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VOLUNTARY PARTICIPATION AND SPITE IN PUBLIC GOOD PROVISION EXPERIMENTS: AN INTERNATIONAL COMPARISON

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Voluntary Participation and Spite in Public Good Provision Experiments: An International Comparison*

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Abstract

This paper studies public good provision in the laboratory using the voluntary contribution mechanism, in a cross-cultural experiment conducted in the United States and Japan. Our environment differs from the standard voluntary contribution mechanism because subjects first decide whether or not to participate in providing this public good. This participation decision is conveyed to the other subject prior to the subjects' contribution decisions. We find that only the American data support the evolutionary stable strategy Nash equilibrium predictions, and that behavior is significantly different across countries. Japanese subjects are more likely to act spitefully in the early periods of the experiment, even though our design changes subject pairings each period so that subjects never interact twice with the same opponent. Surprisingly, this spiteful behavior eventually leads to more efficient public good contributions for Japanese subjects than for American subjects.

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Voluntary Participation and Spite in Public Good Provision Experiments:

An International Comparison

1. Introduction

Culture and national character have played a central role in explaining differences in business management and performance across countries, both in the popular press and in management research. Theoretical research in economics, however, almost universally fails to consider cultural differences, although recent laboratory research has identified the potential role of cultural norms in influencing economic outcomes—particularly in the context of bargaining (e.g., Buchan, Johnson and Croson, 1999; Kachelmeier and Shehata, 1992; Roth et al., 1991). This cultural influence often arises through differences in *fairness* norms. For example, if someone feels that they are being treated unfairly, this may trigger a *spiteful* response; i.e., "a malicious desire to harm...another person."[1] If this desire is triggered by harmful actions of the other person towards oneself, this spiteful response should be viewed as (negative) reciprocal behavior.

In this paper we examine spiteful behavior and cultural differences by studying public good provision in the laboratory using the voluntary contribution mechanism, in experiments conducted in the United States and Japan. Our environment differs in three ways from the standard linear voluntary contribution mechanism (e.g., Isaac and Walker, 1988). First, we employ two-person groups. Second, the payoffs from the public good are nonlinear. Third, and perhaps most importantly, subjects decide whether or not to participate in funding this public good in an initial stage, and this participation decision is conveyed to the other subject prior to the subjects' contribution (or "investment") decisions. This allows reciprocity-motivated subjects to reward positive participation decisions and to spite negative participation decisions by their opponent. We find that Japanese subjects are significantly more likely to spite their opponents for non-participation, even though our design changes subject pairings each period

[1] *Random House College Dictionary*, 1979.

so that subjects never interact twice with the same opponent. Surprisingly, this spiteful behavior eventually leads to more efficient outcomes for Japanese subjects than for American subjects.

While cultural differences are inconsistent with the standard income-maximizing economic model, such differences have been well documented in psychology, sociology and anthropology. A major construct in theoretical discussions in these fields is collectivism-individualism (e.g., Hofstede, 1980). More collectivist (Eastern) cultures value group harmony over individual interests, and they often turn to the principle of equality to resolve disputes. By contrast, the individualist orientation of many Western cultures places emphasis on individual inputs and rights, with an overall goal to maximize individual rewards. These are broad generalizations, of course, but empirical research in these other disciplines has documented significant cultural differences consistent with this collectivism-individualism construct.[2]

Cultural differences have also been studied in economics and management. For example, Buchan, Johnson and Croson (1999) present a detailed review of the literature on cultural differences in bargaining and in psychology, highlighting how this research suggests that culture influences fairness norms. They then provide laboratory evidence from ultimatum bargaining that supports the hypothesis that Japanese subjects prefer earning distributions that are more equal than American subjects prefer. In ultimatum bargaining, a spiteful response is represented by a rejection of an offer that provides a significantly smaller allocation to the respondent.[3] Their findings are consistent with the interpretation in our experiment that "unfair" non-participation decisions are more likely to invoke a spiteful response by Japanese

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[2] For examples: in hypothetical award allocation problems, Japanese students perceive equal earnings as more "fair" compared to Australian students, even when efforts of the hypothetical workers were unequal (Kashima et al., 1988); when dividing earnings Chinese subjects more frequently followed an equality rule than American subjects (Leung and Bond, 1984); and Australian children more commonly followed their self-interest than Japanese children when allocating chocolate rewards (Mann et al., 1985).

[3] Buchan et al. actually use the *strategy method*, in which respondents' demands of their share of the surplus determine whether an offer is rejected. Their data indicate that Japanese respondents demand more than American respondents do, so the Japanese subjects are more likely to reject an offer of a given size.

subjects who chose to participate in funding the public good.[4] In a very different context with simple two-stage extensive form games, Beard et al. (1997) find that Japanese subjects are more willing to reject unequal payoff allocations than are American subjects. This leads to more "secure" play in the Japanese treatments; that is, the first decision maker is less likely to offer a Pareto superior but more asymmetric payoff distribution in the sessions conducted in Japan.

Although Saijo and Nakamura (1995) and others document substantial spiteful behavior by Japanese subjects, not all evidence supports the hypothesis that Japanese subjects act more spitefully than their western counterparts. In their ultimatum game study, Roth et al. (1991) find that Japanese subjects' rejection rates (controlling for the offer amount) are no higher and are sometimes lower than American subjects' rejection rates. Brandts et al. (1997) do not find significant differences in public goods contributions across three European countries and Japan, and Okada and Riedl (1999) are unable to identify significant differences in a coalition formation game conducted in Japan and Austria. Moreover, some research in management has downplayed the importance of cultural differences as an explanation for differences in performance of Japanese and Western manufacturing enterprises, emphasizing instead, for example, differences in monitoring technology (Aoki, 1988; Aron, 1990).

One possible source of the mixed results in previous economics experiments could be other differences in university subject pools. In nearly all previous experimental economics research that studies cultural differences, subjects are recruited from one university in each country. We believe that it is important to determine whether between-country differences are greater than within-country differences in behavior in order to identify cultural or nationality effects confidently. We therefore collect data at multiple universities within each country. The results indicate that nationality differences have a greater influence on outcomes than within-country university subject pool differences.

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[4] In recent work, however, Roelofs and Sigler (1998) measured the individualism and collectivism values of American subjects using a questionnaire and find little difference in public goods contribution for subjects who scored differently on these measures.

The remainder of the paper is organized as follows. Section 2 describes the laboratory environment and experimental design, and summarizes the hypotheses. Section 3 presents the results. Section 4 offers our interpretation based on recent research on non-monetary preferences (e.g., Fehr and Schmidt (1999) and Bolton and Ockenfels (1999)). Section 5 concludes.

2. Experimental Environment, Design and Hypotheses

2.1 Environment

We compare participation and investment of American and Japanese subjects using a new version of the voluntary contribution mechanism. The laboratory environment implements a two-stage game. In the first stage, subjects simultaneously choose whether or not they participate in the voluntary contribution mechanism. In the second stage, knowing the other subject's participation decision, subjects who selected participation in the first stage choose contributions to the public good.

Two subjects, *a* and *b*, may fund each public good and subject i (=a,b) has w_i units of initial endowment of a private good. Each subject who participates in funding the public good must allocate w_i between her own consumption of the private good (x_i) and her public good investment (y_i). From the total public good investment, each subject receives $y=y_a+y_b+w_y$, where w_y is the initial level of the pubic good. That is, the nonexcludable public good available for consumption by each subject is the sum of the investments of two subjects and the initial level of the public good. Note that non-participants who choose not to fund the public good still consume it, as is the usual case for the voluntary contribution mechanism. Each subject's decision problem is

$$\max u_i(x_i, y) \text{ subject to } x_i+y_i=w_i,$$

where $u_i(x_i, y)$ is subject i's payoff function. We use an identical Cobb-Douglas type payoff function to transform contributions toward the public good and consumption of the private good into each subject's payoffs: $u_i(x_i, y) = x_i^{\alpha} y^{1-\alpha}$, where $\alpha \in (0, 1)$. Using a monotonic transformation, we employ the following payoff function:

$$u_i(x_i, y) = \frac{\{x_i^{\alpha} y^{1-\alpha}\}^{\beta}}{50} + 500 .$$

Our experiment sets (w_a, w_b, w_y)=(24, 24, 3), α=0.47, and β=4.45. With these parameters, if both subjects participate in funding the public good the Nash equilibrium investment pair of the voluntary contribution mechanism is $(\hat{y}_a, \hat{y}_b)$=(7.69, 7.69), and the payoff level is $u_i(\hat{x}_i, \hat{y})$=7089, where $\hat{x}_i$=24-7.69=16.31 and $\hat{y} = \hat{y}_a + \hat{y}_b + w_y$=18.38. The Pareto efficient level of the public good is determined uniquely by the Samuelson condition and the feasibility condition. Its symmetric contribution level is (y_a^*, y_b^*)=(12.02, 12.02). Therefore, the Pareto efficient level of the public good is 27.04=12.02+12.02+3. Clearly, the level of the public good with the voluntary contribution mechanism is less than the Pareto efficient level of the public good, which is the standard problem of this provision mechanism.

