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MARKET NICHE, FLEXIBILITY AND COMMITMENT*

by
SUREN BASOV
La Trobe University and University of Melbourne
and
VLADIMIR SMIRNOV
ANDREW WAIT†
University of Sydney

We study a market-entry game in which the potential entrants wish to coordinate their actions (i.e. enter different market segments rather than compete directly). If (i) the firms have an option to wait, and (ii) each firm has a different reaction time after they have decided to wait, the unique outcome that survives the iterated elimination of weakly dominated strategies favors the less flexible firms.

1 Introduction

Market entry is one of the most fundamental decisions a firm has to make. A firm contemplating entry will have to consider many things, but in strategic situations a crucial factor will be the decisions of its rivals. Suppose, for example, two firms are both considering entering one of two markets. Each firm prefers the same market provided it enters it alone; however, they both prefer to be in a different market rather than to compete head-on with their rival. The separate markets in this scenario could represent producing different products or setting up in different geographical regions, for example. This game has two asymmetric pure-strategy Nash equilibria. An issue, as with all coordination-type games, is which of the possible equilibria will be selected. It is this issue—the selection of equilibria—that we address in this paper. To do this, we augment the basic coordination game outlined above by allowing the firms involved to wait, which could allow them to observe the other firm's action (if one was taken), and by letting the firms have different reaction times. As it turns out, the addition of these two assumptions, which are realistic in many situations, resolve the equilibrium selection issue. We find that the unique outcome that survives the iterated elimination of weakly dominated strategies favors the ability to commit. Notably, while the motivating example here is an Australian battle of the sexes, our approach can also resolve the equilibrium selection issue in a standard coordination game; all that is important is that the Nash equilibria are preferred differently by the players.

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It is interesting to compare our approach with other methods of addressing the problem of equilibrium selection in coordination games. One standard approach in the literature is to use evolutionary dynamics to arrive at a unique prediction in a game. This equilibrium refinement technique seems fruitful when applied to games of pure coordination; see, for example, Foster and Young (1990), Kandori *et al.* (1993) and Young (1993). It has been shown that an evolutionary process usually favors the risk-dominant equilibrium in these games. Note that this technique requires the two pure-strategy equilibria to have qualitatively different properties (e.g. generically only one of them is risk-dominant). This approach, however, fails when the set of equilibria is itself symmetric. In some games, for example, the battle of the sexes or the Australian battle of the sexes, Nash equilibria differ only in the names assigned to the players, i.e. the equilibria are not qualitatively different. Therefore, no anonymous evolutionary dynamics can be used to select one equilibrium; this is the kind of situation we address in this paper.

Another approach used to resolve the equilibrium selection issue is to allow pre-game communication. For instance, Farrell (1987) considered how cheap talk can facilitate coordination among entrants in a game similar to the one analyzed in this paper. However, there are some situations in which non-binding communication is not possible, or when it will be ineffective. Farrell's model requires that if a firm decides not to enter a market it would prefer the other firm enter that market. Clearly, this assumption will not always hold. We investigate the situation in which cheap talk is not possible. Finally, Shaffer (2004) showed that licensing requirements can help coordinate entry by otherwise symmetric potential entrants.

At this point let us motivate the augmentations we introduce to the standard coordination model. First, in many situations a player can delay making an investment decision; rather it can wait and observe what its competitor does. Firms could adopt this wait-and-see tactic in an attempt to avoid a joint-location decision or to avoid coordination failures regarding the adoption of new technology standards. Therefore, we enrich the strategy space by allowing for an additional option to wait. Second, rarely is there symmetry between the players in real life; in a stylized model many of these details about the different players are assumed away. To capture one of these potential differences between competitors, we assume that each firm has a different ability to commit to wait for some minimal time. In terms of the model, we assume that one firm, once it has decided to do so, must wait for two periods before reconsidering its entry decision. The other firm, however, can rethink its decision to wait more quickly—it can reconsider its action after just one period.[1] For example, a steel producer may use a Martin oven

[1]Gilbert and Harris (1984) make a similar assumption in their preemptive investment model, in which firms have different reaction times between receiving information and being able to take an action.

for its production process.[2] If the firm decides to switch it off and allows their opponent to observe the process, it will commit to a minimum waiting time, which is necessary to make it operational again. This could also arise if there is a technician or someone with a special skill required to start the process, and he/she is only available periodically (perhaps he/she is a contractor who is on call who cannot necessarily be brought back at a moment's notice). Alternatively, the decision-making processes of two firms could be different. For example, assume the decision to enter a new market must be made by the board of directors of both potential entrants. It could be the case that the boards meet biannually at one firm and annually at another. In this case, if the second firm opted to wait at its board meeting it is committed to wait and not enter the new market for a whole year. The same cannot be said for the firm with biannual board meetings. In combination, the option to wait and the different abilities to commit to the length of time involved in any waiting decision resolve the coordination problem. As we show below, the game is a further example of how the ability to commit can increase the payoff of a firm and that additional flexibility is not always advantageous.

