Imminent Entry and the Transition to Multimarket Rivalry: Messy Markets in a Laboratory Setting*

by

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April 2012

*This is a preliminary draft. Please do not use without permission from the authors. Support from the Paul Lowham Research Fund and the University of Wyoming School of Energy Resources is gratefully acknowledged. Any opinions, findings, conclusions, or recommendations expressed in this paper are those of the authors and do not necessarily reflect the views of the funding source.

Abstract

When there is a known probability of imminent entry, the pre-entry behavior of incumbent firms is modeled. Experimental markets are used to collect data on pre- and post-entry production when there is an announced time of possible entry; some markets experience entry and other do not. In all pre-entry markets competition is more intense. Post-entry behavior in all markets is more competitive compared to a baseline that had no threat. There is evidence that post-entry multimarket contact raises outputs in one market and lowers them in the other, behavior we refer to as a conduit effect.
Keywords: Entry, Rivalry, Market Experiments

JEL Classifications: L1, L4, C9

I. Introduction

When firms enter new markets they create or extend product operations. Entry (and its threat) upsets the strategies of incumbent firms. There is new or potential rivalry. A new entrant also establishes links to other markets, if they operate in more than one market. The entrant is a conduit through which events in one market can impact behavior in other markets. Learning in one market can be transferred through the conduit firm to other markets. A web of multimarket producers creates messy market connections (Phillips and Mason (March 2001)).

Imminent entry is part of the transition to a different market structure. There is a period of time during which the already-producing firms have a reasonable belief that another firm will enter the market. This may be known because capital is being put in place, or there has been an announcement that a new firm is planning to begin operations. As communities develop, some firms have widely known business plans to extend operations as populations and/or household incomes reach a target level. During this transition are incumbent firms more or less cooperative compared to the identical market structure without the threat of entry? How does behavior compare in the post-entry period to a market structure that has a long history with no memory of entry? In this paper we study transitions before and after the point of entry.

This paper models behavior as if firms use trigger strategies to punish each other for non-cooperative actions. The repeated game has a known transition point at which the number of firms randomly increases by one. There may be no entry, but until the transition point there is a threat of entry. When entry occurs, it is from a firm extending its operations into another market. The analytics has enough structure to tell us that it is difficult to predict behavior before and after the possible time of entry. In order to learn more about behavior we construct experimental duopoly and triopoly markets, where as a baseline, quantity choosers go for an indefinite period of time without any threat of entry. We compare this behavior to duopoly markets that have a threat of entry. When entry does occur it comes from one of the duopoly firms extending its operations into a second market. We study behavior before and after the known transition point. A description of the experimental design will give a clearer picture of the market structures before and after the announced transition date of entry.

II. Experimental Market Designs

Subjects make choices from a payoff table for an indefinite number of periods. The row choice made by one subject is the column value of a counterpart. The intersection of the row and column in the payoff table shows earnings for the period. The payoff table represents the normal form of a stage game (Friedman, 1983). The use of payoff tables in experiments has a history that predates their description of oligopoly markets. Rapoport, Guyer and Gordon (1976) and Colman (1982), for instance, provide extensive surveys of literally hundreds of experiments that use payoff tables to generally learn more about rivalry and bargaining behavior. Surveys of how researchers have used payoff tables to study non-cooperative behavior are provided by Davis and Holt (1993, Chapter 2), Friedman and Sunder (1994, Chapter 9), Kagel and Roth (1995), and Plott (1989).

A schematic (Figure 1) of the experimental market structures before and after the period of potential entry is a helpful introduction to a description of the experimental design. Before entry there are six duopoly markets with 12 subjects choosing quantity from a payoff table. Figure 1 at the top illustrates the pre-entry configuration. There are 25 choice periods in the pre-entry market structure. In period 26, subjects 9 and 11 enter another market as shown in the bottom half of Figure 1 in the post-entry configuration. This creates two triopoly markets (markets 1 and 3). It leaves two “siloed” duopoly markets that had a threat of entry, but no entry (markets 2 and 4). We refer to these markets as siloed because the firms do not participate in any other markets. Finally, the transition date creates two "connected" duopoly markets that had a threat of entry, but no entry, however one of the firms operates in two markets (markets 5 and 6). After the transition period (period 25) subjects make choices for at least 25 periods. After period 50 there is a 20% probability of stopping.

As baseline treatments, 12 duopoly markets in two experimental sessions operated for 50 periods and a random end point; there was no possibility of entry, nor was there a threat of entry. Eight triopoly markets were conducted the same way during two sessions of 12 subjects each. These baselines allow us to test for differences in behavior before and after period 25 of the experiment. Altogether there are three experimental designs: the entry design described in Figure 1 (four sessions with 12 subjects each) and then baseline duopoly and triopoly markets.

Subjects for each of the three experimental market structures were recruited from upper level undergraduate economic classes. They reported to a reserved classroom with a personal computer at each seat. At the beginning of a session, instructions were read aloud as subjects followed along on their own copy. Questions were taken and one practice period was held with sample payoff tables different from those used in the experiment. The samples showed a table when two people made a row choice, and a table for which three people made a row choice. In the practice period, a monitor randomly chose a column value while subjects, at the same time, chose a row value from a sample payoff table. Payoffs from the intersection of a row and the monitor's column were recorded on a record sheet by every subject. Each person was checked during the practice period to insure that everyone understood payoff tables and correctly recorded their choices and earnings. Earnings were measured in a fictitious currency called tokens. At the end of the experiment, tokens were exchanged for cash at the rate of $1.00=1000 tokens.

In each market period subjects were instructed to type their row choices into their personal computer. Subjects were anonymously paired for the duration of the experiment, and paired individuals were not in proximity to each other. Once everyone had made their choices, the linked computer screens reported back to subjects their choices, earnings, and balance. Subjects kept track of this information and they always could check the computer's calculations from the payoff tables provided to them. Subjects were informed of the rival's choice and earnings. Finally, all participants knew that the first part of the entry design would last 25 periods. The second part would have at least 25 periods. They were informed that there was an 80% chance of continuing after period 50. After period 50, the computer would randomly generate a number between 0 and 100, and the experiment would end in the period the random number did not exceed 20. Sessions generally ended between periods 50 and 55, and took about 2 hours. Earnings averaged about $25 per subject. The instructions read to subjects when there was a forthcoming threat of entry are provided at the end of this paper.

All of the markets described in Figure 1 are experimentally designed as two or three person repeated games, where the payoff tables are derived from linear demand conditions. Agents face fixed costs but no variable costs. The inverse demand function in the market is $P(Q) = 60 - Q$ where $Q = \sum_{i=1}^{n} q_i, n = 2 \, or \, 3$. Fixed costs are 75. A reduced-in-size copy of the two and three person games is attached at the end of this paper. In the entry design, subjects 9 and 11 are choosing from both tables in the second half of the experiment.

Subjects were never told they were picking outputs, just that they were choosing values from a payoff table where the intersection of their row choice and the other player's column choice determined earnings for the period. In the entry design, subjects were told that in period

25 the tables may or may not change to a larger version with three people choosing row values. The instructions also informed all subjects that they could be making row choices from two tables in each period. Figure 1 shows that the probability of no change in the duopoly market structure is 1/2. We note that two of the duopoly markets became "conduit markets." They are connected to another market through subjects 9 and 11. The probability of a player becoming a multimarket operator, i.e. making choices from two tables, is 1/6. Subjects were informed of these probabilities. The probability of entry occurring is 1/3.[1]

For reference, several possible equilibria choices can be identified in the payoff tables. In the duopoly games the Cournot/Nash quantities are $q_i = 20$. Perfect symmetric collusion is $q_i = 15$. In the triopoly games, the Cournot/Nash quantity is $q_i = 15$ and the perfect symmetric collusive choice is $q_i = 10$.

III. Theory: Pre Entry Behavior

Our experimental setting can be represented as a dynamic game. There are two critical points in time: T_1, when the uncertainty regarding the potential entry is resolved, and T_2, when the random termination commences. For periods $t = 1,\ldots,T_1$ there are two players, who we refer to as 1 and 2. In this epoch of the game the two players simultaneously select outputs q_{1t} and q_{2t} in each period t. At the end of period T_1, the number of players becomes set for the remainder of the game: with probability λ the number of players remains at 2, and with probability $1-\lambda$ the number of players changes from 2 to 3. Whether or not entry occurred, all players choose outputs simultaneously in each period following T_1. Starting with period T_2, at the end of each period t a random termination scheme is invoked: with probability $\theta \in (0,1)$ the game continues

[1] For each of the entry treatments, an equal number of sessions were conducted without informing subjects of the probabilities of these events.

to period t+1, and with probability 1-θ the game terminates at the end of period t. In any period, each player i's payoffs are generated by the stage-game payoff function $\pi(q_{it}, q_{It})$ for i = 1, 2, where q_{It} is the sum of all other players' outputs.

Because of the relatively complex structure of the game, it is conceivable that players could adopt time-varying strategies. Our view is that the most obvious manner in which strategies would change over time is linked to the potential for entry, which differentiates periods $t \le T_1$ from periods $t \ge T_1 + 1$.[2]

Recognizing this feature of the game, we propose the following strategy. In periods t = 1, …,T_1: choose q_2^{c1} if both players have played q_2^{c} in all periods prior to period t; if either party deviated from q_2^{c1} in any period prior to period t, play q_2^{N}. If entry occurred at the end of period T_1 then play q_3^{c2} in period T_1+1 if both players 1 and 2 played q_2^{c1} in all periods t = 1, …,T_1, but play q_3^{N} if either player deviated from q_2^{c} in any period $t \le T_1$; in any period $\tau > T_1+1$ play q_3^{cc} if both players 1 and 2 played q_2^{c1} in all periods t = 1, …, T_1 and all three players chose q_3^{c2} in all periods t = T_1+1,…, τ-1, but play q_3^{N} if either player 1 or 2 deviated from q_2^{c} in any period $t \le T_1$ or if any player deviated from q_3^{c2} in any period t = T_1+1,…, τ-1. If entry did not occur at the end of period T_1 then play q_2^{c2} if both players 1 and 2 played q_2^{c1} in all periods t = 1, …, T_1 and both players 1 and 2 played q_2^{c2} period t = T_1+1,…, τ-1; if either party deviated in any period prior to period t, play q_2^{N}.