The situation just described represents the case in which subjects have already committed to participate during stage 1. However, Saijo and Yamato (1999) demonstrate that a wide class of mechanisms for funding public goods exists in which subjects have incentives not to participate. The voluntary contribution mechanism is one of them. Therefore, the voluntary contribution mechanism is not *voluntary* from the viewpoint of participation incentives.

Consider now the two-stage game shown in Figure 1. In the first stage, subjects simultaneously decide whether or not to participate in the voluntary contribution mechanism. In the second stage, subjects decide how many units of their initial endowment to invest after learning the other subject's participation decision. Notice that non-participation is different from zero investment with participation. Once a subject decides to participate in the mechanism, his opponent must choose her investment *without* knowing the other subject's investment. On the other hand, if a subject chooses non-participation, then his opponent knows that he invests nothing.

In our experiment, subjects choose integer investments. If both subjects decide to participate in the mechanism, then the Nash equilibrium of that subgame is for each subject to contribute 8, and each earns 7345. No other Nash equilibria arise due to our use of a discrete strategy choice set. If one subject participates in the mechanism and the other does not, then the participant maximizes her payoff at y_i=11 and earns 2658. The non-participant invests nothing and earns 8278. If both choose not to participate in the mechanism, both subjects receive 706. These payoffs are summarized in the normal form game payoff table shown in Table 1.

The game in Table 1 is a version of the well-known Hawk-Dove game, sometimes referred to as "chicken." Although the usual representation of the public good provision problem is a Prisoners' Dilemma game, the proper representation is a game of chicken once participation in the mechanism is a choice variable. Two pure strategy Nash equilibria exist: either one of subjects participates in the mechanism. In the mixed strategy Nash equilibrium, each subject *i* chooses 0.68 as her participation probability p_i. Among these three equilibria, the mixed strategy equilibrium is the unique evolutionary stable strategy (ESS) equilibrium.[5]

2.2 Design and Procedures

We conducted three sessions in Japan and two sessions in the United States. As shown in Table 2, we conducted sessions at two different universities in each country.[6] Twenty subjects participated in each session for a total of 100 separate subjects. Each subject was randomly paired with each other subject one at a time—a so-called "strangers" design. The same game was repeated for 19 periods, 4 for practice and 15 for monetary reward, so as not to pair the same two subjects more than once. No subject had prior experience in a public good provision experiment. Sessions required approximately 2 hours to complete. The mean payoff

[5] See Maynard Smith (1982). Our use of a "strangers" design—randomly repairing subjects each period—also makes coordination on an asymmetric pure strategy equilibrium extremely difficult.

[6] We conducted two sessions in Tokyo to test whether a difference in instruction and record sheet wording—"your opponent" versus "the person you are paired with"—affects behavior. As we document below, results are substantially unaffected by this difference in phrasing. Saijo et al. (1999) presents additional analysis of the Japanese data (only) and provides further evidence that the wording does not systematically influence choices.

per subject was $26.75 ($1=100 Yen for the Japanese sessions). The maximum payoff among the 100 subjects was $38.75, and the minimum payoff was $12.25.

The twenty subjects in each session were seated at desks in a relatively large room, and each had a randomly chosen identification number. These identification numbers were not displayed publicly. In each period we made ten pairs out of the twenty subjects. The pairings were determined in advance so as not to pair the same two subjects more than once. Each subject received an experimental procedure sheet, a record sheet, payoff tables, 15 investment sheets, and 4 practice investment sheets. Instructions were given by tape recorder to minimize the interaction between subjects and experimenters.

Before choosing their investment, subjects decided whether or not they would participate in the voluntary contribution mechanism. These decisions were collected by experimenters and then redistributed to the paired subjects. After this redistribution of the participation decisions, subjects who decided to participate in the mechanism chose their investment on an investment sheet by circling an integer between 0 and 24. Experimenters collected these investment sheets and then redistributed them to the paired subjects. During the redistribution, subjects were asked to fill out the reasons why they chose these numbers. After this redistribution, subjects calculated their payoffs from the payoff tables. Then the next round started.

It was common knowledge that every subject had the same payoff function. We distributed three kinds of payoff tables to avoid any possible misunderstanding. Table 3 is the detailed payoff table provided to subjects in real rounds: the rows are for the subject's own investment numbers and the columns are for the opponent's investment numbers. We also presented a rough payoff table summarizing average payoffs for sets of 9 or 12 payoff cells shown in Table 3, as well as an iso-payoff map. Most subjects indicated in their post-experiment questionnaire that they used the detailed payoff table (Table 3) only. We gave subjects three minutes to study these three payoff tables before the practice rounds and ten minutes to study them before the real rounds. The payoff function and tables used for practice and real rounds were different.

The sessions in Japan were conducted in Japanese, and the sessions in America were conducted in English. The instructions and forms were translated from Japanese to English by the two bilingual co-authors. The exchange rate used to translate payoffs from Japan to America was $1=100 Yen.

As mentioned in the introduction, our use of multiple university subject pools in each country is an important aspect of the design for our objective to study cultural differences. Differences in results for any two universities could be due to subject pool effects unrelated to culture and nationality. To establish a significant cultural difference one must show that *between-country* differences are greater than *within-country* differences. We should also highlight the fact that there exist important similarities between sets of universities across countries. Purdue University and the University of Tsukuba both have a major emphasis on engineering and science and are both in (relatively) small "college towns" with predominantly university-resident students. By contrast, Tokyo Metropolitan University and the University of Southern California are both situated in major urban centers with many off-campus "commuter" students. Subject pool differences other than nationality and culture are therefore substantially lower within these sets of universities, and these other subject pool differences are considerably greater within countries.

2.3 Hypotheses

Our first task is to determine if behavior differs across the two countries. Therefore, we first test the following null *cultural hypotheses.*

Hypothesis 1: *The rate of participation is equal across countries.*

Hypothesis 2: *The mean investment per subject is equal across countries, (a) conditional on one subject participating and (b) conditional on both subjects participating.*

Hypothesis 3: *The overall efficiency is equal across countries.*

We also test whether within-country differences are more or less significant than between-country differences across sessions.

The second set of *equilibrium hypotheses* is based on the theoretical discussion above. Because we reject Hypotheses 1-3 in favor of significant country effects, we test the following hypotheses separately for each country.

Hypothesis 4: *The rate of participation is 68 percent, corresponding to the mixed strategy ESS participation rate.*

Hypothesis 5: *(a) Conditional on one subject participating, the mean investment for the participating subject is 11 units; and, (b) conditional on both subjects participating, the mean investment per subject is 8 units.*

3. Results

3.1 Between Country Comparison[7]

Result 1: *Hypothesis 1 is rejected in the final third of the sessions.*

Support: Panel A of Figure 2 presents the participation rate by period for each of the five sessions. In the first half of the sessions the variation in participation rates across periods is clearly more significant than any differences across sessions; however, in the final third of the sessions the American participation rates (shown with dashed lines) are always below the Japanese participation rates.

