"Playing Safe in Coordination Games" (PSCG) was motivated by Harsanyi and Selten's solution concept for coordination games. Harsanyi and Selten postulate an lexicographic ordering of payoff and risk dominance.[1] According to their theory, payoff dominance is the first criterion to be applied if both criteria are conflicting. This directly leads to the prediction that if there exists only one payoff dominant equilibrium in the game, it will be chosen most of the time. This lexicographic ordering is, however, not a very plausible concept. Skepticism is nourished by the fact that standard economic theory would suggest a different approach to predicting experimental behavior in coordination games. Microeconomics teaches us that Economic actors are willing to accept certain risks, if the gains are large enough to outweigh the risk. Equilibrium selection would accordingly depend on risk as well as payoff dominance. These theoretical considerations were backed up further by the experiments conducted by Straub and Friedman. Straub found some evidence indicating a trade-off between payoff and risk dominance and Friedman showed that the number of payoff dominant plays increases with a widening gap between the 2 Nash equilibrium. This experimental evidence as well as van Damme's theoretical argument that payoff dominance in coordination games would have to be based on a notion of collective rationality led to the research idea and results presented in PSCG.

The experimental design consists of four different game structures that were played four times (3 inexperienced and one experienced) in each of the two different phases using either the fixed or the random match protocol. Phase I consisted of subjects playing the same game structure across 8 decision rounds obtaining feedback about the outcome every time. Phase II consisted of four different games played at once without feedback. The reason for the two matching protocols was to test for the role of social history (in the random match case) and the role of reputation (in the fixed match case). Social history in this context is defined as the experience players accumulated by playing against other players (without ever playing the same person twice and thus coming close to a one-shot game). In this context players can only get a general idea of how future players will react and therefore the authors expected deductive reasoning to prevail. Deductive reasoning on the part of the players simply means that because the use of past experience to predict future behavior involves a considerable amount of noise, subjects rely more heavily on the information inherent to the game structure and its logical implications. In the fixed match protocol the authors expected inductive reasoning to play a somewhat greater role because of experience collected in past games. The "reputation" of the player is known to its opponent, who can adjust his behavior accordingly. Even though inductive reasoning is not logically sound (that something happened repeatedly in the past does not guarantee that it will happen in the future, even for human beings), it seems to guide behavior in an astonishing way.

All subjects that participated in those experiments were volunteers, drawn from the undergraduate population of Indiana University in cohorts of size 10. Subjects earned an average of $15 to $20 by participating for approximately 45 minutes. After being randomly assigned to a computer station, the computerized instructions for

[•] Critical summary of: Playing Safe in Coordination Games: The Role of Risk Dominance, Payoff Dominance, Social History, and Reputation, Working Paper W97-12, Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, by Schmidt, D., Shupp, R., Walker, J. M., Ostrom, E.

[1] Payoff dominance suggests that if there are multiple Nash equilibrium in a game, the players should chose the one that uniformly generates the higher payoffs. Risk dominance suggests that rational players will pick the equilibrium that appears less risky, given the payoffs of the game, if they do not exactly know what the other player will chose.

Phase I informed the subjects that they would participate in a series of 2x2 symmetric bi-matrix games. Depending on whether the group was assigned a random match or fixed match protocol, the subjects were told either that they would be randomly matched with other subjects without ever playing the same person twice or that they would be playing against the same person for the whole time. Since the computer was used to match the subject's decisions, no subject new whom he was playing in both protocols. The game played within each decision round was described as a board game with the choice between option A and B. The payoff structure was common knowledge and the screens were arranged in a way that each player saw himself as a row player. After each round the subjects were informed about the outcome of their game. Subjects did not receive any information about other matches (outcomes).

After the completion of Phase I, subjects received a handout describing Phase II. The subjects were presented with a game sheet that contained all four 2x2 symmetric bi-matrix coordination games and were told to choose either A or B. As before, subjects in the fixed match protocol were informed they would be matched with the same person they were matched in Phase I and subjects in the random match protocol were informed they would be matched with a person they were never matched with before. Upon completion, all answer sheets were collected and each subject was matched with another one to calculate the earnings.