To determine if this strategy can be part of a subgame-perfect equilibrium, we first define q_n^{dm} as the Nash best response when the other n-1 players have chosen q_n^{cm}, n = 2 or 3, m = 1 or 2. We write the corresponding payoffs as π_n^{dm}. If the player chooses q_n^{cm}, i.e. he does not

[2] It is also true that periods after T_1 but prior to T_2 differ from period T_2 and after in that it is common knowledge the probability the game will terminate during the first set of dates is nil. The discussion in the text can be adapted to incorporate this additional complication, but at the cost of complicating the exposition.

deviate, then he earns payoffs π_n^{cm}. We assume that π_n^{cm} is a concave function of q_n^{cm}; this is true for the linear-quadratic payoff structure we employ in our experimental design. Finally, we denote the one-shot Cournot/Nash equilibrium payoffs as π_n^N. For the strategy we outlined above to be part of a subgame-perfect equilibrium, these payoffs must satisfy incentive constraints for three epochs. For values of $t \geq T_2$, the incentive constraints take the form

$$\pi_n^{d2} + \theta\pi_n^N/(1-\theta) \leq \pi_n^{c2}/(1-\theta) \Leftrightarrow \pi_n^{d2} - \pi_n^{c2} \leq \theta(\pi_n^{d2} - \pi_n^N), \tag{1}$$

where n = 2, 3 indexes the actual number of players during this epoch. For values of $t = T_1 + 1, \ldots, T_2 - 1$ the incentive constraints take the form

$$\pi_n^{d2} + (T_2\text{-}t\text{-}1)\pi_n^N + \pi_n^N/(1-\theta) \leq \pi_n^{c2}(T_2 - t) + \pi_n^{c2}/(1-\theta)$$

$$\Leftrightarrow \pi_n^{d2} - \pi_n^{c2} \leq (1-\theta)(T_2 - t)(\pi_n^{c2} - \pi_n^N) + \theta(\pi_n^{d2} - \pi_n^N), \tag{2}$$

again for t = 2, 3. Since it is clear that (2) will be satisfied if (1) is, we focus on constraint (1) below. Finally, for values of $t = 1, \ldots, T_1$ the incentive constraints take the form

$$\pi_2^{d1} + (T_1\text{-}t)\pi_2^N + (T_2\text{-}T_1)E\pi^N + E\pi^N/(1\text{-}\theta) \leq \pi_2^{c1} + (T_1\text{-}t)\pi_2^{c2} + (T_2\text{-}T_1)E\pi^{c2} + E\pi^{c2}/(1\text{-}\theta) \Leftrightarrow$$

$$\pi_2^{d1} - \pi_2^{c1} \leq (1\text{-}\theta)(T_1\text{-}t)(\pi_2^{c1}\text{-}\pi_2^N) + (1\text{-}\theta)(T_2\text{-}T_1\text{+}1)(E\pi^{c2}\text{-}E\pi^N) + \theta(\pi_2^{d1}\text{-}E\pi^N + E\pi^{c2}\text{-}\pi_2^{c1}) \tag{3}$$

where $E\pi^N = \lambda\pi_2^N + (1\text{-}\lambda)\pi_3^N$ and $E\pi^{c2} = \lambda\pi_2^{c2} + (1\text{-}\lambda)\pi_3^{c2}$.

A compact interval of values satisfies each constraint, where the constraint just binds at the smallest such value. If the perfectly collusive value fails to satisfy these constraints, then the largest feasible cooperative payoffs are induced where constraint (1) binds and constraint (3) just binds at $t = T_1$, and so for the remainder of the section we shall focus on this case. Accordingly, we seek the three values $(q_2^{c1}, q_2^{c2}, q_3^{c2})$ that solve the system of three equations

$$\pi_2^d - \pi_2^c = \theta(\pi_2^d - \pi_2^N), \tag{4}$$

$$\pi_3^d - \pi_3^c = \theta(\pi_3^d - \pi_3^N), \tag{5}$$

$$(1\text{-}\theta)(\pi_2^{d1} - \pi_2^{c1}) = \{(1\text{-}\theta)(T_2\text{-}T_1) + 1\}(E\pi^{c2}\text{-}E\pi^N) \tag{6}$$

In light of equations (4) and (5) we have $E\pi^{c2} = (1\text{-}\theta)E\pi^{d2} + \theta E\pi^{N}$, where $E\pi^{d2} = \lambda\pi_2^{d2} + (1\text{-}\lambda)\pi_3^{d2}$. It follows that eq. (6) can be rewritten as

$$(\pi_2^{d1} - \pi_2^{c1}) = \{(1\text{-}\theta)(T_2\text{-}T_1) + 1\}(E\pi^{d2}\text{-}E\pi^{N}). \quad (7)$$

The deviation profits π_2^{dm} are determined by the output q_2^{cm}; similarly, π_3^{d2} is determined by q_3^{cm}. Accordingly, equations (4), (5) and (6) determine the three critical values for the strategy outlined above.

The central question we study in this paper is: how does the threat of entry affect firms' ability to collude? One way to interpret the model above in relation to this question is to ask what impact a change in λ will have on outputs chosen between periods 1 and T_1. Increasing λ to 1 corresponds to eliminating the possibility of entry; because such a change will raise the right-hand side of equation (7) it will facilitate smaller values of q_2^2 (which, all else equal, imply a larger temptation to deviate). Intuitively, the threat of entry reduces the value of continued cooperation, and so one expects to see larger outputs when there is a threat of entry than where no such threat exists. On the other hand, behavior in advance of entry must surely entail smaller outputs than would be observed in a 3-firm industry. Accordingly, there are two hypotheses associated with our experimental design:

Hypothesis H1: An experimental design with two firms and potential entry will have larger outputs than will an experimental design with two firms and where no such possibility exists;

Hypothesis H2: An experimental design with two firms and potential entry will have smaller outputs than will an experimental design with three firms (i.e. where entry has already taken place).

Notice that Hypothesis *H1* is not true in a standard Cournot/Nash framework: in such an environment, firms would produce the output q^n with or without the threat of entry. It is only when there is a tendency to produce smaller outputs, as with collusive or quasi-collusive behavior, that the threat of entry will matter.

IV. Theory: Post Entry Behavior

We model the post entry period as a repeated infinite game with no threat of entry. Players operating in a single duopoly market will continue to cooperate by choosing the quantity where the incentive constraint $\pi_n^{dm} + \theta\pi_n^{N}/(1 - \theta) \leq \pi_n^{cm}/(1 - \theta)$ is just binding. For generalized linear conditions on demand and costs some level of cooperation is achievable for $0 \leq \theta \leq 9/17$ (see for example Gibbons (1992) pp. 102-107). Hence we would expect duopoly markets without multi-market contact to produce quantities smaller than the Cournot/Nash level.

In figure 1 players 9 and 11 operate in two markets; they make choices in a duopoly and a triopoly. These players face two distinct incentive constraints. As we describe in Phillips and Mason (2001), it is likely one of these markets will be more cooperative than the other. Different degrees of cooperation could reflect different degrees of "rationality" among players that emerges from their history of play (Kreps (1990)). This potential heterogeneity motivates subjects to learn about their rival(s) mode of behavior, and may facilitate a similar level of cooperation in the two markets. One can think of learning as altering the incentive constraint(s), by changing the weight put on future returns (effectively, θ), and this will change the quantities at which the incentive constraints bind. In Phillips and Mason (2001) we have shown that this sort of learning can be transferred from one market to another, so that an agent's presence in multiple markets can create a conduit for cooperative behavior. In this way, choices in market X are useful in explaining choices in market Y.

With multimarket contact – that is, all producers meeting in the same markets – players will cooperate, deviate or punish in all markets. Accordingly, the individual incentive constraints can be combined, so that the optimal level of cooperation equalizes the ratio of marginal profit from collusion to marginal profit from deviation across all markets (Phillips and Mason (1992)). Firms with multi-market contact can improve on the isolated collusive regime by selecting outputs that break the incentive constraint in one market, slacken the incentive constraint in the second market, but still meet the pooled constraint. When the multi-market contact is in markets that have the same demand and cost conditions except for two versus three symmetric firms, then rivals can gain by producing relatively more in the triopoly market and less in the duopoly market.

Remarkably, we have found that conduit firms operate as if they have a pooled incentive constraint. In our earlier conduit experiments (Phillips and Mason (2001)) we have found significant measures of Granger causality in an X and Y market, where an increase in X output causes an increase in Y output and vice versa. This causality reflects the underpinnings of mutual forbearance and a pooled incentive constraint. That is, if defection from agreement occurs it will take place in both markets. Similarly, if punishment occurs it also will take place in both markets. Simple learning rules in the market environment may promote this kind of mirrored behaviour. Learning is bounded and in complicated environments controlled by experience. Agents facilitate their learning from experience by simplifying.

It is possible that the multimarket producer, in order to interpret the actions of different rivals, treats all rivals as having a single common strategy. The multimarket producer therefore uses the same rule by which to adjust to the actions of different rivals. In turn, this strategy may force the X and Y market rivals to adjust quantities in different directions. The strategy of the multimarket agent may break “the constraint” in the Y market and crate slack in the X market. The conduit firm will generate market outcomes very similar to that of the same firms meeting in different markets.

The foregoing discussion suggests that behavior in experimental duopolies may differ when one compares regimes where both players operate in just the one market with regimes in which one player operates in both the duopoly and a second market. In our experimental design, this comparison is readily available after period 25 in the central treatment: of those pairs that did not experience entry (and so remain a duopoly), half of the pairs include a subject who has been placed in a second market while the other half included subjects that are participating in one market only. In the discussion below, we term the second cohort “no entry, no multi-market contact” and the first cohort “no entry, multi-market contact.” An interesting behavioral question then regards the comparison of these two cohorts.

V. Econometric Model

We now turn to a rigorous analysis of choices in our pre-entry and post-entry experimental design. The goal is to estimate the equilibrium choice for a typical agent. We analyze the experimental data by treating each session as a pooled cross section time series.[3] In the sample, the cross-sectional element is given by the number of participants, with the number of observations per subject determined by the length of the session in which he or she participated.