Table 4 presents a formal test of Hypothesis 1 using a random-effects probit model of the participation decision, with subjects as the random effect. It presents ten pairwise comparisons for the five sessions. The alternative to Hypothesis 1 that across-country differences are more significant than within-country differences is supported: five of the six

[7] Unfortunately, subject 11 in the USC session was confused regarding the subject identification numbers and investment choices. She was the only subject (of the 100) that participated in this experiment who appeared confused. She thought the identification numbers were the investment choices, so she typically used her opponent's identification number (rather than her opponent's investment choice) when calculating her payoffs. In what follows we remove this obviously confused subject from the data prior to analysis, but our qualitative conclusions are generally robust when statistics are recalculated using this confused subject.

across-country comparisons shown in the highlighted box in the lower left of the table are significant (at the ten-percent level), while none of the four within-country comparisons are significant.

Panel B of Figure 2 presents the same data pooled within the two countries. The pooled random effects probit model strongly rejects the hypothesis of no country differences (*t*=3.05). We also compared participation frequencies across countries by period using Fisher's exact test. This nonparametric test rejects the null hypothesis of equal participation rates at the five-percent significance level in periods 6, 11, 12, 13, 14 and 15.

Result 2: *Hypothesis 2(a) is rejected but Hypothesis 2(b) is not.*

Support: Panel A of Figure 3 presents mean investments by the participating subject when only one subject participates, for each of the five sessions. Substantial variation exists across periods, partly because these means (by session) are often based on a small sample size—typically three or four subjects due to the high participation rates illustrated in Figure 2. In addition to the substantial variability, careful inspection of Figure 3A suggests the impression that investments are often higher in the American sessions (the dashed lines). For example, mean investments in the two American sessions exceed those in all three Japanese sessions in 4 periods, and with the exception of the final period a Japanese session always has the lowest mean investment.

Table 5 formalizes the sessions' comparison with one participating subject using a random effects model. Four of the six across country investment differences are significant, while only one of the four within country differences is significant. Panel B of Figure 3 presents mean investments along with standard error bands when pooling the sessions within a country. This figure indicates that investments with one participant are lower in the Japanese sessions, by about two units on average. Pooling across periods and across countries with a random effects model, Hypothesis 2(a) is strongly rejected (*t*=4.56). Moreover, a period-by-period nonparametric Wilcoxon signed rank test rejects Hypothesis 2(a) at the five- percent level in periods 3, 8 and 11.

Figure 4 presents mean investments when both subjects participate. These data fail to reject Hypothesis 2(b), indicating no systematic differences in investments across countries when both subjects participate. The pairwise session comparisons shown in Table 6 often support significant within country differences and often fail to detect significant across country differences. Overall, differences across sessions are small in real terms, and Panel B of Figure 4 indicates that the pooled country effect on investments with both subjects participating is insignificant (pooled random effects model t=1.89).

3.2 Equilibrium Hypotheses

Result 3: *Hypothesis 4 is supported in the American data, but not the Japanese data.*

Support: Panel B of Figure 2 presents the participation rate by period, pooled within countries. With the exception of period 1, the participation rate in the Japanese data exceeds the mixed strategy ESS prediction of 68 percent in every period. The participation rate in the American data fluctuates around the mixed strategy prediction, exceeding the predicted rate in about one-half of the periods. We test the null hypothesis that the participation rate is 68 percent using a binomial test. Under this null hypothesis, the probability of observing 48 or more participation decisions out of 60 (80 percent) is less than five percent. The Japanese participation rate exceeds this critical 5-percent threshold in periods 5 through 7 and periods 10 through 15. For the American sample we have 39 subjects (recall that we omit the confused subject in the USC session; cf. footnote 6). Under the null hypothesis of a 68 percent participation rate, the probability of observing 32 or more participation decisions out of 39 (82 percent) is less than five percent. The American participation rate exceeds this critical value only in period 4.

Tests of a mixed strategy equilibrium based on aggregate choice frequencies may mask differences across individuals' choice frequencies that may or may not be consistent with a mixed strategy equilibrium (Brown and Rosenthal, 1990). We therefore also examined the overall participation rates separately for each of the 99 subjects. The mean participation rate among the 60 Japanese subjects was 0.80 (12 of 15 decisions), and the median participation rate was 0.87 (13 of 15 decisions). The corresponding mean and median participation rates for the 39 American subjects were 0.69 and 0.73. Note that the ESS rate of 0.68 implies on average slightly more than 10 participation decisions. Only 14 of the 60 Japanese subjects (23.3%) participated 10 times or less, while the other 46 Japanese subjects (76.6%) participated 11 times or more. The frequency of participation rates below and above the ESS prediction was more even among the 39 American subjects—17 (43.6%) below and 22 (56.4%) above. Fifteen of the 60 Japanese subjects (25%) and 5 of the 39 American subjects (12.8%) were apparently using a pure strategy, as they participated in 15 out of 15 periods. Using the 60 separate subject observations, the Japanese data reject the ESS prediction of 0.68 at better than the 0.0001 significance level using the non-parametric Wilcoxon signed-rank test. This same test does not reject the ESS participation rate in the American data (Wilcoxon p-value=0.61).

Result 4: *Hypothesis 5 is supported in the American data but not the Japanese data, although the evidence against Hypothesis 5(b) is relatively weak in the Japanese data.*

Support: Panel B of Figure 3 presents the average investment pooled within countries with one subject participating. Mean investment falls below the prediction of 11 for both countries, but investments are lower in the Japanese data (Result 2). Over all 136 investments with one participant in the Japanese sessions, 43 (32%) were 11; over all 122 investments with one participant in the American sessions, 77 (63%) were 11. Period-by-period Wilcoxon signed rank tests reject the null hypothesis of 11 at the five- percent level for the Japanese data in periods 1 through 4, 8 and 10 through 12. This same test never rejects the null in the American data. The sample size is slightly smaller for these tests in the American data (an average of 8.1 observations per period for the American data versus an average of 9.1 for the Japanese data), but this lower power is unlikely to be the main cause of the lack of significance in the American data.

Panel B of Figure 4 presents the average investment by country when both subjects participate. The American data reject the Nash prediction of 8 at the five- percent level only in periods 9, 10 and 11 (Wilcoxon test). The Japanese data reject the Nash equilibrium using this same test in all periods *except* periods 1 and 4. Nevertheless, compared to the case of one participant (Figure 3B), the Nash equilibrium has substantial drawing power overall. We therefore conclude that Hypothesis 5(b) is not rejected economically in both countries.

3.3 Efficiency

Result 5: *Hypothesis 3 is rejected in the final third of the sessions.*

Support: Figure 5 presents the average efficiency—defined as the percentage of the maximum available earnings realized by subjects—for the Japanese and American sessions by period. If both subjects participate and choose the Pareto optimal investment of 12, they each earn 9090.[8] If both subjects participate and choose the Nash investment of 8, they each earn 7345, for an efficiency of 7345/9090=81 percent. This is displayed on the figure as a horizontal dashed line. The horizontal solid line on the figure displays the predicted efficiency of the ESS equilibrium, 5829/9090=64 percent.

The average efficiency differences in the two countries are not significant at the five-percent level in any individual period using a Wilcoxon test. Figure 5 suggests, however, that efficiency in the Japanese data begins to exceed efficiency in the American data toward the end of the sessions. This is due to the greater participation among Japanese subjects (c.f. Figure 2). When pooling periods into the first, middle and final thirds of the session, a Wilcoxon test rejects the hypothesis that efficiency is equal across countries, but only in the final third of the session (p-value<0.01).[9]

4. Summary and Interpretation

The overall pattern of our results can be summarized as follows. The American data are roughly consistent with the mixed strategy ESS equilibrium of this two-stage game (Results 3

[8] Asymmetric collusion could generate even higher payoffs, but such coordination is extremely difficult in this strangers design that randomly reassigns pairs each period.

[9] We would have preferred to use a random effects model for this test that pools observations across periods, as we do elsewhere in this paper. The efficiency observation is defined for *pairs* of subjects, however, and in our strangers design the pairs were randomly reassigned each period. Therefore, random subject or random pair effect specifications are impossible.

and 4). In the Japanese data, this equilibrium is generally rejected. Behavior of Japanese and American subjects is typically significantly different (Results 1 and 2). Relative to their American counterparts, Japanese subjects tended to participate more and invest less when only one subject of the pair chose to participate. This presents an important puzzle: What is different between Japanese and American subjects that could explain their differences in behavior? As discussed in the introduction, differences in the propensity to spite one's opponent can explain these differences across countries.

