An Overview on Experimental Market Entries

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Contents

1 Introduction

Not only for psychologists but for economists as well market entry games are of high importance for a better understanding of how market participants behave when deciding if or if not to enter a market. Potential other market entrants are often common knowledge or can be estimated as well as the capacity of the market that is also limited in the way that excess entry of the market lead to losses instead of gains. Since coordination between firms is prohibited each potential entrant has to decide privately. Therefore it is an incentive to understand the individual and group behavior in such situations. Behavior on entering markets has been much investigated as it is showed in the article. Further on the general game structure is described, Nash equilibriums in such games are evaluated as well as several experiments are compared.

2 The classical game

In 1988 Kahnemann conducted a group experiment that should investigate individual and group behavior regarding entry of a single market. It is outlined for instance in Rapoport (1995). The game is played by n symmetric agents and is iterated R rounds. On each round each agent i has to take an action from her action set $s_i = \{0, 1\}$ whereby 0 means not to enter and 1 means entering the market. This action has to be decided privately, with cooperation before, during, and after prohibited but without any time constraints. The decision might be based on the market capacity c[1] which is common knowledge. On each round c is chosen randomly whereby $1 < c < n$. The classical game was conducted with zero entry costs.

The individual payoff is described and computed afterwards with the general payoff function:

$$p_j = \begin{cases} k, & \text{if } j \in \bar{E} \\ (k + rk(c - e)), & \text{if } j \in E \end{cases} \tag{1}$$

$\bar{E}$ denotes the agents not entering whereas E are the agents that enter the market. e is the accumulated $s_i, i = 1..n$ which is equal to $|E|$. In case of not entering an agent would always get a payoff of k[2]. The payoff for each agent entering the market depends on the total number of entrants i.e. the higher the number of entrants the lower the individual payoff. In case of excess entry and $r > 1$ the individual payoff is negative what means entrants will lose money. Kahnemann experimented with parameters: $n = 15, R = 20, 3 < c < 12, k = \$0.25, r = 2$. The experiment showed that as c varied the total number of entrants e has been always in the interval $c - 2 < e < c + 2$.

[1] $c \in \mathbb{N}$

[2] r and k are arbitrary constants; $r, k \in \mathbb{R}; r \geq 1$.

3 Theoretical solutions of the game

For this kind of non cooperative n-person coordination games the major solution concept is Nash equilibrium in which each agent knows that equilibrium and won't get an incentive in case of deviating from her strategy unilaterally (cf. Rapoport (1995); Sundali et al. (1995); Zwick & Rapoport (2002)). For instance there is an equilibrium if the payoff for entering is equal to staying out of the market.

In a pure strategy an agent chooses an action for sure from her action set s_i whereas in mixed strategy the action is chosen randomly over the action set s_i with a probability p.

Imaging a game with a payoff function as follows:

$$u_i(s) = \begin{cases} 0 & \text{if}\, s_i = 0 \\ 5 \cdot [(n-1) - N(s)] & \text{if}\, s_i = 1 \end{cases} \tag{2}$$

This payoff function is very similar to the original one where k is equal to 0, p_j is named as u_j, the capacity c is expressed by $(n-1)$ and $N(s)$ states the current number of entrants.

3.1 Pure strategy

The present payoff function has $\binom{n}{c}$ and additionally $\binom{n}{c-1}$ pure equilibriums. The equilibriums are given for $N(s)* = c$ and $N(s)* = c-1$. Actually that is supported by every strategy vector $s = (s_1, \ldots, n)_1$that applies to

$$\sum_{i=1}^{n} s_i = N(s)*$$

Respectively for $n = 2$ there are three Nash equilibriums. We can determine $\binom{n}{n-1} = \binom{2}{1} = 2$ pure strategy Nash equilibriums whereas only one of two agents enter the market and additionaly $\binom{n}{(n-1)-1} = \binom{2}{0} = 1$ equilibriums whereas none of both agents enter the market. In the first case both agents would get a payoff of zero since the non-entrant is paid zero as stated by the payoff function and the respective entrant will get zero as well[3]. Each player won't get an incentive if she deviates from this strategy i.e. an entrant would get a payoff of zero as well if she would decide not to enter. If the non-entrant would decide to enter there was an excess entry ($N(s) = 2$) that leads to an individual payoff of -5 for both. The case in which none of both enter is also seen as an equilibrium since none of both would get an incentive as it would lead to the equilibrium already mentioned.

Hence for $n = 3$ six pure strategy Nash equilibriums have to be considered.

[3]Payoff for entrant if $n = 2$ and $N(s) = 1$: $5 \cdot [(2-1) - 1] = 0$

$\binom{n}{n-1} = \binom{3}{2} = 3$ whereas two of three agents enter and $\binom{n}{(n-1)-1} = \binom{3}{1} = 3$ whereas one of three agents enter.

Compared to $n = 2$ increasing the total number of agents by one means increasing the number of equilibriums two times.

3.2 Mixed strategy

As stated by Sundali et al. (1995) in a (symmetric) mixed equilibrium each player enters the marked with a probability $p = p(c)$. The general assumption is risk neutrality.