The structural model we estimate to test these hypotheses is based on the relation

$$C_{it} = \beta_i + \varepsilon_{it}, \tag{8}$$

[3] Experimental economists have often analyzed mean choices over a subset of the play in similar settings. Such an approach is inferior to our procedure because it neglects learning and dynamic adjustments, which can distort the results (Alger, 1987).

where C_{it} represents the market output chosen by subject pair i in period t, β_i is the equilibrium or "steady-state" choice for pair i, and ε_{it} is a disturbance term. Because subjects' decisions are simultaneous, an individual's choice can be influenced only by a counterpart's past choices. As an individual adjusts his or her choices in approaching equilibrium, the history of the game provides important information. This can occur either because agents are learning about their rival's rationality (Kalai and Lehrer, 1993) or because of signalling, aimed at coordinating on a more profitable regime (Shapiro, 1980). The implication is that the disturbance term in equation (12) may contain subtle dynamic effects more than first-order ones. The most parsimonious time-series structure that includes such subtle effects is a second-order autoregressive process, which yields:

$$C_{it} = \alpha_i + \rho_1 C_{it-1} + \rho_2 C_{it-2} + u_{it}, \quad (9)$$

where $\alpha_i = \beta_i(1 - \rho_1 - \rho_2)$, and we impose the regularity conditions $|\rho_1| < 1$, $|\rho_2| < 1$, and $|\rho_1 + \rho_2| < 1$ (Fomby, Hill and Johnson, 1988).

To estimate this regression model, we regard our dataset as a pooled cross-section/ time-series sample. This requires the same number of observations for each element of the cross-section, i.e., each subject pair. Hence, we pooled all subject pairs in each treatment for periods t = 1, . . . , 25 in each of the markets. In each case, we estimated the system of equations defined by equation (9) for all subject pairs, allowing intercepts to vary between subject pairs in a given treatment, and slopes to vary between different treatments.

We propose a fixed-effects approach to analyze choices. This approach assumes that variations between subjects within a given design can be captured through differences in the intercept term, α_i.[4] However, the dynamic adjustment terms, ρ_1 and ρ_2, as well as the variance of the disturbance term, u_{it}, are assumed equal for all pairs in a given design. Also, we assume no contemporaneous covariance between subject pairs and that u_{it} is serially uncorrelated:

$$E(u_{it}u_{jw}) = 0 \text{ if } i \neq j \text{ or } t \neq w,$$

where w is a time period different from t.

With this structure, it is straightforward to obtain asymptotically efficient, consistent estimates of the parameters α_i, ρ_1 and ρ_2. Once consistent and efficient estimates of these parameters are obtained, we construct the average intercept in treatment n as

$$\alpha_n = \Sigma \alpha_i / N_n, \tag{10}$$

where N_n is the number of pairs in treatment n. We are interested in the equilibrium behavior of a typical subject in each of the treatments. If agents choose the steady-state value for several consecutive periods, then the deterministic version of equation (6) may be used to derive the equilibrium output for subject pair i in treatment n as

$$\beta_i = \alpha_i/(1 - \rho_1 - \rho_2). \tag{11}$$

Because we are interested in the central tendency in each design, we then use these estimates of each pair's equilibrium to obtain the average choice for the design:

$$\beta_n = \Sigma \beta_i / N_n = \alpha_n/(1 - \rho_{1n} - \rho_{2n}) \tag{12}$$

Finally, we can use covariance information from the maximum-likelihood estimates of α_n, ρ_{1n} and ρ_{2n} to construct consistent estimates of the covariance structure for the steady-state values β_n for each treatment n (Fomby, Hill, and Johnson, 1988).

[4] Essentially, this approach employs a regression model with pair-specific dummy variables; the coefficients on the dummies reflect the underlying parameters α_i. Alternatively, one can analyze the residuals from a regression with a common intercept, and allow for deviations from that intercept for pair *i* to arise through the average value of the residual for pair *i*.

VI. Data and Analysis: First 25 Periods (Pre Entry)

We apply this regression model to each of three experimental designs. Control 2 represents the control design where there is no threat of entry, and there are two players in each market throughout the experiment. In Figure 2 average choices in these markets are plotted and labelled as "control2." Choices as market output begin at about 35 units and fluctuate around this level for all 25 periods. The Cournot/Nash quantity is 40 for the market, so there is a noticeable degree of tacit cooperation in the market that is sustained.

Control 3 represents the control design where there is no threat of entry, and there are three players in each market throughout the experiment. Average choices in this market environment also are plotted in Figure 2 as "control3". Total outputs in the market are consistently about 40 units and range between 40 and 45 units for the duration of the 25 periods. The Cournot/Nash quantity is 45 units. The experimental data exhibit a tendency to produce a few units below this level in the market.

The schedule label "duop" in Figure 2 represents the treatment effect and labelled treatment 1 in Table 1 – the design where entry occurs probabilistically at the end of period 25. Choices are consistently greater than those in Control 2 and trend upwards to choices that just below 40 units. Choices in duop generally average between those in the two controls. They are closer to the Cournot/Nash choice of 40 than those in Control 2.

The data summarized in Figure 2 are directly relevant to the two hypotheses we posed above. The results from our regression model, as applied to each of the three treatments, are provided in Table 1. In this table, parameter estimates for α_n, ρ_{1n} and ρ_{2n} are presented for designs n = 1, 2 and 3. The corresponding standard error is given, in parentheses, below the relevant point estimate. We also present the implied steady state choice, β_n, along with its standard error (in parentheses). Below these estimates we give the R^2 goodness of fit statistic for the regression, as well as the number of observations.

We note first that for all designs, the estimates of ρ_1 and ρ_2 are all less than one in magnitude, as is $|\rho_1 + \rho_2|$. Thus, the conditions for dynamic stability are satisfied, so we may properly regard the estimated value of β_n as the steady-state choices in each design *n*. Comparing the designs, we see that the estimated steady state choice in treatment 1 lies between the estimated steady state values for the two control treatments. The difference in estimated steady state choices are $\beta_2 - \beta_1 = 3.5487$ and $\beta_3 - \beta_2 = 4.5753$; both differences are statistically different from 0 at better than the 1% confidence level, confirming our two hypotheses. This set of experiments confirms the prediction of the model that the threat of entry leads duopoly players to produce more up to the time of the random entry date.

VII. Data and Analysis: Second 25 Periods (Post Entry)

Figures 3 and 4 respectively plot post entry duopoly and triopoly choices along with baseline choices from markets that had no threat of entry. In both market environments there are striking contrasts between the baseline and the entry-threatened players. Figure 3 shows that after period 25, the baseline duopoly groups are become tacitly more cooperative to the end of the experiment. Duopoly pairs, that remained duopoly pairs after period 25, on the other hand, become increasingly less cooperative. Choices hoover around the Cournot/Nash level of 40, and appear to be greater than 40.

Indeed as Table 2 reports, the estimated steady state choice level of the threatened duopoly pairs is $\beta_{1a} = 41.189$. For duopolies with multimarket contact (markets 5 and 6) the steady state is $\beta_{1b} = 40.125$. The estimated steady state of the unthreatened, baseline duopoly pairs is $\beta_2 = 37.654$. Differences between the treatment duopolies and the baseline are significant as noted in table 2, while the β_{1a} and β_{1b} steady state choices are not significantly different from the predicted Cournot/Nash choice and not significantly different from each other. From the plot in figure 3, it appears that the entry-threatened duopoly pairs attempt to tacitly coordinate much like the base line group, and successfully do so until about period 37, and then revert to the Cournot/Nash level as the punishment choice. We suggest that the relatively competitive history before period 25 makes it too difficult to coordinate.

Figure 4 describes triopoly choice behavior for markets in which there is entry after period 25. The treatment effect is duopoly markets becoming triopolies. New triopoly choices are compared to baseline triopoly choices for which there was no threat of entry for at least 50 periods. The baseline is clearly more cooperative than the newly creates triopolies. Baseline choices are settling in at levels below the Cournot/Nash choice of 45, yet significantly above the fully collusive level of 30. Table 2 shows the steady state choice level at $\beta_3 = 40.396$.

The estimated steady state is significantly greater for the new triopolies; as reported in Table 2, $\beta_{1c} = 44.504$. These higher choice levels similar to those made by the triopoly baseline in the first 25 periods; where the steady state choice level was estimated in Table 1 at 42.884. It is possible that once entry occurs that all history is forgotten from the duopoly era, and players are working on tacit agreement with a clean slate.

Finally, a comparison of subject behavior in those pairs where there is no multi-market contact with behavior in those pairs where there is multi-market contact is intriguing. The steady state choice in the cohort where one subject chooses in two markets is numerically smaller than the steady state choice in the cohort where both subjects choose in one market only, although the difference is not statistically important. From this observation we infer there is some indication that multi-market contact can serve as a conduit for cooperation, though the evidence is not very strong. Referring to Figure 5, it would seem that any differences between these two cohorts do not appear until after period 37; that is, they are subtle, and slow to emerge. This pattern is consistent with our earlier work (Phillips and Mason (2001)), where we observed that producers in conduit markets behave as if they have a pooled incentive constraint: Operation in two markets leads to higher outputs in one market and lower outputs in the other.

VIII. Discussion

Against the backdrop of duopoly and triopoly markets for which there is no threat of entry, we use a trigger strategy model to describe behavior, and then empirically investigate how firms behave in experimental markets when there in an imminent threat of entry. When duopolists are completely informed of the time and probability of entry they are significantly less cooperative than firms without such a random threat of entry. Imminent entry in some markets enhances competitive behavior in all markets in the pre-entry period.

Even if entry does not materialize, we find that compared to a baseline without a threat of entry, players are substantially and significantly less cooperative in the post-entry period. Players are unable to overcome their competitive history. Effectively they have lower discount factors that force them to produce greater quantities. We also find evidence of a conduit learning effect in the markets where there is multimarket contact. The players making choices in both a triopoly and a duopoly market behave as if they have a pooled incentive constraint that leads to higher choice levels in the triopoly market and relatively lower choices in the duopoly market. The lower choices in the duopoly markets, however, are still greater than choices in duopoly markets without a threat of entry. These output shifts in the two markets indicate the multimarket producer is trying to teach its rivals in the other markets to mutually forebear in a fashion that treats the rivals as if they have common ownership.

These experimental results expand our understanding of how the threat of entry in concentrated markets affects competitive behavior. The threat posed as a randomized event independent of current output (and price) choices has the impact of making all markets in the threatened set of markets more competitive. Our experiments are showing a significant output increase of 10%, but more importantly agents are moved close to the Cournot/Nash choice. We might expect that once the threat is past and agents are assured there is no further threat of entry that they would return to a level of tacit agreement described by baseline behavior that never had a threat of entry. However, the experimental data show there is a lasting legacy of the entry event that carries forward into the indefinite future. All the markets that experience the random threat continue to be more competitive, continuing to behave as if they are Cournot/Nash players.