To see how these differences arise, consider the initial 5 periods of play. Participation rates are similar across countries for these initial periods (Figure 2B). However, the investment by the participating subject when only one subject participates is substantially higher in the American data than in the Japanese data for these initial periods (Figure 3B). That is, the Japanese subjects appear much more willing to "punish" their opponent for not participating. By investing, say, 7 instead of the best response of 11, the participating subject reduces her payoff from 2658 to 2210, a difference of 448. This spiteful behavior reduces the non-participating subject's payoff from 8278 (if his opponent invests the best response of 11) to 4018 (if his opponent instead invests 7), a difference of 4260. In this environment, a spiteful subject can sacrifice only a small amount to punish her opponent severely. This is similar to rejecting a relatively low offer in the ultimatum game.

But why would subjects reduce their own earnings to punish non-participants, especially since they never encounter the same subject twice in this strangers design?[10] This is a problem familiar to experimental economists and it arises repeatedly in bargaining and other laboratory games. The evidence seems clear that subjects in many situations do not seek simply to maximize monetary earnings, and several recent studies have introduced non-monetary factors into players' objective functions (Fehr and Schmidt, 1999; Bolton and Ockenfels, 1999; Levine, 1998). For example, in Bolton and Ockenfels' model of equity, reciprocity and

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[10] We even observe non-payoff-maximizing contributions in the final period 15, even though the final period was announced in the instructions (see Figure 3).

competition (ERC), individuals are motivated by their relative payoff standing in addition to their own pecuniary payoff. Their model is consistent with results from ultimatum and dictator experiments, gift exchange games, and market (Bertrand and Cournot) experiments, among others.

Similarly, in Fehr and Schmidt's model subjects have "inequity aversion," so they prefer higher but equal earnings among participants in their group. Utility payoffs are equal to monetary payoffs less inequity costs that rise as the difference between a subject's own and other's monetary payoff increases.[11] In the model some subjects suffer both from earning more as well as earning less than their counterparts, but the cost of advantageous inequality is assumed to be no more than the cost of disadvantageous inequality. Fehr and Schmidt demonstrate that their model can describe many outcomes in ultimatum games, market games with both proposer and responder competition, as well linear voluntary contribution mechanism games with and without punishment opportunities. They even go as far as to derive parameter distributions of the relative tradeoff of monetary gains and inequity aversion that describes behavior across games, which we can use to assess conveniently the effectiveness of this approach in describing the new data reported here. Applying their distribution of preferences to our subjects, it is straightforward to show that when only one subject participates the optimal contribution is 11 for 30 percent of the subjects (these 30 percent are standard "money-maximizers"), is 6 for 30 percent of the subjects, is 4 for another 30 percent of the subjects, and is 1 for the remaining 10 percent.[12] The mean of this distribution is 6.4.

The distribution of contributions in the Japanese data is remarkably close to this predicted distribution if one makes allowances for a bit of choice error for the lower contributions. Figure 6 shows that when they are the only participant, 32 percent of the Japanese subjects contributed 11, 26 percent contributed 6 or 7, 11 percent contributed 3 or 4,

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[11] In particular, for a two-person game player i's utility is $U_i(x) = x_i - \alpha_i \max\{x_j - x_i, 0\} - \beta_i \max\{x_i - x_j, 0\}$, $i \neq j$, where x_k denotes monetary earnings ($k = i, j$), $\alpha_i \geq \beta_i$, and $1 > \beta_i \geq 0$.

[12] For this calculation one only needs the distribution of α, because the participant's earnings are always lower than the non-participant's earnings. β is only used for cases of advantageous inequality. We use Fehr and Schmidt's distribution of $\alpha = \{0, 0.5, 1, 4\}$ in proportions of $\{0.3, 0.3, 0.3, 0.1\}$.

and 13 percent contributed 0 or 1. However, the point we wish to emphasize is that the Fehr and Schmidt model—and the related models of Bolton and Ockenfels (1999) and Levine (1998)—are culturally neutral. Consequently, they cannot explain the difference in the Japanese and American results.

One interpretation is that the Fehr and Schmidt model is a good approximation for the American subject pool, but that the distribution of preference types is different than in the Japanese subject pool. Figure 6 shows that when they are the only participant, 63 percent of the American subjects contributed 11, 13 percent contributed 6 or 7, 3 percent contributed 3 or 4, and 7 percent contributed 0 or 1. That is, one needs to raise the proportion of subjects with α=0 to describe the American data. Alternatively, our results suggest that refitting the Fehr and Schmidt model to the American data is less appealing than simply retaining the standard money-maximizing model of preferences. After all, the American data are broadly consistent with this standard model (Results 3 and 4).

A consequence of the low contributions by the Japanese subjects when they are the only participant is to considerably reduce the incentives for Japanese subjects to forego participation. In the Fehr and Schmidt model, some subjects prefer not to earn *more* than the other subject does, all other things equal. But the incentive to participate in the Japanese data is clear even based on only the monetary payoffs. Table 7 summarizes the normal form game for the participation decision based on *realized* average monetary earnings during the first 5 periods in the two countries. Compare these payoff tables with the theoretical monetary payoffs based on the stage two Nash equilibrium shown in Table 1. The realized monetary payoff matrix based on the early Japanese data (Table 7A) indicates that *participation is a dominant strategy*. The early experience of Japanese subjects indicates that "non-participation doesn't pay," and we believe this is a primary explanation of the high participation rate (rejecting the ESS prediction of 68 percent) observed in the Japanese data. By contrast, for the American data (Table 7B), all monetary payoffs are reduced compared to the theoretical predictions in Table 1 (except, of course when both fail to participate); however, the Hawk-Dove property of this payoff matrix is preserved.[13]

To summarize, consistent with models that include relative payoffs in the utility function such as Bolton and Ockenfels (1999) and Fehr and Schmidt (1999), we find that Japanese subjects often punish opponents who fail to participate. This punishment occurs even though our design allows subjects to interact only once during the experiment (recall that this is common knowledge). This (non-myopic best response) behavior by Japanese subjects increases their participation relative to their American counterparts who behave roughly consistent with the standard money-maximizing model. Perhaps most striking is that the increased participation observed for the Japanese subjects eventually increases efficiency compared to the efficiency of the money-maximizing Americans. Evaluated in isolation, spite may not seem to be a desirable cultural or personality trait; but in strategic environments such as this one, it improves efficiency.

5. Conclusion

In this paper we presented a laboratory experiment in two-person public goods provision, in which subjects first announce whether they will participate in the voluntary contribution mechanism. The subgame perfect Nash equilibrium of this game applies, of course, to any economic decision-makers regardless of their cultural background. The evolutionary stable strategy equilibrium of this game involves participation about two-thirds of the time. This prediction, as well as many others we test, is supported only for the data gathered using American subjects. Japanese subjects participated more often than the ESS prediction. This "over-participation" generated efficiency that exceeds that observed for American subjects toward the end of the sessions.

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[13] In an earlier version of this paper (Cason et al., 1998) we also presented a simple reinforcement learning model to demonstrate that subjects' participation decisions respond to their previous experience. In particular, we show that subjects are more likely to participate if their earnings when participating in previous periods increase relative to their earnings when not participating in previous periods.

Although the data from the Japanese sessions generally fail to support the theoretical equilibria based on only pecuniary payoffs, they are consistent with alternative utility payoffs that include nonpecuniary considerations (Bolton and Ockenfels, 1999; Fehr and Schmidt, 1999). We observe Japanese subjects who frequently "punish" non-participants with low contributions, and this kind of (negative) reciprocal behavior is how we interpret the term "spite" in our context, as distinct from simple rivalistic behavior in which a subject seeks merely to earn more than his opponent. The data are inconsistent with such rivalistic motivations, because such motivations are more likely to lead to *less* participation than the ESS prediction since nonparticipation guarantees payoffs greater than or equal to those of the opponent. It is also unlikely that rivalistic choices would be so close to the Nash equilibrium when both subjects participate (Figure 4) because rivalistic subjects have a strong incentive to reduce their public good investment.