The paper is organized in the following way. Section 2 builds a formal model of the entry game and argues that the unique outcome that survives the elimination of the weakly dominated strategies is the one that favors the firm with the commitment option. Several extensions are examined in Section 3, including a consideration of the case of more than two firms. Section 4 takes a closer look at the equilibrium selection issues in the extended game and concludes.

2 The Model

Consider a game $\Gamma = (S_1, S_2, u_1, u_2)$, where S_i is the strategy set of firm i, and $u_i : S \to R$ is its Bernoulli utility function, defined on the set of strategy profiles $S = S_1 \times S_2$, where $i = 1, 2$. Assume that the game has two strict pure-strategy Nash equilibria, (s_1^1, s_2^1) and (s_1^2, s_2^2), where $s_1^1, s_1^2 \in S_1$ and $s_2^1, s_2^2 \in S_2$.[3] Assume also that the firms prefer different equilibria. In addition, assume that each firm gains a higher payoff in its preferred Nash equilibrium than with any other strategy profile:

$$u_i(s_1^i, s_2^i) > u_i(s_1, s_2) \tag{1}$$

for any $(s_1, s_2) \neq (s_1^i, s_2^i)$, where $i = 1, 2$.

[2]A Martin oven, named after Pierre Martin, is used in the process to transform raw iron into steel by reducing the carbon content in the iron.

[3]Note that this is a simplifying assumption; the existence of additional Nash equilibria would not have any effect on the analysis.

As an example (also discussed below), this game could be an entry game with two firms and two potential markets. It could be that each firm has a preference about which market it enters; however, each firm prefers to be in a particular market (niche) alone.

Now, augment the game to allow each firm the option to wait, denoted as W. Moreover, assume that Firm 1, if it opts to wait, has to wait for at least two periods, while Firm 2 only has to wait for one period. That is, Firm 2 can revise its decision more quickly than its rival.[4] The differences in reaction time of the firms could arise from the use of alternative technologies or decision-making processes, as discussed in the Introduction. Notably, what is important is how quickly a firm can reverse its commitment to wait relative to its rival, rather than the absolute period of time involved.[5]

If both firms take an action simultaneously at time zero—i.e. they use one of the strategies S_i and do not opt for W—the realized payoffs are the same as in the original game described above. If one of the firms enters at time zero while the other firm waits, the waiting firm can choose its best response to its rival's action. If both firms decide to wait at time zero, Firm 2—as it can react relatively quickly—will choose the action s_2^2 to ensure the outcome is its preferred Nash equilibrium. For example, in a market-entry game, Firm 2, after observing that Firm 1 has waited, will quickly enter the market and occupy the most profitable niche. In the next period, after it has waited for the required time and having observed Firm 2's choice, Firm 1 will choose s_1^2 (enter the other market in the entry game).

As at least one of the firms decides to wait, the remaining subgame can be uniquely solved using backward induction in the way described above. That is, we can collapse the two stages of the game into a simultaneous move game: $\Gamma' = (S_1', S_2', u_1', u_2')$, where $S_i' = S_i \cup \{W\}$, W stands for waiting and $u_i': S' \to R$ is defined on the set of strategy profiles $S' = S_1' \times S_2'$.

It is clear that it is a weakly dominant strategy for Firm 2 to choose W in the initial period. Indeed, consider any strategy $s_1^* \in S_1'$ of Firm 1. By definition of the payoffs in the reduced game Γ'

$$u_2\left(s_1^*, W\right) \geq u_2\left(s_1^*, s_2\right) \tag{2}$$

for any $s_2 \in S_2'$. Assuming that Firm 2 plays W, Firm 1 will play s_1^1 and the equilibrium will be (s_1^1, W). By definition of the payoffs in Γ' we have

[4]An alternative representation could be to set up the model as a dynamic game. The equilibrium we describe below will be the unique sequential equilibrium of that game. There is little advantage using the dynamic game in terms of exposition, however, as the appropriate game tree will be infinite because the option to wait is available at each period.

[5]Furthermore, the absolute periods of waiting need not be long; consequently, we assume that waiting is not costly. In addition, although there is a potentially infinite horizon in this model, the first-mover advantage inherent in the game ensures that waiting indefinitely is not an equilibrium outcome.

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

FIG. 1 The Normal Form of a Standard Entry Game

$$u_i(s_1^1, W) = u_i(s_1^1, s_2^1) \tag{3}$$

for $i = 1, 2$.