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TABLE 1: Regression Results for Choices Prior to Period 25

parameter	Control 2 (duopoly control)	Treatment 1 (duopoly/entry threat)	Control 3 (triopoly control)
α_n	38.865 (2.7847)	30.721 (3.2343)	45.133 (4.7839)
ρ_{1n}	-0.0634 (0.0486)	-0.0952 (0.0545)	0.0788 (0.0812)
ρ_{2n}	-0.0547 (0.0482)	0.2933 (0.0502)	-0.1312 (0.0732)
β_n	34.760 (0.2495)	38.308 (0.3437)	42.884 (0.5987)
R^2	.9773	.9802	.9641
observations	460	414	184

Note: $\beta_2 - \beta_1 = 3.5487$; standard error = 0.4265; t-statistic = 8.3203

$\beta_3 - \beta_2 = 4.5753$; standard error = 0.6918; t-statistic = 6.6140

TABLE 2: Regression Results for Choices after Period 25

parameter	Control 2 (duopoly control)	Treatment 1a (no entry; no multi-market contact)	Treatment 1b (no entry; multi-market contact)	Treatment 1c (entry occurs at end of period 25)	Control 3 (triopoly control)
α_n	18.650 (1.082)	20.363 (3.020)	26.227 (1.992)	42.692 (2.2023)	24.204 (1.6846)
ρ_{1n}	0.2482 (0.0702)	0.5019 (0.1797)	.1513 (0.0951)	0.0738 (0.0892)	0.2983 (0.0854)
ρ_{2n}	0.2565 (0.0744)	0.0037 (0.1021)	.1950 (0.0821)	-0.0331 (0.0822)	0.1026 (0.0916)
β_n	37.654 (0.5096)	41.187 (0.8724)	40.125 (0.5398)	44.504 (0. 6355)	40.396 (0.8900)
R^2	.9885	.9869	.9902	.9742	.9713
observations	276	138	138	138	184

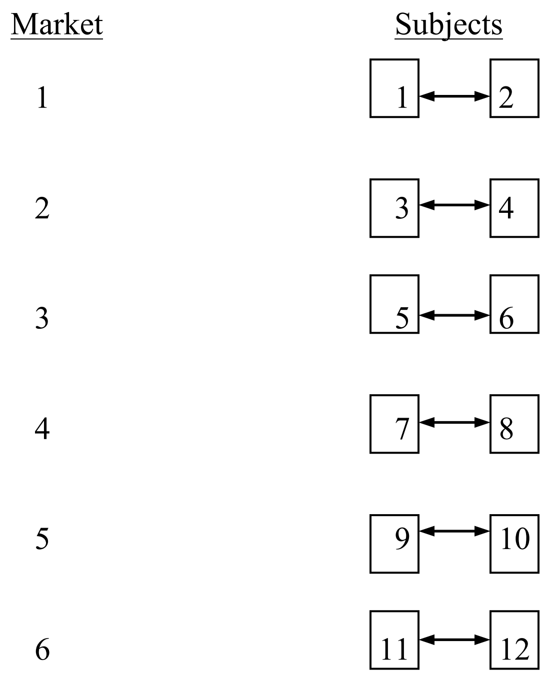
Note: $\beta_2 - \beta_{1a} = 3.533$; standard error = 1.010; t-statistic = 3.497

$\beta_3 - \beta_{1c} = 4.1082$; standard error = 1.094; t-statistic = 3.757

$\beta_{1a} - \beta_{1b} = 1.062$; standard error = 1.026; t-statistic = 1.0352

Figure1: Initial Market Structure: Six Duopoly Markets; 12 quantity-choosing subjects.

There are 25 choice periods in this part of the game.



Reconfigured Market Structure: Subjects 9 and 11 enter a second market.
There are at least 25 choice periods in this part of the game.

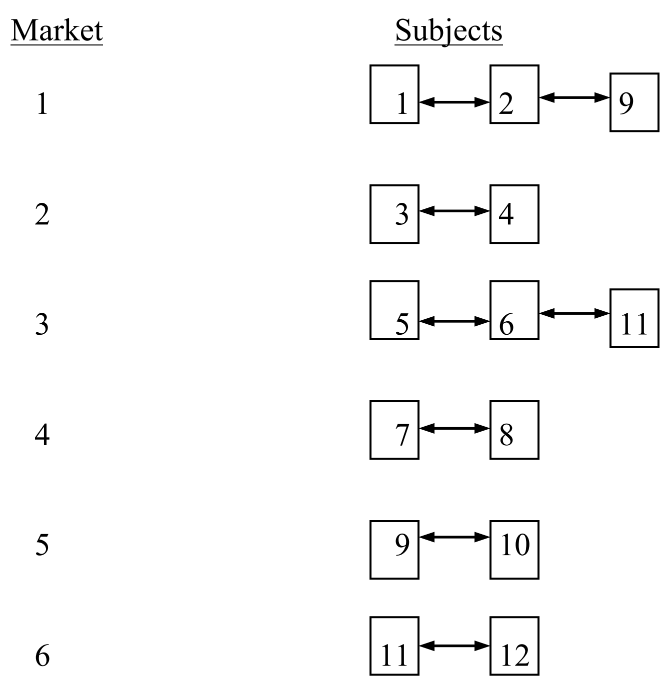


Figure 2: Duopoly and Triopoly Choices in First 25 Periods before Entry in Some Markets.

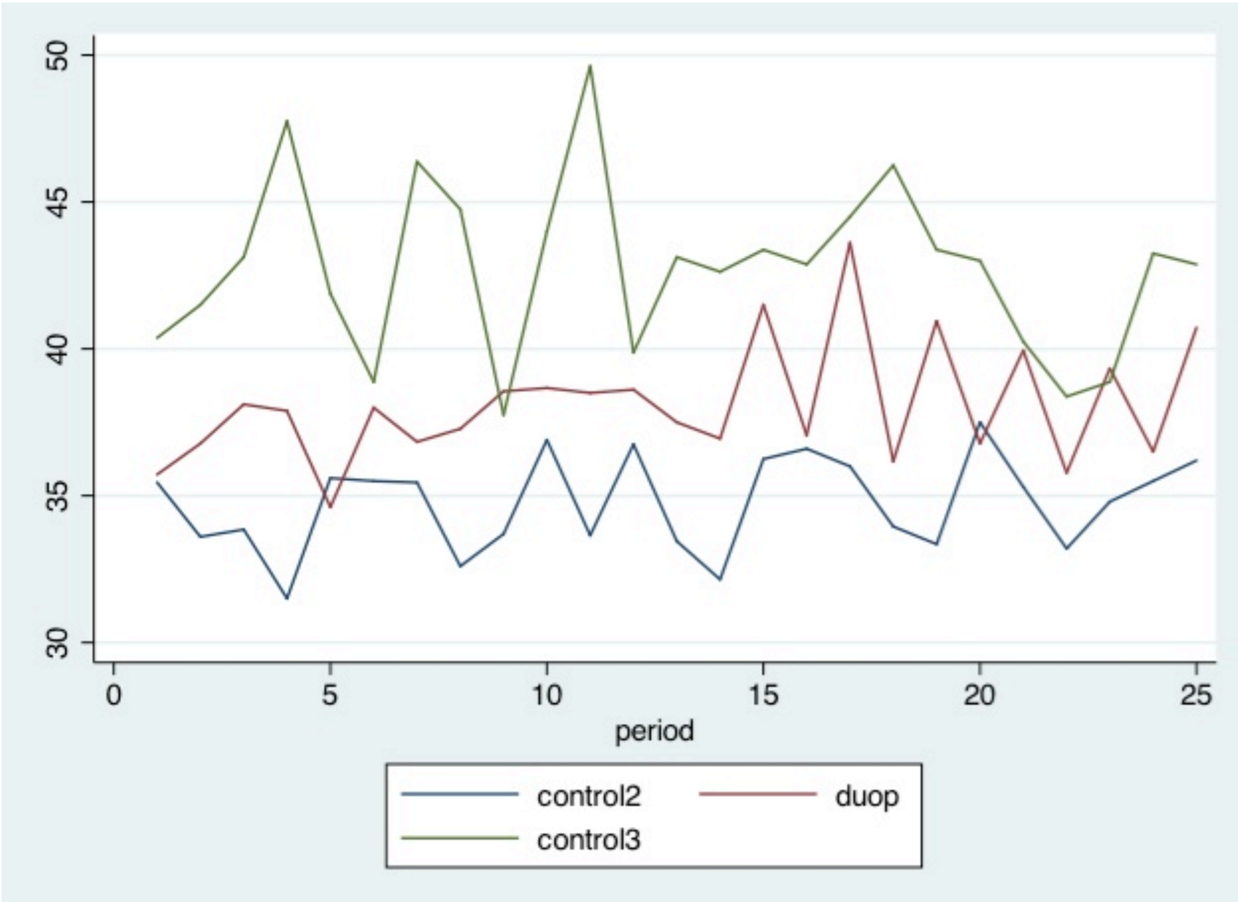


Figure 3: Duopoly Choices in Second 25 Periods after Entry in Some Markets.