Our results regarding the differences across countries are consistent with the hypothesis that Japanese subjects have a greater propensity to spite their opponents who fail to participate in funding the public good. This spiteful tendency of Japanese subjects has been identified in different previous public good environments (Saijo and Nakamura, 1995), but in the present setting it leads to more efficient outcomes than realized by American subjects. These individualized punishments are a special feature of two-person public goods environments, although spiteful punishments have also been observed recently in larger public goods groups when punishments can be directed to specific individuals—and this behavior also improves efficiency (Fehr and Gachter, 1998). In future research we plan to interact Japanese and American subjects in the *same* sessions in environments such as this and the ultimatum game. This will indicate whether the lack of a shared cultural background initially increases disequilibrium behavior (e.g., spiteful rejections).

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	Player 2: Participate p_2	Not Participate $1-p_2$
Player 1: Participate p_1	7345, 7345	2658, 8278
Not Participate $1-p_1$	8278, 2658	706, 706

Nash equilibria: (p_1, p_2) = (1, 0), (0, 1), (0.68, 0.68)

Evolutionary Stable Strategy (ESS): (p_1, p_2) = (0.68, 0.68)

Table 1. First Stage Participation Payoffs Based on Nash Equilibrium Investments in the Second Stage

Session Name	Voluntary Participation?	University	Country
Tsukuba	Yes	Univ. of Tsukuba	Japan
USC[a]	Yes	Univ. of So. Calif.	United States
Tokyo	Yes	Tokyo Metro. Univ.	Japan
Tokyo′[b]	Yes	Tokyo Metro. Univ.	Japan
Purdue	Yes	Purdue University	United States

Notes: Each session employed 20 subjects for 4 practice periods and 15 actual periods. Subjects were randomly re-paired each period.

[a] One subject in the USC session misunderstood the instructions, and her choices are removed from the data prior to the analysis.

[b] The instructions wording in the Tokyo′ session differed slightly from the other 4 sessions as a robustness check. In the Tokyo′ session the phrase "the person you are paired with" replaced the phrase "your opponent" everywhere in the instructions, record sheets, questionnaires and payoff tables.

Table 2. Summary of Five Laboratory Sessions

Your Investment Number

Your Opponent's Investment Number

Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648	2585	2470	2309	2106	1871	1614	1349	1091	858	669	543	500
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001	2905	2755	2555	2313	2038	1743	1443	1154	894	685	548	500
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385	3252	3061	2819	2534	2217	1881	1543	1220	933	703	552	500
3	1554	1888	2232	2575	2902	3202	3463	3675	3831	3925	3952	3911	3801	3626	3391	3102	2770	2406	2027	1648	1290	973	721	556	500
4	2017	2401	2787	3160	3508	3817	4078	4281	4420	4488	4483	4403	4250	4028	3743	3404	3020	2608	2181	1759	1363	1015	740	561	500
5	2578	3010	3432	3831	4193	4507	4762	4950	5064	5101	5057	4934	4733	4459	4119	3725	3287	2821	2344	1877	1441	1060	760	566	500
6	3244	3718	4171	4590	4960	5272	5515	5681	5766	5765	5677	5504	5249	4918	4519	4065	3568	3045	2516	2000	1522	1106	781	571	500
7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800	5406	4944	4425	3866	3282	2696	2129	1607	1155	802	576	500
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385	5924	5393	4806	4179	3532	2886	2265	1696	1206	825	582	500
9	5907	6475	6984	7422	7779	8043	8209	8271	8225	8073	7816	7458	7007	6472	5867	5207	4508	3793	3084	2407	1789	1259	849	588	500
10	7031	7616	8130	8561	8897	9132	9257	9270	9168	8951	8624	8193	7664	7051	6367	5628	4854	4067	3292	2555	1886	1315	874	594	500
11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359	7661	6892	6070	5217	4354	3509	2710	1987	1372	899	600	500
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090	8302	7444	6534	5596	4654	3736	2871	2092	1432	926	606	500
13	11158	11749	12229	12589	12820	12916	12875	12694	12376	11925	11349	10656	9860	8976	8022	7019	5992	4967	3972	3039	2201	1494	953	613	500
14	12796	13372	13824	14144	14323	14356	14243	13982	13576	13033	12358	11565	10667	9681	8627	7526	6406	5292	4217	3213	2315	1559	982	620	500
15	14570	15123	15538	15808	15925	15888	15694	15344	14844	14199	13420	12520	11514	10419	9258	8055	6836	5631	4473	3394	2433	1626	1012	627	500
16	16484	17003	17372	17583	17630	17513	17229	16783	16179	15426	14535	13521	12399	11191	9918	8606	7285	5984	4738	3582	2555	1695	1042	635	500
17	18539	19016	19328	19471	19439	19232	18850	18299	17583	16714	15704	14568	13324	11995	10605	9180	7751	6350	5013	3777	2681	1767	1074	642	500
18	20739	21163	21409	21474	21353	21047	20559	19893	19057	18064	16926	15661	14290	12834	11320	9776	8235	6730	5298	3978	2812	1841	1107	650	500
19	23086	23447	23617	23594	23374	22960	22355	21566	20602	19476	18203	16803	15296	13706	12063	10395	8737	7123	5593	4187	2947	1917	1141	659	500
20	25583	25870	25954	25832	25504	24972	24241	23319	22218	20951	19536	17992	16342	14614	12835	11038	9257	7531	5899	4403	3087	1996	1176	667	500
21	28231	28433	28420	28190	27743	27083	26217	25154	23907	22491	20924	19230	17431	15556	13636	11704	9796	7953	6214	4625	3231	2078	1212	676	500
22	31034	31141	31020	30670	30094	29296	28285	27071	25669	24095	22370	20516	18561	16533	14465	12393	10354	8388	6540	4855	3380	2162	1249	685	500
23	33993	33993	33753	33273	32557	31611	30445	29071	27505	25764	23872	21852	19733	17546	15325	13106	10930	8838	6877	5092	3533	2248	1287	694	500
24	37111	36993	36622	36001	35135	34030	32699	31155	29416	27500	25432	23239	20949	18595	16214	13843	11525	9303	7224	5337	3691	2337	1326	703	500

Table 3. Detailed Payoff Table Provided to Subjects

Session	Session: USC	Purdue	Tsukuba	Tokyo
Purdue	0.505 (0.615)			
Tsukuba	1.648* (0.099)	0.934 (0.350)		
Tokyo	2.727* (0.006)	1.888* (0.059)	0.970 (0.332)	
Tokyo′	2.455* (0.014)	1.720* (0.085)	0.690 (0.490)	0.261 (0.794)

Notes: In each cell, the first number is the *t*-statistic testing the null hypothesis that the participation probability does not differ between the row session and the column session, using a random effects probit model (with the subject as the random effect). The number in parentheses is the *p*-value associated with the test statistic. The statistics that reject the null hypothesis of no differences across sessions at the ten-percent level are highlighted with asterisks.

Table 4. Participation Rate Tests Across Sessions: Pooled Across Rounds using a Random Effects Error Specification

Session	Session: USC	Purdue	Tsukuba	Tokyo
Purdue	1.628 (0.104)			
Tsukuba	0.405 (0.685)	2.961* (0.003)		
Tokyo	2.485* (0.013)	6.639* (0.000)	2.199* (0.028)	
Tokyo′	1.558 (0.119)	4.234* (0.000)	1.574 (0.116)	0.793 (0.428)

Notes: In each cell, the first number is the *t*-statistic testing the null hypothesis that the mean investment with one subject participating does not differ between the row session and the column session, using a random effects model (with the subject as the random effect). The number in parentheses is the *p*-value associated with the test statistic. The statistics that reject the null hypothesis of no differences across sessions at the ten-percent level are highlighted with asterisks.

Table 5. Mean Investment with One Subject Participating Tests Across Sessions: Pooled Across Rounds using a Random Effects Error Specification

Session	USC	Purdue	Tsukuba	Tokyo
Purdue	2.272* (0.023)			
Tsukuba	1.240 (0.215)	1.974* (0.048)		
Tokyo	1.330 (0.184)	4.611* (0.000)	3.281* (0.001)	
Tokyo′	1.218 (0.223)	1.268 (0.205)	1.084 (0.278)	3.825* (0.000)

Notes: In each cell, the first number is the *t*-statistic testing the null hypothesis that the mean investment with both subjects participating does not differ between the row session and the column session, using a random effects model (with the subject as the random effect). The number in parentheses is the *p*-value associated with the test statistic. The statistics that reject the null hypothesis of no differences across sessions at the ten-percent level are highlighted with asterisks.