The optimal probability for the present payoff function can be computed by solving the following equation. The payoff for not entering is equal to zero. To be indifferent to enter or not to enter the expected payoff for entering would be equal to the left hand side of the equation.

$$\sum_{s=0}^{n-1} \binom{n-1}{s} p^s (1-p)^{n-s-1} (5 \cdot [(n-1) - N(s)]) \quad = \quad 0 \tag{3}$$

Consequently for $n = 2$ the optimal probability for entering the market is equal to zero.[4]

Thus for $n = 2$ nobody would enter since the expected number of entrants is $n \cdot p* = 2 \cdot 0 = 0$. Hence on average the second mentioned pure strategy equilibrium applies.

For $n = 3$ the optimal probability for entering the market is equal to 0.5. The expected number of entrants is $n \cdot p* = 3 \cdot \frac{1}{2} = 1.5$. This is exactly the mean of both pure strategy equilibriums mentioned for $n = 3$.

According to Sundali et al. (1995) the probability for payoff functions following the general structure (as formula 1) is equal to $p* = \frac{c-1}{n-1}$. Hence the probability for the present payoff function is given by $p* = \frac{(n-1)-1}{n-1} = 1 - \frac{1}{n-1}$. The average count of entrants is $\mu(n) = n \cdot \frac{n-2}{n-1} = \frac{n^2-2n}{n-1}$. This fits to the made calculations.

4 Experimental investigations of market entry

There are several experiments concerning market entry e.g. (1) Rapoport (1995), (2) Sundali et al. (1995) and (3) Zwick & Rapoport (2002).

Experiments in listed papers are based on rules of the classical game with some parameters manipulated according to the research questions.

In contrast to the other experiments only in (1) subjects could lose their own money. In (2) and

[4]See calculation in the appendix.

Table 1: Particular parameters of investigated experiments

reference	experiment #	total n	n per game	R	endowment
Rapoport (1995)	1	16	16	20	-
	2	14	14	20	-
	3	14	14	20	-
Sundali et al. (1995)	1	20	20	60	34 francs ($5.10)
	2	60	20	100	34 francs ($5.10)
Zwick & Rapoport (2002)	1	144	6	96	HK$60 (appr. $7.70)

(3) subjects were paid an endowment.

In (1) and (2) they used the same payoff function based on the original one (see formula 1) with parameters k=1$ and r=2$.

In a sharp contrast (3) investigated a payoff structure (cf. formula 4) that is not a linear one.

$$H(d_j,m)\begin{cases} v & \text{if}\, d_j = 0 \\ e/m - k_i & \text{if}\, d_j = 1\,\text{and}\, m \leq h \\ -k_i & \text{if}\, d_j = 1\,\text{and}\, m > h \end{cases} \tag{4}$$

Regarding this payoff function h represents the market capacity, m denotes the number of current entrants.

In all experiments the individual final payoff could be taken home by the participants.

All studies demonstrated some same effects. Exactly as Kahnemann already stated - the higher the market capacity the higher the number of entrants what means that in all cases e varied with c (or h as it is denoted for the market capacity in (3)).

In what follows individual differences, research questions and experimental procedures are outlined.

4.1 Study 1: Individual Strategies in a market entry game

Based on the classical game conducted by Kahnemann the findings of this study (cf. Rapoport (1995)) should be verified and understand. The game should investigate the influence of losing real money as well and study the consistency of individual strategies. Further on the study determine if there is a learning effect due to delayed feedback. Thus after each session feedback has been given but no within session feedback. 16 PhD students with formal training in game theory participated in the first of three experiments. Due to illness this number decreased to 14 for the second and third one. In each experiment all subjects had 20 trials in which a c value from a set of $3,\ldots,12$ was announced. Thus there were a possible maximum loss of -25[5] and a maximum gain of $+23$[6].

In the first experiment with no exception $c > e$[7]. That observation changed in the following two experiments respectively the difference became smaller[8] and there were on average more excess entry. Despite a decreasing difference the aggregate data do not support the existence of a Nash equilibrium. Most individual strategies followed the pattern "enter if and only if $x1 \leq c \leq x2$" whereas $x1$ and $x2$ were some self-chosen values. Using of pure strategies became more consistent with more experience. Many subjects changed their pure strategies between sessions but the tendency of market entry increases with more experience.

4.2 Study 2: Coordination in market entry games with symmetric players

Sundali et al. (1995) conducted two experiments in which in the first participated 20 subjects of undergraduates, graduates and a few university employees.

In each of six blocks all subjects had 10 trials[9] in which a c value from a set of $1,...,19$ - but only odd numbers - was announced. Each c occurred six times but in different blocks and in a random order. Thus there were a possible maximum loss of -37[10] and a maximum gain of $+37$[11].