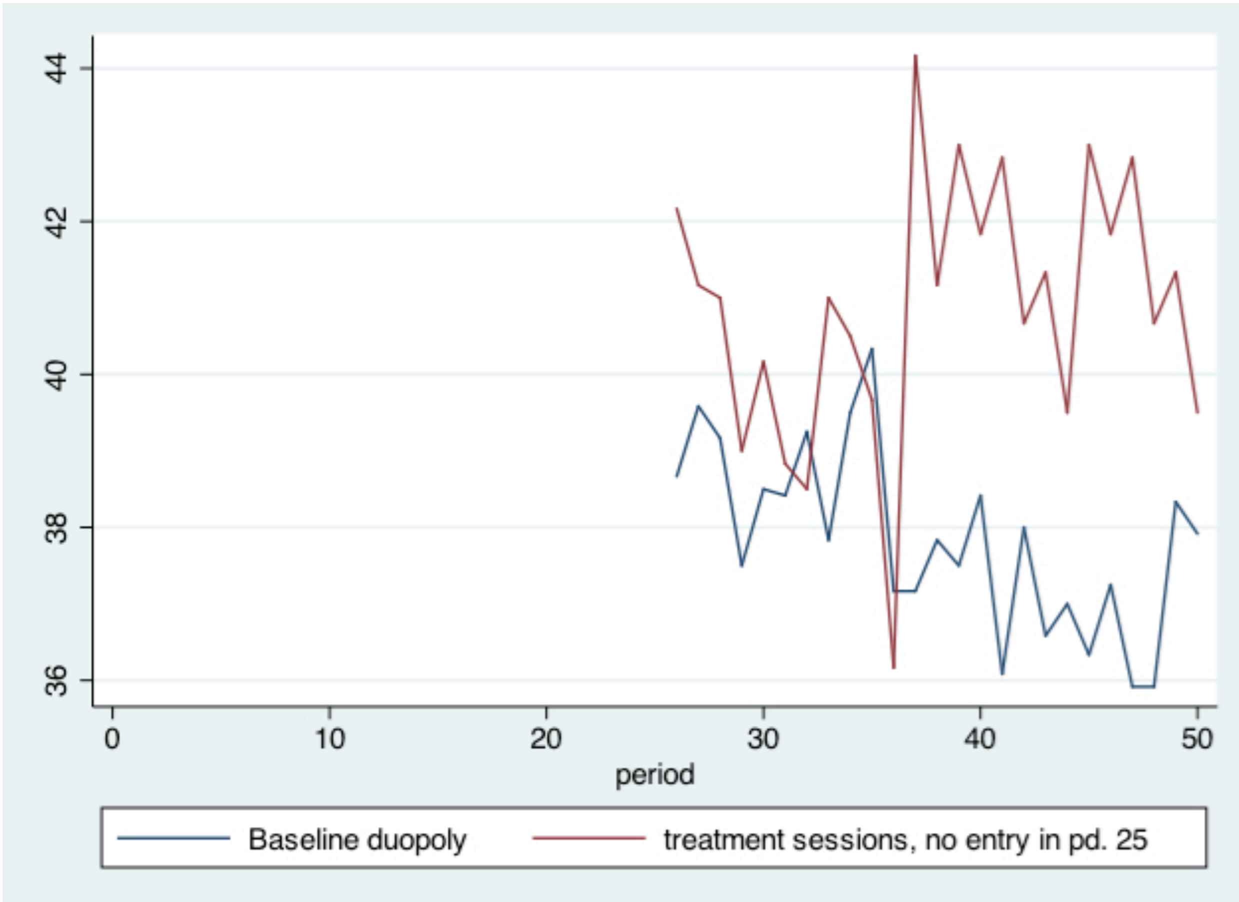


Figure 4: Triopoly Choices in Second 25 Periods after Entry in Some Markets.

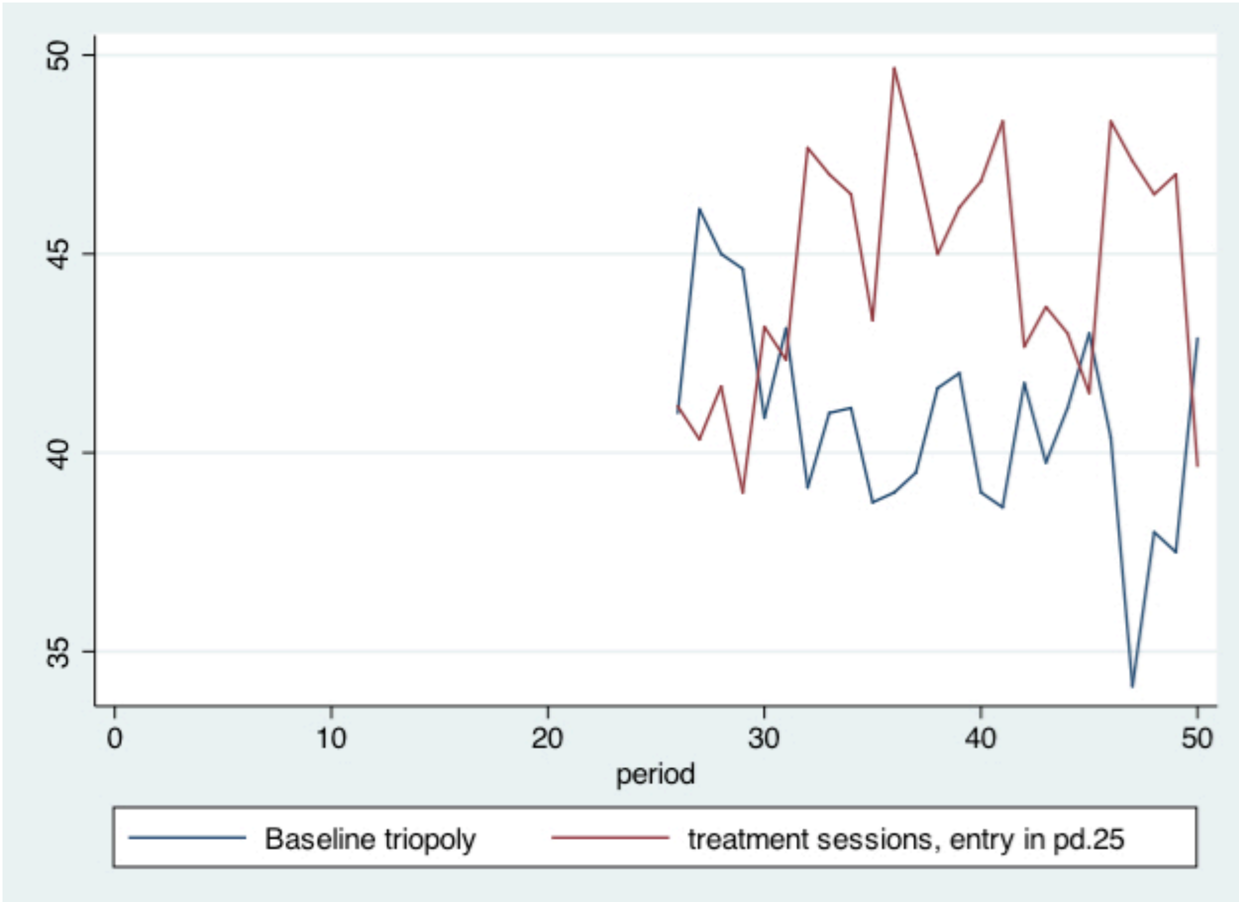
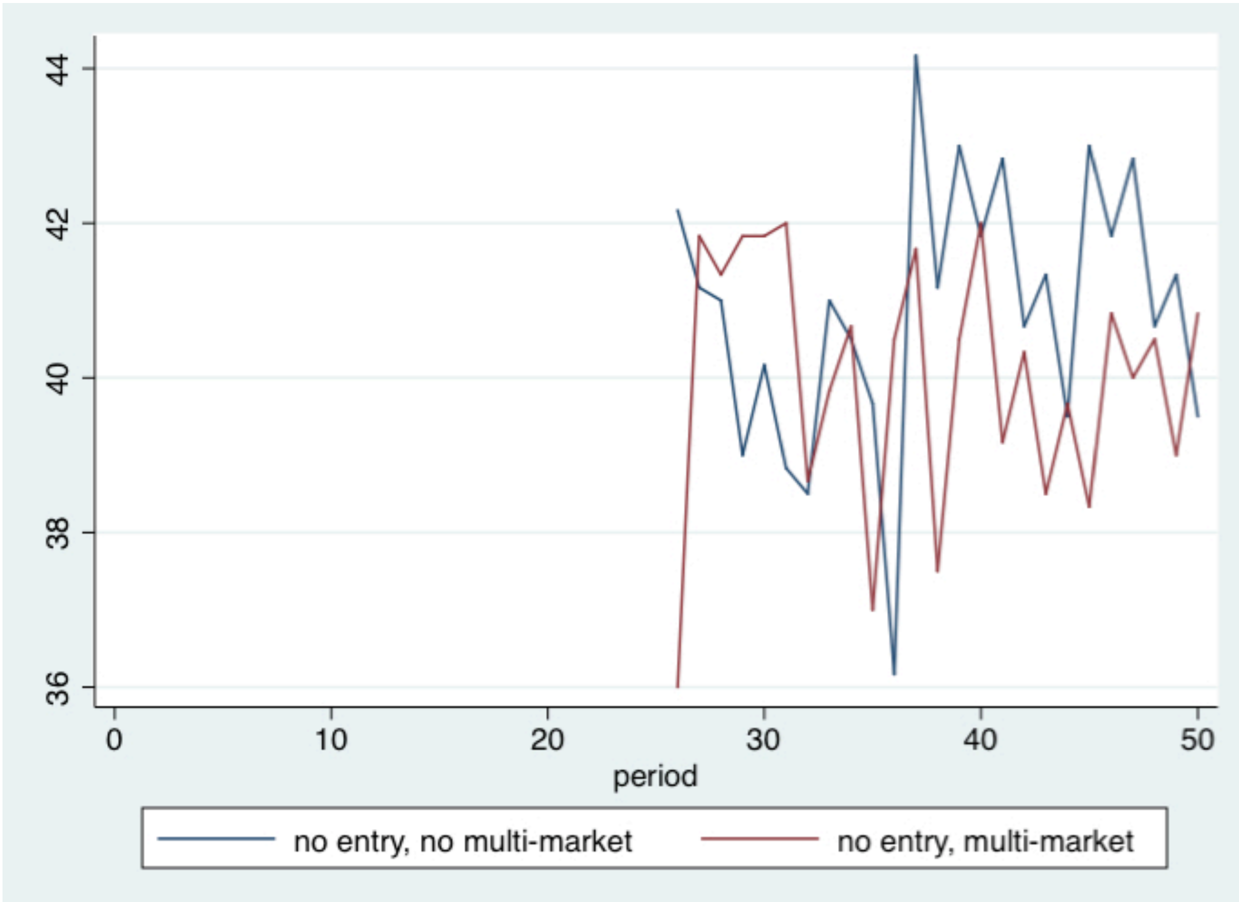


Figure 5: Duopoly Choices in Second 25 Periods: the Effect of Multi-Market Contact.



INSTRUCTIONS

This is an experiment in the economics of market decision-making. The University of Wyoming and other funding agencies have provided funds for the conduct of this research. The instructions are simple. If you follow them carefully and make good decisions you may earn a CONSIDERABLE AMOUNT OF MONEY, which will be PAID TO YOU IN CASH at the end of the experiment.