Table 6. Mean Investment with Both Subjects Participating Tests Across Sessions: Pooled Across Rounds using a Random Effects Error Specification

Player 1:	Player 2: Participate p_2	Not Participate $1-p_2$
Participate p_1	6570, 6570	2049, 4795
Not Participate $1-p_1$	4795, 2049	706, 706

Table 7A. First Stage Participation Payoffs Based on Average Payoffs in the Second Stage Through Period 5 (Japanese Data)

Player 1:	Player 2: Participate p_2	Not Participate $1-p_2$
Participate p_1	7167, 7167	2400, 7279
Not Participate $1-p_1$	7279, 2400	706, 706

Table 7B. First Stage Participation Payoffs Based on Average Payoffs in the Second Stage Through Period 5 (American Data)

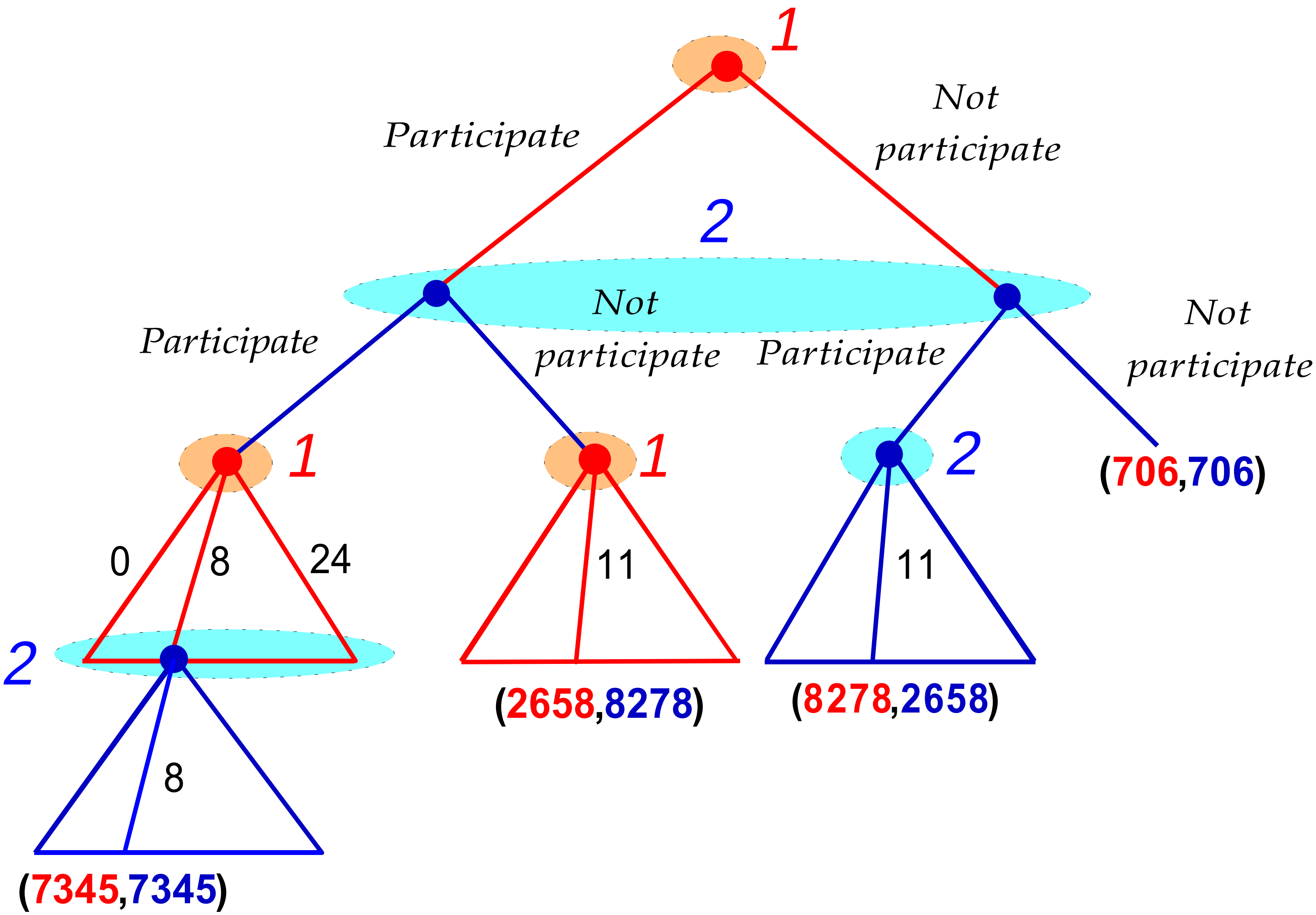

Figure 1. The game tree when subjects can choose whether or not to participate in the voluntary contribution mechanism.

