alternative is for u_t to converge to some limit $u < B$. For any $\varepsilon > 0$, there would be $T(\varepsilon)$ such that $|u_t - u| < \varepsilon$ for all $t \geq T(\varepsilon)$. For $t > T(\varepsilon)$, (6) then implies that $q_t (B - u) < 2\varepsilon$. Thus, we have $q_t \rightarrow 0$. But then (6) implies that $u_t \rightarrow M$, which we know is impossible because $u_t \leq B < M$.

Since $u_t \rightarrow B$, (6) also tells us that q_t converges monotonically to 1. Thus, when there is a long horizon, equilibrium requires each potential entrant to "talk very tough," and relatively little contribution to coordination is made by these early negotiations. This suggests that the probability of successful coordination may be bounded away from 1 as $T \rightarrow \infty$. We now show that this is so.

Consider the limiting behavior as $T \rightarrow \infty$ of the probability of a failure of coordination,

$$(7) \quad \phi_T = [(1-q_T)^2 + q_T^2][(1-q_{T-1})^2 + q_{T-1}^2] \dots [(1-q_1)^2 + q_1^2][(1-p)^2 + p^2].$$

Whether or not $\phi_T \rightarrow 0$ is equivalent to whether the series $\sum \log [(1 - q_t)^2 + q_t^2]$ diverges (to $-\infty$). Since $q_t \rightarrow 1$ in a complicated way, direct attack on the problem is difficult. However, we can readily get an answer using a different method.

By symmetry, the probability $(1 - \phi_T)$ of successful coordination is split equally between the two eventual outcomes (In, Out) and (Out, In). With probability $\phi_T/[p^2 + (1-p)^2]$ the firms go through all T rounds of communication

without reaching agreement; then with probability p^2 both enter and with probability $(1-p)^2$ neither does. Hence,

$$(8) \quad u_T = \frac{1}{2}(1 - \phi_T)M + \frac{1}{2}(1 - \phi_T)B \\ + \phi_T \frac{p^2}{p^2 + (1-p)^2}(-L) + \phi_T \frac{(1-p)^2}{p^2 + (1-p)^2}0$$

Since u_T converges to B as $T \rightarrow \infty$, we have in the limit

$$B = \frac{1}{2}(1 - \phi)M + \frac{1}{2}(1 - \phi)B - \phi \frac{p^2}{p^2 + (1-p)^2}L$$

$$(9) \quad \phi \left(\frac{M+B}{2} + \frac{p^2 L}{p^2 + (1-p)^2} \right) = \frac{M-B}{2}$$

which, substituting in for p from (2), gives

$$(10) \quad \phi = \frac{M-B}{M+B + \frac{2M^2}{M^2 + (B+L)^2}L}$$

Suppose that $B/M = \beta < 1$ while $L/M = \lambda$. Then (2) gives

$$(11) \quad p = \frac{1}{1 + \lambda + \beta}$$

Hence, without communication, the probability of coordination failure is:

$$(12) \quad p^2 + (1-p)^2 = \frac{1 + (\lambda + \beta)^2}{(1 + \lambda + \beta)^2}$$

From (10), the corresponding probability with many rounds of communication is:

$$(13) \quad \phi = \frac{1 - \beta}{1 + \beta + \frac{2}{1 + (\beta + \lambda)^2} \lambda}$$

$$= \frac{(1 - \beta)[1 + (\beta + \lambda)^2]}{(1 + \beta)[1 + (\beta + \lambda)^2] + 2\lambda}$$

The ratio $\phi/[p^2 + (1 - p)^2]$ is therefore

$$(14) \quad R \equiv \frac{(1 - \beta)}{(1 + \beta)[1 + (\beta + \lambda)^2] + 2\lambda} [1 + \lambda + \beta]^2$$

As $\beta \rightarrow 1$ this ratio converges to zero: essentially the prospect of coordination failure disappears - because the conflict in the entry game vanishes when $\beta = 1$. As $\beta \rightarrow 0$, the ratio converges to 1: when $\beta = 0$, there is no reason ever to say "Out," and communication cannot help. It is easy to check from (14) that $R < 1$ whenever $\beta > 0$: communication helps. But $R > 0$ whenever $\beta < 1$: the conflict that is present because $B < M$ creates inefficiencies.

Thus we see that the symmetric equilibrium of the extended game in which we allow for non-binding "announcements" involves some failure of coordination, even as the time available for "reaching an agreement" expands indefinitely. The equilibrium strategy is to be "very tough" early on ($q_t = 1$), so that early periods contribute little to the chance of reaching agreement.

3. CONCLUSION

We have asked how costless verbal communication may help identical potential entrants to achieve asymmetric coordination in a game of entry into a natural monopoly. Studying the symmetric mixed strategy equilibrium of the extended game in which self-enforcing "agreements" are followed, we solved for the probability ϕ of a failure of coordination. We showed that, while ϕ is reduced by communication, it does not go to zero. While the potential entrants' joint interest in avoiding mix-ups enables them to coordinate to some extent, coordination is limited by the conflict inherent in the fact that it is better to be the single entrant than not.

The traditional approach to entry has simply assumed that this coordination problem is solved. This paper shows that that is a questionable assumption, even if potential entrants communicate. Dixit and Shapiro (1986) have taken an opposite approach and asked how much failure of coordination there will be, and how it will be repaired ex-post, when there is no ex-ante coordination. This paper shows that, at least in some cases, that is too pessimistic a view: even if there is no possibility of binding agreements or of staking out a market position in advance, simple communication can achieve partial coordination.

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