This experiment has two parts. In the first part, you will be paired at random with *one* other person, and in the second part you will continue to be matched with this *same person and possibly one or two* other individuals. It is not certain the group configurations will change, so the second part of the experiment may be just like the first. The identity of other participants will never be revealed, nor will they ever know who you are. Over several market periods you and other participants will at the same time choose values from a table consisting of rows and columns.

In the table, the values YOU may choose are written down the left hand side of the table and are row values. You will always pick a row value. The row values selected by the other participant(s) are written across the top of your table. Hence the row value of the other person become your column value, and when there are two other participants, the column values are added together to make your column value. The other one or two people in your group will always pick your column value. The intersection of the row and column value in the table determines your earnings for that period. All of you will be selecting values from identical tables.

Earnings are recorded in a fictitious currency called tokens. At the end of the experiment tokens are redeemed for cash at the exchange rate of 1000 tokens = $1.00. All earnings will be paid to you in cash at the end of the experiment. To begin, you will be given an initial balance of 1000 tokens ($1.00). You may keep this money plus any you earn.

Two sample tables are provided on page 3. The table at the top of the page is a sample of rows and columns from the first part of the experiment. Notice that down the left side of either table you may select values from 1 to 6. In the first part of the experiment the table has the same number of rows as columns, because you are matched with just one other person. Your earnings in a period are decided by the intersection of the row choice each of you makes. The choice made by the other participant becomes the column in the payment table. Say you choose 3 and the other person picks 2. Earnings at the intersection of row 3 and column 2 are 195.

In the event you are matched with two other people, the sum of the values the other two participants can choose becomes the column value. The new table has more columns than rows, as shown at the bottom of the next page. For example, if you pick 5 and the other two people pick numbers that add to 10, then at the intersection of row 5 and column 10 the entry 75 represents your earnings in tokens. Or, you may have picked 2 and the other people might have chosen a sum that was 12. At the intersection of row 2 and column 12 your earnings would be 40. The other people will always have the same table. So if you pick 5 on the table, then both of the other people will have a column value that is at least 5. This number is added to a choice made by one of the other unknown participants.

Notice that for any row you choose, the same column values in both tables pay equal token amounts. For example if you choose row 4, the column 3 pays the same in both tables. In both tables larger column values reduce your earnings, but the table with two other participants is longer, and there is more potential to reduce your earnings as column values get larger.

There are three possible types of matches with other participants in the second part of the experiment. The type of each match and the probability of it occurring are: (l) you continue to be grouped with the same person as in the first part of the experiment, the probability of this occurring is 1/2; (2) a third person gets added to your group of two with probability 1/3, or (3) you will continue to make choices with the same person as in part one of the experiment, and also join another group of two people. In the last case, you will make two row choices from two tables like those shown on the next page. The probability of this occurring is 1/6.

SAMPLE PAYMENT TABLE WITH ONE OTHER PARTICIPANT

The Other Participants' Summed Choices

Your Choice	1	2	3	4	5	6
1	80	75	70	65	60	55
2	150	140	130	120	110	100
3	220	195	180	165	150	135
4	260	240	220	200	180	160
5	300	275	250	225	200	175
6	330	300	270	240	210	180

SAMPLE PAYMENT TABLE WITH TWO OTHER PARTICIPANTS

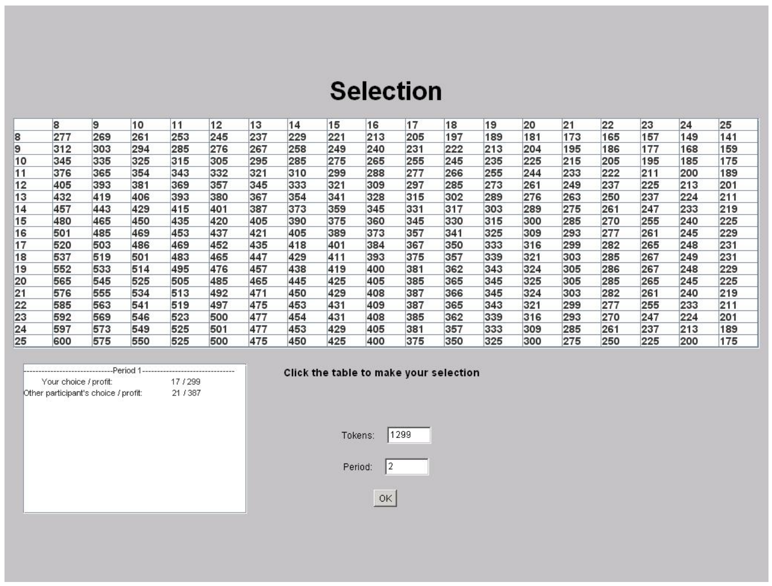
The Other Participants' Summed Choices

Your Choice	2	3	4	5	6	7	8	9	10	11	12
1	75	70	65	60	55	50	45	40	35	30	25
2	140	130	120	110	100	90	80	70	60	50	40
3	195	180	165	150	135	120	105	90	75	60	45
4	240	220	200	180	160	140	120	100	80	60	40
5	275	250	225	200	175	150	125	100	75	50	25
6	300	270	240	210	180	150	120	90	60	30	0

Examples of screens that can appear on your terminal during a choice period are now presented.

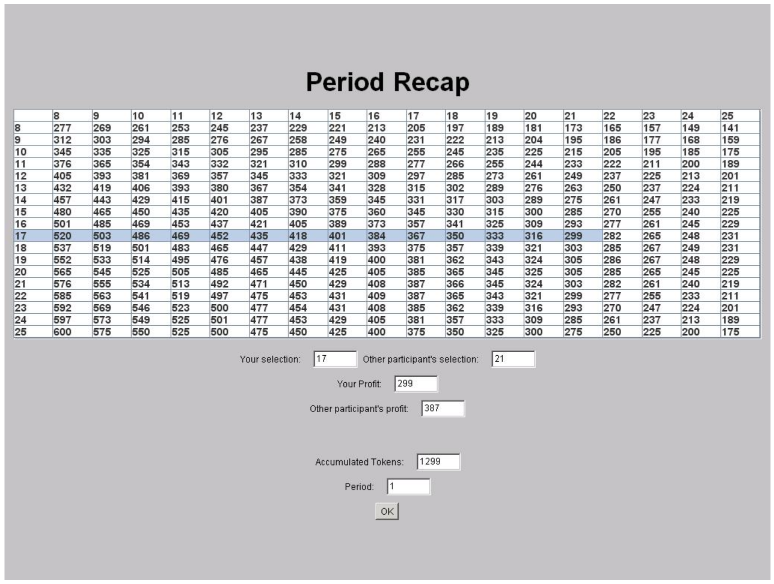
First Part of the Experiment with Two Participants Choosing from the Same Table

The screen for everyone during the first part of the experiment and perhaps all through the experiment will require at least one row choice. While you are making a choice the following screen will be on your computer:



	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
8	277	269	261	253	245	237	229	221	213	205	197	189	181	173	165	157	149	141
9	312	303	294	285	276	267	258	249	240	231	222	213	204	195	186	177	168	159
10	345	335	325	315	305	295	285	275	265	255	245	235	225	215	205	195	185	175
11	376	365	354	343	332	321	310	299	288	277	266	255	244	233	222	211	200	189
12	405	393	381	369	357	345	333	321	309	297	285	273	261	249	237	225	213	201
13	432	419	406	393	380	367	354	341	328	315	302	289	276	263	250	237	224	211
14	457	443	429	415	401	387	373	359	345	331	317	303	289	275	261	247	233	219
15	480	465	450	435	420	405	390	375	360	345	330	315	300	285	270	255	240	225
16	501	485	469	453	437	421	405	389	373	357	341	325	309	293	277	261	245	229
17	520	503	486	469	452	435	418	401	384	367	350	333	316	299	282	265	248	231
18	537	519	501	483	465	447	429	411	393	375	357	339	321	303	285	267	249	231
19	552	533	514	495	476	457	438	419	400	381	362	343	324	305	286	267	248	229
20	565	545	525	505	485	465	445	425	405	385	365	345	325	305	285	265	245	225
21	576	555	534	513	492	471	450	429	408	387	366	345	324	303	282	261	240	219
22	585	563	541	519	497	475	453	431	409	387	365	343	321	299	277	255	233	211
23	592	569	546	523	500	477	454	431	408	385	362	339	316	293	270	247	224	201
24	597	573	549	525	501	477	453	429	405	381	357	333	309	285	261	237	213	189
25	600	575	550	525	500	475	450	425	400	375	350	325	300	275	250	225	200	175

This is a selection screen on which you make your row choice. You may pick any row in the table by highlighting the row with your mouse and clicking. Once you are satisfied with your choice hit the OK button. In the screen shown above it is period 2 and a row choice has not yet been made. Notice however that in period 1, this person chose row 17 and the other participant chose row 21. At the intersection of row 17 and column 21, this person earned 299 tokens. After all subjects hit the OK button, a recap screen will appear as follows. This is the screen shown for period 1 after row 17 was highlighted by this person and the other participant highlighted row 21 on his or her table.