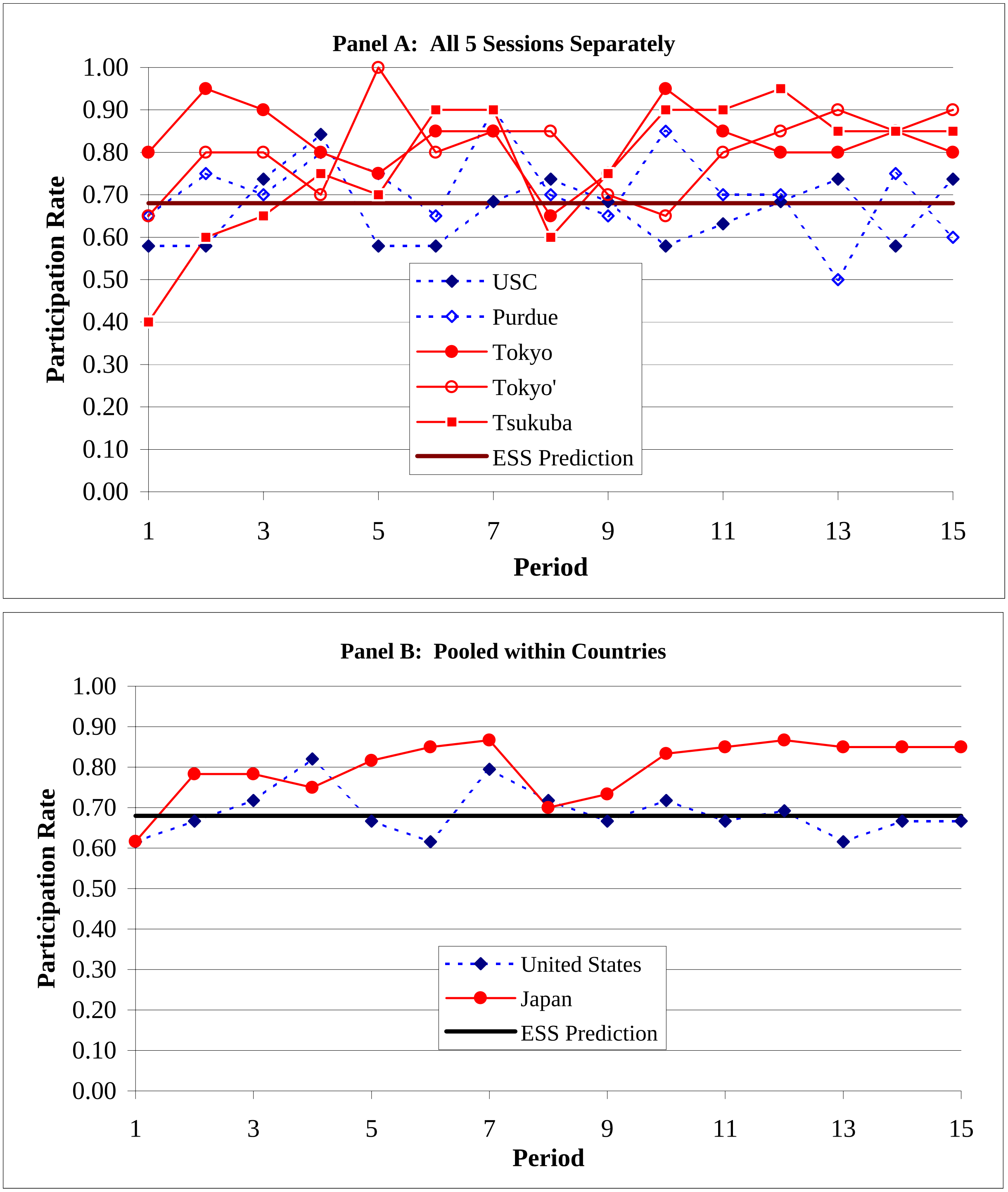

Figure 2: Participation Rate, by Session and by Country

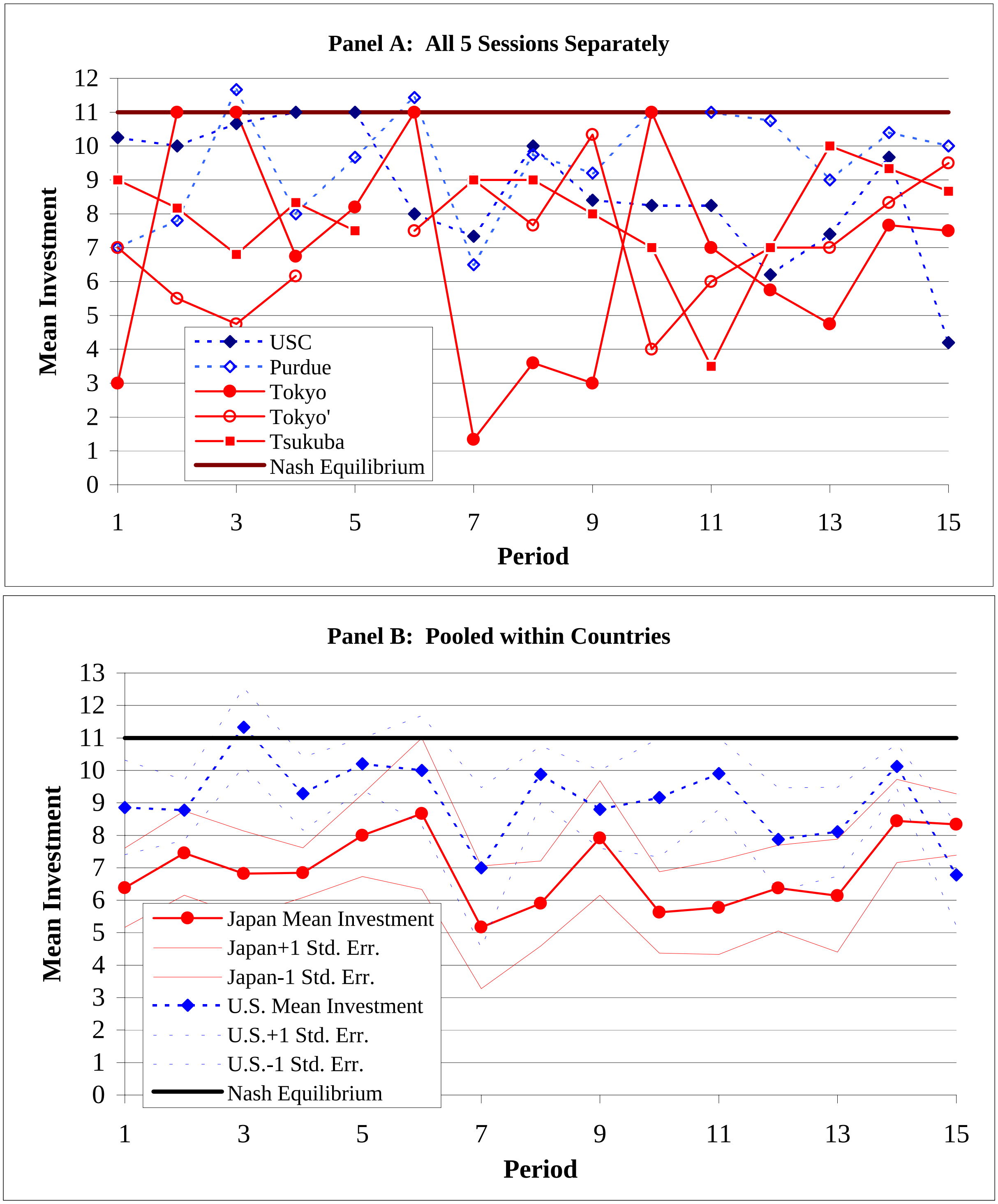

Figure 3: Mean Investment when only One Subject Participates, by Session and by Country

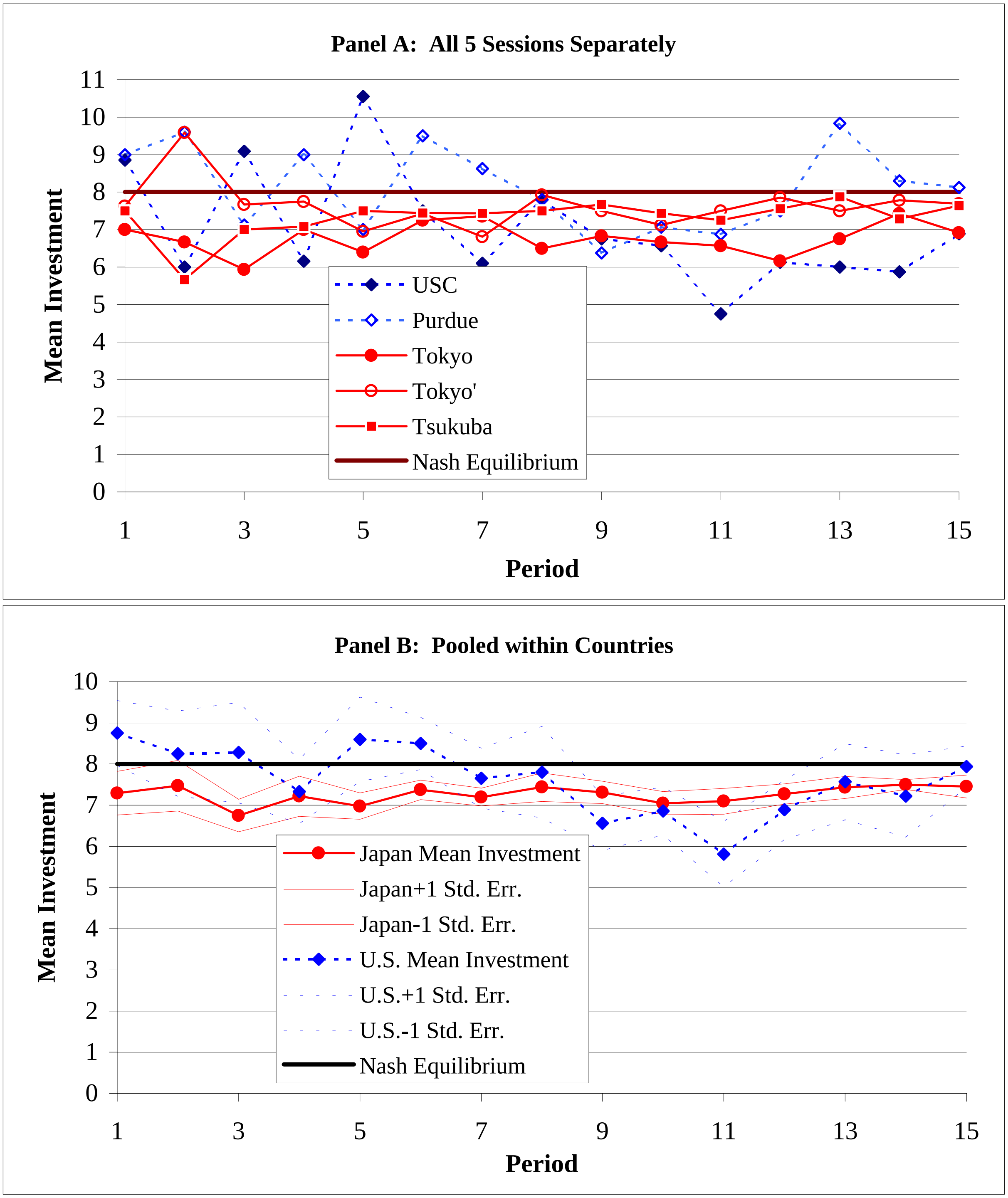

Figure 4: Mean Investment per Subject when Both Subjects Participate, by Session and by Country