Subjects were paid an endowment of 34 francs ($5.10) and subsequent gains and losses were added. In this experiment no feedback was given concerning their performance at no time. The first experiment should investigate if there are behavioral regularities e.g. from the economical perspective - how strategy evolves on the aggregate level - with other words do tacit coordination evolve. From the psychological perspective it should determine if individual decision policies could be investigated and how they evolve. As a result there is a sharp contrast between individual and group behavior. Several individual decision rules could be determined whereas no indication that subjects settled on pure strategies were given. Subjects differed considerably from their decision rules between blocks but nevertheless tacit coordination emerges quickly on the aggregate level. This group behavior was not observed before in absence of feedback.

Experiment 2 should investigate under the same conditions but some modifications if the results of experiment 1 will be affected if subjects receive trial to trial feedback and if they will converge to deterministic decision rules. Therefore after each trial subjects were told the number of entrants m, the subject's payoff tor the trial and the subject's cumulative payoff. Now the

[5] $c = 3$; $m = 16$ assumed: payoff per entrant: 1$+2$(3-16)=-25$.
[6] $c = 12$; $m = 1$ assumed: payoff for the one and only entrant: 1$+2$(12-1)=23$.
[7] On average c - e = 3.55.
[8] experiment 2: $c - e = 1.2$; experiment 3: $c - e = -0.05$.
[9] What meant 60 trials all together.
[10] $c = 1$; $m = 20$ assumed: payoff per entrant: 1$+2$(1-20)=-37$.
[11] $c = 19$; $m = 1$ assumed: payoff for the one and only entrant: 1$+2$(19-1)=37$.

number of trials has been increased to 100 and subjects could make notes. The number of subjects has been increased in the second one to 60 subjects of undergraduates, a few graduates and university employees. This time these subjects were assigned to 3 groups a 20. The experiment showed that feedback does not affect subjects to settle on pure strategies but if feedback is given group behavior stabilizes more quickly. Again there were several individual strategies that did not diminish due to feedback.

4.3 Study 3: Tacit Coordination in a decentralized market entry game with fixed capacity

As already mentioned a non-linear payoff function (see payoff function 4) has been investigated in Zwick & Rapoport (2002). e denotes the market potential and was set to HK$500. This market potential is allocated to each entrant until there is no excess entry. In case of excess entry there is a fixed negative payoff for all entrants ($-k$).

In contrast to prior studies staying out won't gain anything ($v = 0$). Further on entrants have to pay an entry fee and costs for entrants in case of excess entry are several times higher compared the other payoff functions.

This study investigates coordination behavior as well as which variables lead to coordination success or failure. Therefore h and k have been manipulated and set to (1, 3) and (5, 50).

144 undergraduate students participated in groups of six. According to different matching protocols subjects were assigned to fixed or random groups and told according to what protocol they have been assigned.

Subjects lost on average 13 percent of their endowment. Four clusters of individual subjects can be determined. Subject type 1 plays always the same action, type 2 plays randomly whereby the probability follows the mixed strategy equilibrium, type 3 plays randomly as well but does not fit the particular probability and type 4 is violating any model that assumes randomization. The subjects decision was significantly influenced by success or failure of last iteration of game. Manipulating parameter such as the market capacity, entry fee and method of subject assignment to groups (fixed vs. random) have significant effects e.g. the higher the entry fee the lower the entry rate and in case of fixed assignment the entry rate decreases significantly compared to random assignment. In contrast to the other studies no evidence for convergence to equilibrium on the aggregate level as well as on individual level could be observed.

Appendix

Calculation of p for $n = 2$:

$$\begin{aligned}
\sum_{s=0}^{2-1} \binom{2-1}{s} p^s (1-p)^{2-s-1} (5 \cdot [(2-1) - N(s)]) &= 0 \\
\binom{2-1}{0} p^0 (1-p)^{2-0-1} (5 \cdot [(2-1)-1]) + \binom{2-1}{1} p^1 (1-p)^{2-1-1} (5 \cdot [(2-1)-2]) &= 0 \\
1 \cdot 1 \cdot (1-p) \cdot 0 + 1 \cdot p \cdot 1 \cdot -5 &= 0 \\
-5p &= 0 \\
p &= 0
\end{aligned}$$

Calculation of p for $n = 3$:

$$\begin{aligned}
\sum_{s=0}^{3-1} \binom{3-1}{s} p^s (1-p)^{3-s-1} (5 \cdot [(3-1) - N(s)]) &= 0 \\
\binom{3-1}{0} p^0 (1-p)^{3-0-1} (5 \cdot [(3-1)-1]) + \binom{3-1}{1} p^1 (1-p)^{3-1-1} (5 \cdot [(3-1)-2]) & \\
+ \binom{3-1}{2} p^2 (1-p)^{3-2-1} (5 \cdot [(3-1)-3]) &= 0 \\
1 \cdot 1 \cdot (1-p)^2 \cdot 5 + 2 \cdot p \cdot (1-p) \cdot 0 + 1 \cdot p^2 \cdot 1 \cdot -5 &= 0 \\
5 \cdot (1-p)^2 - 5p^2 &= 0 \\
5 - 10p + 5p^2 - 5p^2 &= 0 \\
p &= \frac{1}{2}
\end{aligned}$$

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