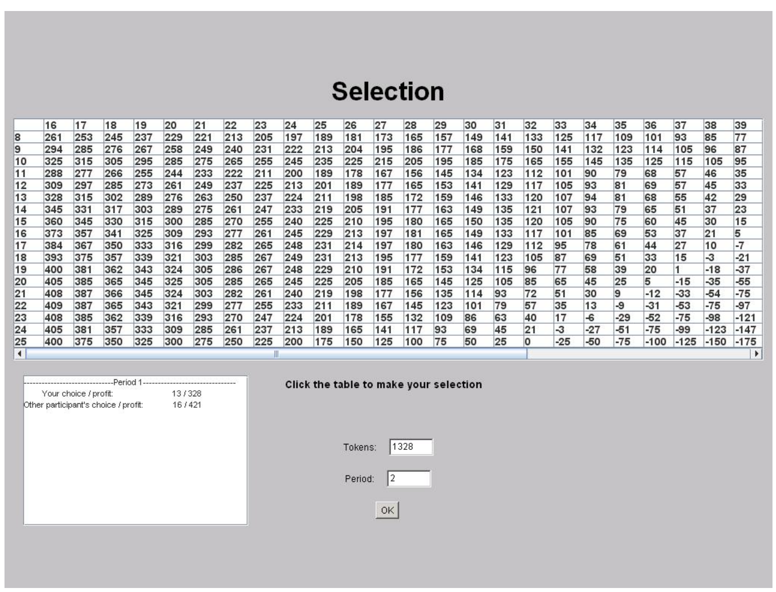
Period Recap

	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
8	277	269	261	253	245	237	229	221	213	205	197	189	181	173	165	157	149	141
9	312	303	294	285	276	267	258	249	240	231	222	213	204	195	186	177	168	159
10	345	335	325	315	305	295	285	275	265	255	245	235	225	215	205	195	185	175
11	376	365	354	343	332	321	310	299	288	277	266	255	244	233	222	211	200	189
12	405	393	381	369	357	345	333	321	309	297	285	273	261	249	237	225	213	201
13	432	419	406	393	380	367	354	341	328	315	302	289	276	263	250	237	224	211
14	457	443	429	415	401	387	373	359	345	331	317	303	289	275	261	247	233	219
15	480	465	450	435	420	405	390	375	360	345	330	315	300	285	270	255	240	225
16	501	485	469	453	437	421	405	389	373	357	341	325	309	293	277	261	245	229
17	520	503	486	469	452	435	418	401	384	367	350	333	316	299	282	265	248	231
18	537	519	501	483	465	447	429	411	393	375	357	339	321	303	285	267	249	231
19	552	533	514	495	476	457	438	419	400	381	362	343	324	305	286	267	248	229
20	565	545	525	505	485	465	445	425	405	385	365	345	325	305	285	265	245	225
21	576	555	534	513	492	471	450	429	408	387	366	345	324	303	282	261	240	219
22	585	563	541	519	497	475	453	431	409	387	365	343	321	299	277	255	233	211
23	592	569	546	523	500	477	454	431	408	385	362	339	316	293	270	247	224	201
24	597	573	549	525	501	477	453	429	405	381	357	333	309	285	261	237	213	189
25	600	575	550	525	500	475	450	425	400	375	350	325	300	275	250	225	200	175

The second part of the experiment may continue with the same two people choosing rows in the table, but there can be changes in the experiment described as follows.

Second Part of the Experiment with Three Participants Choosing from the Same Table

In the second part of the experiment you might have three people making row choices. The choice screen will then take a form that is like the table in the first part of the experiment, except that it is longer because the column amounts are the sum of what the other two people choose. The Selection screen is shown below:



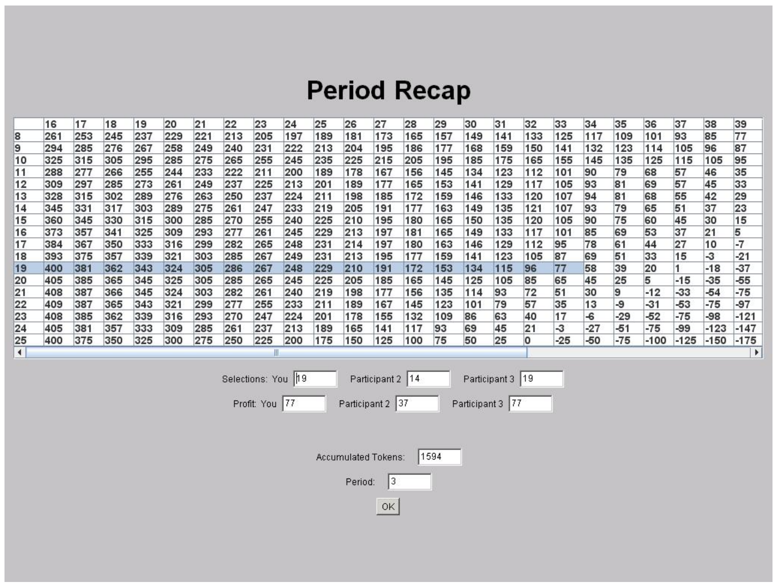
Selection

	16	17	18	19	20	21	22	23	24	25	26	27
8	261	253	245	237	229	221	213	205	197	189	181	173
9	294	285	276	267	258	249	240	231	222	213	204	195
10	325	315	305	295	285	275	265	255	245	235	225	215
11	288	277	266	255	244	233	222	211	200	189	178	167
12	309	297	285	273	261	249	237	225	213	201	189	177
13	328	315	302	289	276	263	250	237	224	211	198	185
14	345	331	317	303	289	275	261	247	233	219	205	191
15	360	345	330	315	300	285	270	255	240	225	210	195
16	373	357	341	325	309	293	277	261	245	229	213	197
17	384	367	350	333	316	299	282	265	248	231	214	197
18	393	375	357	339	321	303	285	267	249	231	213	195
19	400	381	362	343	324	305	286	267	248	229	210	191
20	405	385	365	345	325	305	285	265	245	225	205	185
21	408	387	366	345	324	303	282	261	240	219	198	177
22	409	387	365	343	321	299	277	255	233	211	189	167
23	408	385	362	339	316	293	270	247	224	201	178	155
24	405	381	357	333	309	285	261	237	213	189	165	141
25	400	375	350	325	300	275	250	225	200	175	150	125

	28	29	30	31	32	33	34	35	36	37	38	39
8	165	157	149	141	133	125	117	109	101	93	85	77
9	186	177	168	159	150	141	132	123	114	105	96	87
10	205	195	185	175	165	155	145	135	125	115	105	95
11	156	145	134	123	112	101	90	79	68	57	46	35
12	165	153	141	129	117	105	93	81	69	57	45	33
13	172	159	146	133	120	107	94	81	68	55	42	29
14	177	163	149	135	121	107	93	79	65	51	37	23
15	180	165	150	135	120	105	90	75	60	45	30	15
16	181	165	149	133	117	101	85	69	53	37	21	5
17	180	163	146	129	112	95	78	61	44	27	10	-7
18	177	159	141	123	105	87	69	51	33	15	-3	-21
19	172	153	134	115	96	77	58	39	20	1	-18	-37
20	165	145	125	105	85	65	45	25	5	-15	-35	-55
21	156	135	114	93	72	51	30	9	-12	-33	-54	-75
22	145	123	101	79	57	35	13	-9	-31	-53	-75	-97
23	132	109	86	63	40	17	-6	-29	-52	-75	-98	-121
24	117	93	69	45	21	-3	-27	-51	-75	-99	-123	-147
25	100	75	50	25	0	-25	-50	-75	-100	-125	-150	-175

The columns in this table range from 16 to 50, since the other two participants in the experiment could each choose 8 (adding to 16) or 25 (adding to 50) for their row values. There is a horizontal scroll bar at the bottom of the table that takes the table from column 16 to column 50. Notice that in period 1, this person chose row 13 and the sum of the other choices was 16. This person earned 328.

Each person is shown a period recap of choices and earnings as shown in the screen below.



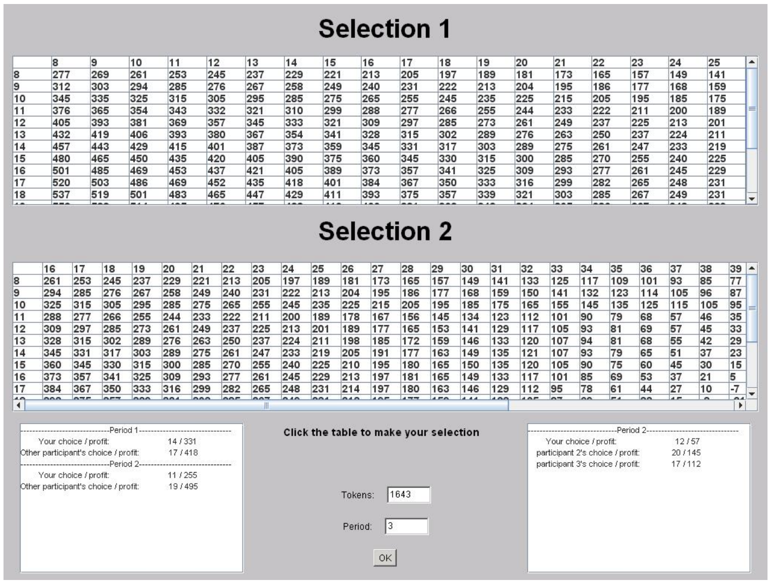
	16	17	18	19	20	21	22	23	24	25	26	27
8	261	253	245	237	229	221	213	205	197	189	181	173
9	294	285	276	267	258	249	240	231	222	213	204	195
10	325	315	305	295	285	275	265	255	245	235	225	215
11	288	277	266	255	244	233	222	211	200	189	178	167
12	309	297	285	273	261	249	237	225	213	201	189	177
13	328	315	302	289	276	263	250	237	224	211	198	185
14	345	331	317	303	289	275	261	247	233	219	205	191
15	360	345	330	315	300	285	270	255	240	225	210	195
16	373	357	341	325	309	293	277	261	245	229	213	197
17	384	367	350	333	316	299	282	265	248	231	214	197
18	393	375	357	339	321	303	285	267	249	231	213	195
19	400	381	362	343	324	305	286	267	248	229	210	191
20	405	385	365	345	325	305	285	265	245	225	205	185
21	408	387	366	345	324	303	282	261	240	219	198	177
22	409	387	365	343	321	299	277	255	233	211	189	167
23	408	385	362	339	316	293	270	247	224	201	178	155
24	405	381	357	333	309	285	261	237	213	189	165	141
25	400	375	350	325	300	275	250	225	200	175	150	125