If we restrict our attention to the trembling-hand perfect equilibria, we can rule out the other pure-strategy equilibria as a weakly dominated strategy cannot be part of any trembling-hand equilibria. Consequently, we can derive the following proposition.

Proposition 1: In the unique trembling-hand perfect equilibrium the more flexible firm plays wait (which is, in fact, a weakly dominant strategy); the less flexible firm will take an action ensuring the payoff of its preferred Nash equilibrium.

This result gives rise to the following corollary.

Corollary 1: The flexible firm is disadvantaged by its ability to react relatively quickly.

2.1 Example: Market Entry

As an illustration of the model, consider an entry game with two firms (1 and 2) and two potential markets, labeled as X and Y. Without an option to wait the entry game is a 2×2 game, in which each firm selects a particular market (niche). The payoffs are given in Fig. 1. This game has the structure of the Australian battle of the sexes.[6]

The game presented in Fig. 1 has three Nash equilibria: two pure-strategy equilibria—(X, Y) and (Y, X)—and a symmetric mixed strategy equilibrium in which X is played with probability 1/3.

Now augment the game to allow each firm the option to wait, denoted by W, but assume that Firm 1 can commit to wait for two periods, while Firm 2 can enter one period after waiting.

[6]Such a payoff structure will arise, for example, in a Hotelling model of spatial competition if one assumes that the consumers are located along the segment, with a density that is increasing from the left to the right end, and the firms can locate only at either end of the segment. In this case strategy X is entering at the left end of the segment, while strategy Y is the strategy entering at the right-hand end, where one assumes that the entry decision is followed by a Bertrand-style price competition.

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

FIG. 2 The Relevant Normal of the Augmented Game

Following the arguments above, the payoffs can be represented as in Fig. 2. This game has four pure-strategy Nash equilibria (X, Y), (Y, X), (W, Y) and (Y, W). Note, however, that strategies X and Y are weakly dominated for Firm 2. Therefore, equilibria (X, Y), (Y, X) and (W, Y) can be ruled out using Selten's (1975) trembling-hand perfection refinement. Therefore, if we restrict our attention to the trembling-hand perfect equilibria the unique outcome is (2, 1) when Firm 1 enters immediately with Y while Firm 2 chooses to wait.

Note that the party that has an apparent advantage of being able to react more quickly is worse off. It is, instead, the firm that can commit to wait that actually does better when the option to wait is added to the simple Australian battle of the sexes coordination game. The firm with the additional flexibility cannot commit not to wait and choose their best response to the other firm's action. This parallels some results in the literature on commitment. In an entry game like Bolton and Farrell (1990), if a firm can commit to enter a market that is a natural monopoly, in equilibrium that firm enters and has an advantage over the other firm (that ends up being the non-entrant). In the standard quantity-setting Stackelberg game, the firm that can commit—by producing first or by establishing a plant of a certain size—has an advantage over the other firm. In these games, it is the other firm (the second entrant) that cannot commit not to use the knowledge it has about the first mover's choice; it is left in the position of having no option but to choose its best response to the other firm's quantity. Here, the firm with greater flexibility cannot credibly commit to wait for a whole period (unlike Firm 1). Rather, once Firm 1 has made its choice (be it X, Y or W) Firm 2 cannot credibly commit not to adopt its best response. Knowing this, Firm 1 can take its action in the knowledge that Firm 2 will choose its best response. In the game here, it is a commitment not to produce—i.e. to have some effective device to wait for a set period of time—that gives a firm an advantage. This allows Firm 1 to effectively select the equilibrium played in the coordination game.

Finally, note that while the example considered here has the structure of an Australian battle of the sexes (with asymmetric pure-strategy Nash equilibria), the same results apply to a standard coordination game. For instance, suppose two firms are to choose between the adoption of one of two technology standards. It could be that while each firm prefers to coordinate on the standard, each has their own preference about which technology is to be adopted. In this case the issue of selection of equilibria can again be resolved provided the firms differ in their ability to commit to wait.

3 Extensions to the Model

In this section we consider several possible extensions to the model. First we investigate the robustness of the results if there are more than two potential entrants. For simplicity let us concentrate on the case of $N = 3$; the argument can be generalized for more than three firms. In a way that parallels the $N = 2$ case, assume there are three Nash equilibria and each firm has their preferred Nash equilibrium. For example, in a market-entry game each of the three firms has to choose which one of the three markets they are going to enter. The firms wish that they each enter a separate market, but have differing preferences about which one they get to enter. Further, as in Section 2, assume that the payoff to a firm in its preferred Nash equilibrium is higher than the payoff from any other outcome.

In addition to the standard game described in the paragraph above, allow each firm to have an ability to wait (W). Again, the firms differ in their ability to commit to wait. Assume that after deciding to wait a firm cannot revise its decision before time t_i, where $t_1 > t_2 > t_3 > 0$.