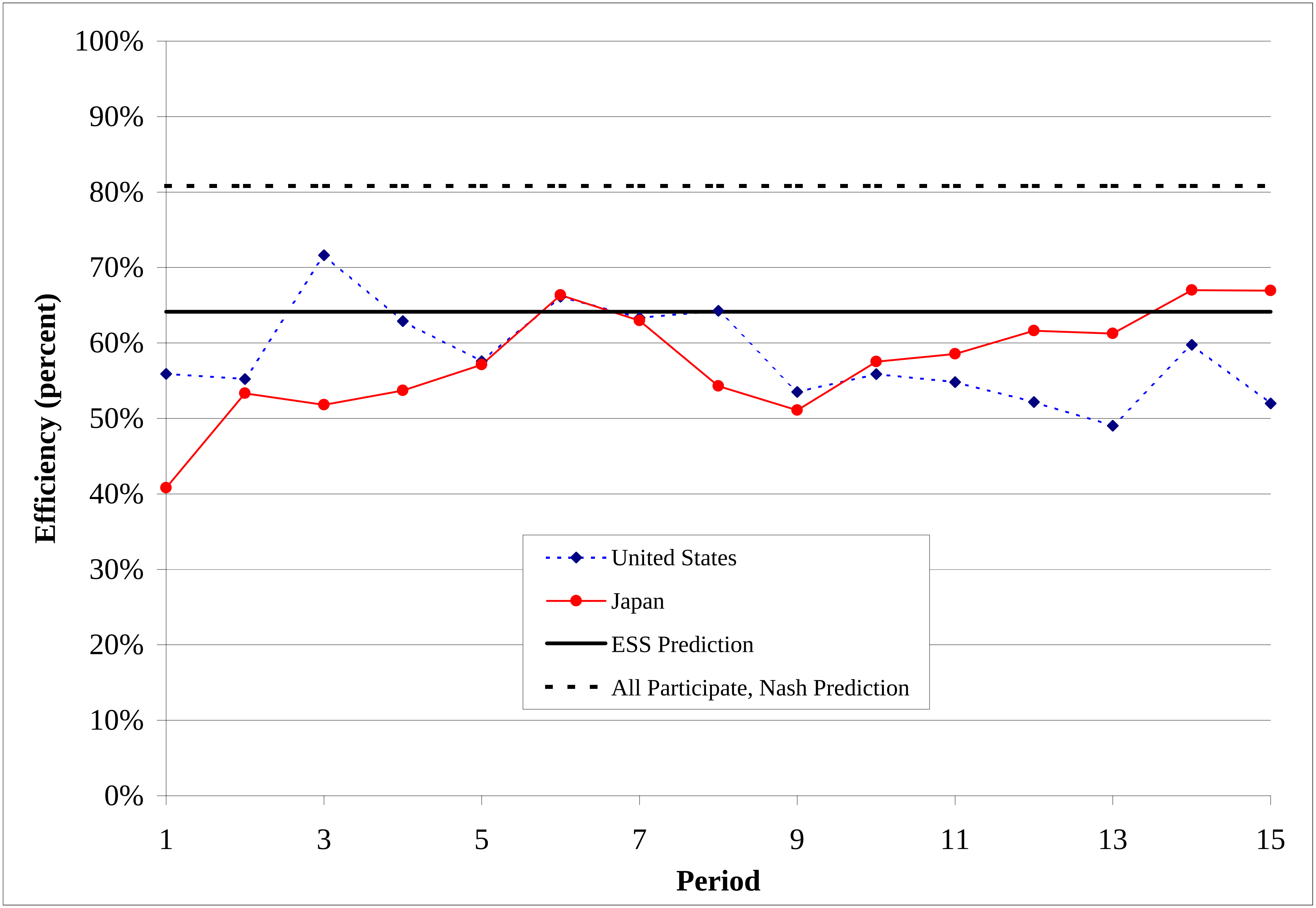

Figure 5: Average Efficiency, by Country

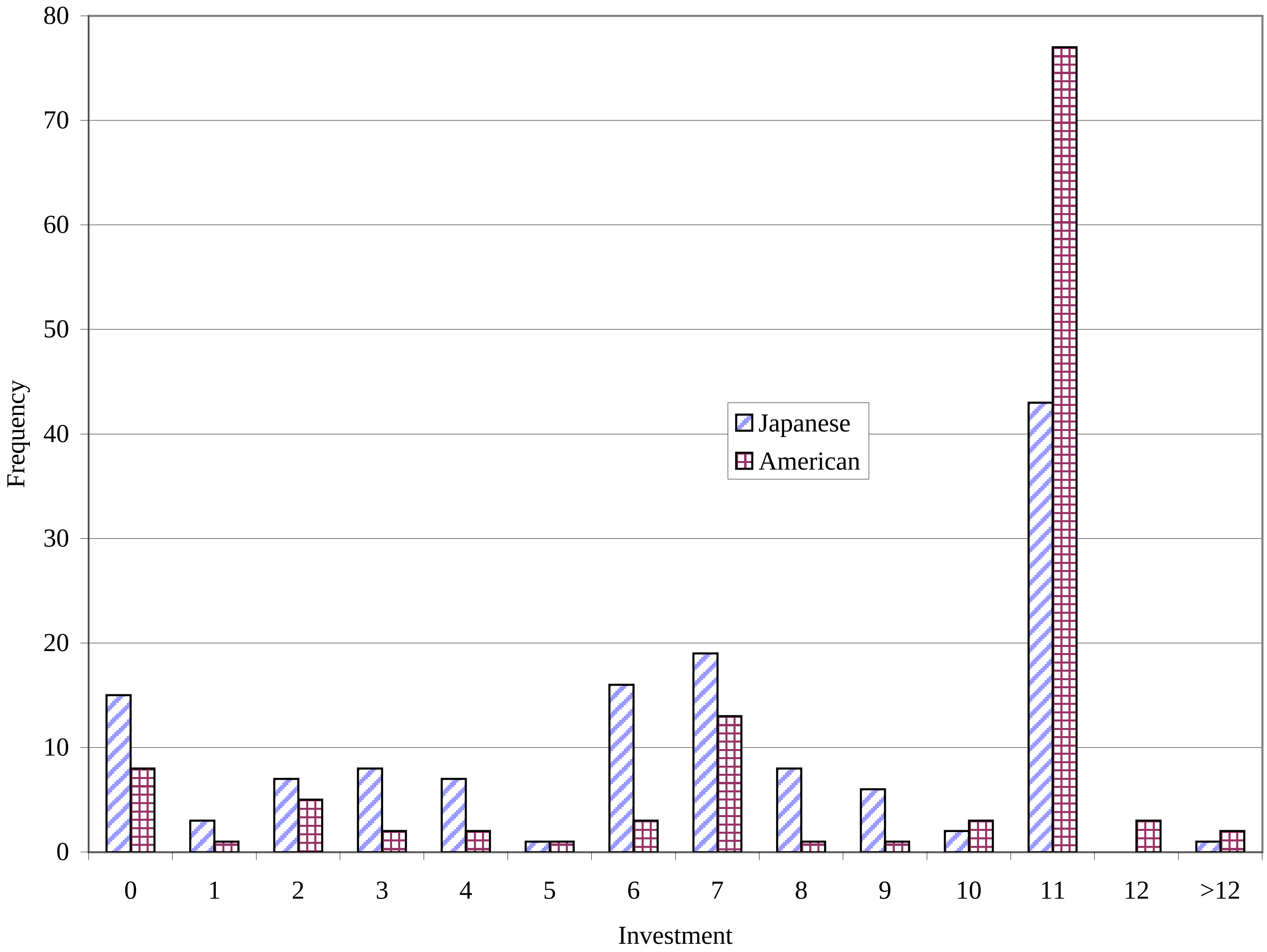

Figure 6: Distribution of Investment when only One Subject Participates, by Country (All Periods)