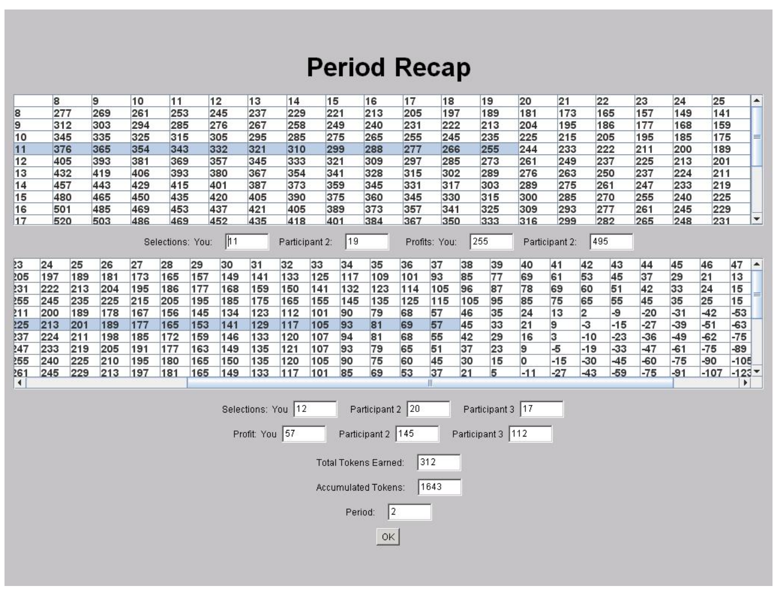
	28	29	30	31	32	33	34	35	36	37	38	39
8	165	157	149	141	133	125	117	109	101	93	85	77
9	186	177	168	159	150	141	132	123	114	105	96	87
10	205	195	185	175	165	155	145	135	125	115	105	95
11	156	145	134	123	112	101	90	79	68	57	46	35
12	165	153	141	129	117	105	93	81	69	57	45	33
13	172	159	146	133	120	107	94	81	68	55	42	29
14	177	163	149	135	121	107	93	79	65	51	37	23
15	180	165	150	135	120	105	90	75	60	45	30	15
16	181	165	149	133	117	101	85	69	53	37	21	5
17	180	163	146	129	112	95	78	61	44	27	10	-7
18	177	159	141	123	105	87	69	51	33	15	-3	-21
19	172	153	134	115	96	77	58	39	20	1	-18	-37
20	165	145	125	105	85	65	45	25	5	-15	-35	-55
21	156	135	114	93	72	51	30	9	-12	-33	-54	-75
22	145	123	101	79	57	35	13	-9	-31	-53	-75	-97
23	132	109	86	63	40	17	-6	-29	-52	-75	-98	-121
24	117	93	69	45	21	-3	-27	-51	-75	-99	-123	-147
25	100	75	50	25	0	-25	-50	-75	-100	-125	-150	-175

In this screen, the person chose row 19, participant 2 chose row 14, and participant 3 chose row 19. The profits of each person are reported and accumulated earnings for each subject are shown. After everyone clicks OK the experiment goes to the next choice period.

Second Part of the Experiment with a Participant Choosing from a Table with Two People and a Table with Three People

Finally, in the second part of the experiment you could have both choice screens already pictured, one screen will correspond to making choices with one other participant with whom you have already been matched, and one will correspond to making choices with two other participants. The latter screen is created from you joining another group of two people. Once making your choice on both tables you receive two Period Recaps as shown below in the bottom screen.



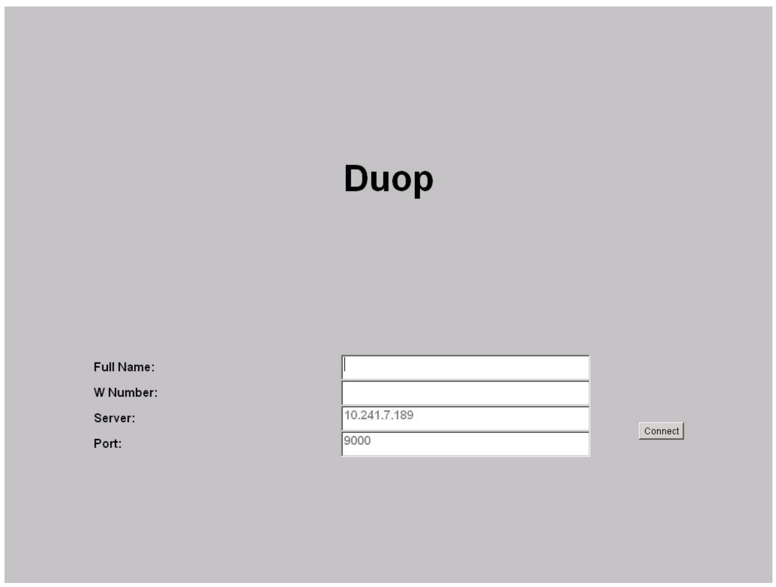


Summary

No one knows when the experiment will end. Choices and adjustments will be made through 25 periods in part one of the experiment. After this, a second phase will begin in which you may (1) continue to be matched with just the participant from the first phase, (2) are matched with an additional person, or (3) make choices from two tables where one continues with your original pairing and the other matches you with two other people. The second phase of the experiment will continue for at least 25 more periods with a 1/5 chance of stopping. After period 50, the computer will randomly generate a number between 1 and 100. If the number falls between 1 and 20 the experiment will end. If the number is bigger than 20 it will continue. Hence the probability of stopping after period 50 is 1/5, and the probability of continuing is 4/5.

Are there any questions about this procedure?

If you now look at your screen you will see that it requires your name and W number:



Your identity will remain confidential and will not be used for any purpose other than to account for our expenditures to the funding agencies. Please do not speak to anyone during the experiment. This is important to the validity of the study and will not be tolerated. If you have a question that you feel was not adequately answered in the instructions please raise your hand and ask the monitor now. Your earnings may suffer if you proceed in the experiment without understanding the instructions!!!!!

Duopoly Payoff Table

		PAYMENT TABLE																	
		The Other Participant's Choice																	
		8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Your Choice	8	227	269	261	253	245	237	229	221	213	205	197	189	181	173	165	157	149	141
	9	312	303	294	285	276	267	258	249	240	231	222	213	204	195	186	177	168	159
	10	345	335	325	315	305	295	258	275	265	255	245	235	225	215	205	195	185	175
	11	376	365	354	343	332	321	310	299	288	277	366	255	244	233	222	211	200	189
	12	405	393	381	369	357	345	333	321	309	297	285	273	261	249	237	225	213	201
	13	432	419	406	393	380	367	354	341	328	315	302	289	276	263	250	23	224	211
	14	457	443	429	415	401	387	373	348	345	331	317	303	289	275	261	247	233	219
	15	480	465	450	435	420	405	390	375	360	345	330	315	300	285	270	255	240	225
	16	501	485	469	453	437	421	405	389	373	357	341	325	309	293	277	261	245	229
	17	520	503	486	469	452	435	418	401	384	367	350	333	316	299	282	265	248	231
	18	537	519	501	483	465	447	429	411	393	375	357	339	321	303	285	267	249	231
	19	552	533	514	495	476	457	438	419	400	381	362	343	324	305	286	267	248	229
	20	565	545	525	505	485	465	445	425	405	385	365	345	325	305	285	265	245	225
	21	576	555	534	513	492	471	450	429	408	387	366	345	324	303	285	261	240	219
	22	585	563	541	519	497	475	453	431	409	387	365	343	321	299	277	255	233	211
	23	592	569	546	523	500	477	454	431	408	385	362	339	316	293	270	247	224	201
	24	597	573	549	525	501	477	453	429	405	381	357	333	309	285	261	237	213	189
	25	600	575	550	525	500	475	450	425	400	375	350	325	300	275	250	225	200	175

Triopoly Payoff Table

PAYMENT TABLE

Combined Choices of Other Participants

Your Choice	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
8	261	253	245	237	229	221	213	205	197	189	181	173	165	157	149	141	133	125	117	109	101	93	85	77	69	61	53	45	37	29	21	13	5	-3	-11
9	294	285	276	267	258	249	240	231	222	213	204	195	186	177	168	159	150	141	132	123	114	105	96	8	78	69	60	51	42	33	24	15	6	-3	-12
10	325	315	305	295	285	275	265	255	245	235	225	215	205	195	185	175	165	155	145	135	125	115	105	92	85	75	65	55	45	35	25	15	5	-5	-15
11	288	277	266	255	244	233	222	211	200	189	178	167	156	145	134	123	112	101	90	79	68	57	46	35	24	12	2	-6	-20	-31	-42	-53	-64	-75	-86
12	309	297	285	273	261	249	237	225	213	201	189	177	165	153	141	129	117	105	93	81	69	57	45	33	21	9	-3	-15	-27	-39	-51	-63	-75	-87	-99
13	328	315	302	289	276	263	250	237	224	211	198	185	172	159	146	133	120	107	94	81	68	55	42	29	16	3	-12	-23	-36	-37	-62	-75	-88	-101	-114
14	345	331	317	303	289	275	261	247	233	219	205	191	177	163	149	135	121	107	93	79	65	51	37	23	9	-5	-19	-33	-47	-61	-75	-89	-103	-117	-131
15	360	345	330	315	300	285	270	255	240	225	210	195	180	165	150	135	120	105	90	75	60	45	30	15	0	-15	-30	-45	-60	-75	-90	-105	-120	-135	-150
16	373	357	341	325	309	293	277	261	245	229	213	197	181	165	149	133	117	101	95	69	53	37	21	5	-11	-27	-43	-59	-75	-91	-107	-123	-139	-155	-171
17	384	367	350	333	316	299	282	265	248	231	214	197	180	163	146	129	112	95	78	61	44	27	10	-7	-24	-41	-58	-75	-92	-109	-126	-143	-160	-177	-194
18	393	375	357	339	321	303	285	267	249	231	243	195	177	159	141	123	105	87	69	51	33	15	-3	-21	-39	-57	-75	-93	-111	-129	-147	-165	-183	-201	-219
19	400	381	362	343	324	305	286	267	248	229	210	191	172	153	134	115	96	77	68	39	20	1	-18	-37	-56	-75	-94	-113	-132	-151	-170	-189	-208	-227	-246
20	405	385	365	345	325	305	285	265	245	225	205	185	165	145	125	105	85	65	45	25	5	-15	-35	-55	-75	-95	-115	-135	-155	-175	-195	-215	-235	-255	-275
21	408	387	366	345	324	303	282	261	240	219	198	177	156	135	114	93	72	51	30	9	-12	-33	-54	-75	-96	-117	-138	-159	-180	-201	-222	-243	-264	-285	-306
22	409	387	365	343	321	299	277	255	233	211	189	167	145	123	101	79	57	35	13	-9	-31	-53	-75	-97	-119	-141	-163	-185	-207	-229	-251	-273	-10	-317	-339
23	408	385	362	339	316	293	270	247	224	201	178	155	132	109	86	63	40	17	-6	-25	-52	-75	-98	-121	-144	-167	-190	-213	-236	-259	-282	-305	-628	-351	-374
24	405	384	357	333	309	285	261	237	213	189	165	141	117	93	69	45	21	-3	-27	-51	-75	-99	-123	-147	-171	-195	-219	-243	-267	-291	-363	-339	-363	-38	-411
25	400	375	350	325	300	275	250	225	200	175	150	125	100	75	50	25	0	-25	-50	-75	-100	-125	-150	-175	-200	-225	-250	-275	-300	-325	-400	-375	-400	-425	-450