If all three firms take an action (do not wait) the payoffs are given by the standard game described above. If one firm waits and the two other firms do not, the firm that waits will choose its best response at time t_i. If two or more firms wait, each firm revises its decision and takes an action when it can; given the different waiting times this occurs sequentially.

This game can be solved using the same logic as in Section 2. The most flexible firm (here Firm 3) has a weakly dominant strategy to wait. Further, the other two firms with the longer waiting times take their respective actions immediately. Thus, in any sequential equilibrium, Firm 1 and Firm 2 select an action (i.e. enter a niche immediately) while the more flexible Firm 3 opts to wait; as in Section 2 no weakly dominated strategy can be part of a sequential equilibrium. Again, the more flexible firm is disadvantaged, finding itself unable to commit to take its most profitable action immediately. Furthermore, unlike the two-player game in Section 2, there are still multiple equilibria in the game, as there is still a coordination problem between the firms that take an action immediately. However, the equilibrium selection issue has been somewhat alleviated as the number of potential pure-strategy equilibria has been reduced by allowing the firms different abilities to commit to wait. A similar point can be made when there are n potential entrants. The most flexible firm will have a weakly dominant strategy to wait and the other $(n - 1)$ firms will enter immediately. Again, the most flexible firm is disadvantaged. There are still multiple equilibria, as there remains a coordination problem with the $n - 1$ firms that entered immediately. This suggests that differing abilities to commit to wait are unlikely to completely resolve the issue of multiple equilibria when there are many potential entrants. The above analysis suggests, however, that it could be part of the solution.

Another direction could be to allow the different abilities to commit to wait not to be common knowledge or have asymmetric information among the players as regards their rivals' abilities to wait.[7] Suppose a firm receives only a noisy signal about the rivals' minimal waiting time. The global games methodology developed by Carlsson and van Damme (1993) leads us to conjecture that in this case in equilibrium each firm will be characterized by an entry time which is a monotonically decreasing function of its minimal waiting time. We leave this line of inquiry for future research.

Finally, even if there are differences in the ability to commit to wait for the entering firms, they all enter immediately; what is crucial is not the difference in their ability to commit between each other but their ability to commit relative to the most flexible firm.

In the basic model in Section 2, and in the three-player game described immediately above, we assumed that the number of firms and markets are the same (i.e. two firms and two markets). The framework developed here does not depend on this assumption, however. Take the entry model of Bolton and Farrell (1990), for example. In the model there are two potential entrants and one market, which is a natural monopoly. If both firms enter, they both earn negative profits. If one firm enters and the other waits, the entrant becomes a monopolist earning positive profits and the non-entrant gets their default (0). Incorporating our augmentation to their model, we can assume that Firm 1 can commit to wait for two periods, whereas Firm 2 can reverse its decision to wait after one period. As above, Firm 2 has a weakly dominant strategy to wait and Firm 1 will find it optimal to enter immediately.

4 Discussion and Concluding Comments

Although many models that describe strategic interaction are symmetric, perfect symmetry rarely holds in real life. In this paper we argued that sometimes to understand the issues of equilibrium selection it is important to look at issues left outside of the standard model. In this model the symmetry was broken by postulating some minimal difference in the waiting time required for one of the firms to enter the market once they had decided to wait. In our augmented game the payoff matrix is no longer symmetric, as (W, W) gives different payoffs for the players. Although we circumvented the issues of equilibrium selection in the original 2×2 game by devising an extended 3×3 game, they still resurfaced later, since the extended game had multiple Nash equilibria. To overcome the problem, we used Selten's (1975) notion of trembling-hand perfect equilibria. Furthermore, it is important to

[7]We thank an anonymous referee for this suggestion.

stress that this difference in waiting time between the firms can be arbitrarily small; an arbitrarily small deviation from the symmetry allows us to choose the equilibrium.

It is worth comparing the results with the equilibrium selection that arise using evolutionary dynamics. In particular, in the model presented here it is seemingly the weaker party—in terms of the party that is the least flexible—that moves first. This is opposite to the result of van Damme and Hurkens (2004). In their model, the firm that sets their price first in the risk-dominated equilibrium is the strong (low-cost) firm.

Our model has the feature that the party that has the apparent advantage of being more flexible is actually worse off, as it is unable to commit not to use its additional flexibility. A similar result arises in the model of Solan and Yariv (2004). They examined a game in which one party has the option to engage in espionage by purchasing a noisy signal of the other player's action. Anticipating the espionage, the non-spying player uses the opportunity to commit to a particular action—in effect the second player becomes the Stackelberg leader. It can be the case that the first player would like to commit not to spy. However, given this is not possible, the player with the opportunity to spy becomes the Stackelberg follower, and is ultimately disadvantaged by its ability to engage in espionage.

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