In order to analyze the data obtained, a generalized concept to measure risk and payoff dominance allowing across games comparisons had to be designed. Generalizing the intuitive approach of Harsanyi and Selten, the authors generated the following method to calculate risk dominance:

$$(1-p)\ u(A,A) + p\ u(A,B) \geq (1-p)\ u(B,A) + p\ u(B,B) \qquad [1]$$

This inequality demonstrates that if player I believes that player II will select B with probability p, than player I should select A if A generates higher expected payoff than playing B. The first choice in the brackets represents the best response of player I depending on the second Choice in the brackets by player II. The probability that player II chooses A is (1-p). If p = 0, implying that player II will play A with certainty, the inequality reduces to

$$(1-p)\ u(A,A) \geq (1-p)\ u(B,A) \qquad [2]$$

where (1-p) = 0. In this case player I should chose A, since (A,A) is preferred to (B,A). If actual payoffs are substituted in inequality 1, the result would be that player I would play A for values of p below some level p* (p bar in PSCG). Given this relationship, one can find a p* such that for any p less than p*, player I would play A. Player II uses the same logic to determine q and q*. As a result player I's p could be interpreted as the probability that q is less than q*. If p* is greater than q*, both players should understand that the belief of player I that (A,A) will be played is greater than the belief that player II supports the outcome (B,B). In order to avoid a coordination failure, they should both play the equilibrium (A,A). If p* =q*, there is no risk dominance involved. If, however, q* > p*, than (B,B) risk dominates (A,A).

To measure payoff dominance is much easier than to measure risk dominance. An equilibrium is said to be payoff dominant if its value is greater than all other equilibria. The role of payoff dominance, as Friedman's results support, depends on the difference between the two equilibria. Since playing the payoff inferior equilibrium results in an efficiency loss, we can measure payoff dominance by the percentage of losses incurred by playing the payoff inferior equilibrium. This measure is obtained by subtracting the (symmetric) payoff inferior outcome from the payoff dominant one and dividing the result by the payoff dominant outcome.

$$[u(B,B) - u(A,A)] / + u(B,B) \quad [3]$$

In this context it is important to note that only payoffs are considered and not utility derived from differing payoffs. Risk dominance is not a measure of risk preference, risk dominance simply means that the "riskiness" is taken into account when expected monetary payoff is maximized. This does not involve a utility function.

Conclusions:

Given the research design and analyzing tools, the authors formed two general conjectures about the type of observable choices. “The frequency of play of the payoff inferior Nash equilibrium will be negatively correlated with the level of payoff dominance and the level of risk dominance will be increasing over the payoff dominant equilibrium.” Players are assumed to focus both on larger gains and avoiding risk. Building on these conjectures 5 research hypotheses were formed that can readily be found on page 7 of PSCG. Due to page limitation, I will skip the presentation of the research hypotheses which are a simple application of the two conjectures on the specific game structures and focus on the experimental results.[2]

Results from experiments conducted in Phase I with a random match protocol lead to the following conclusion.

> **Conclusion 1:** Considerable variation in play of strategy A is observed across rounds and across sessions. For none of the 4 game structures is there complete convergence of play to either strategy A or B across all sessions.[3]

Those findings are opposed to Straub who found a clear contrast between game structures.

> **Conclusion 2:** Support is found for the pairwise research hypotheses based on risk dominance, but not on payoff dominance.

Based solely on risk dominance, A should have been played with a decreasing frequency from Game2>Game3 and Game 4>Game1. This result, as opposed to the payoff dominance ordering could be confirmed in the comparisons for round 1 and 8 and also for the pooled data (rounds 1-8 pooled).

The Phase II, random match protocol experiments support the findings in Phase I.

> **Conclusion 3:** Hypotheses based on risk dominance are supported even more strongly than in Phase I. Hypotheses based on payoff dominance are not supported.

As next step, the authors analyzed the role of social history which led to the following conclusion.

> **Conclusion 4:** The history of choices observed by a subject during Phase I significantly affects the subjects’ own choice in Phase II. More specifically, there is a positive correlation between play of A in Phase II and the frequency of Play of A that a subject encountered in Phase I.

Conclusions 5 and 6 were drawn by analyzing the data for the fixed match protocol in Phase I. As in the random match protocol substantial variation could be observed and the conclusions parallel those of the experiments run in Phase I using a random match protocol..

> **Conclusion 5:** In each of the four game structures, play of both A and B persists throughout all eight periods. Furthermore, the observed frequency of play of A varies considerably across the sessions associated with each game structure.

> **Conclusion 6:** Some support is found for the pairwise research hypotheses based on risk dominance,

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[2] Which is a somewhat demanding task given that no tables or graphs can be used to illustrate the research results. In that respect it is really difficult to give a detailed summary of the findings.

[3] Conclusion 1 as well as all the following conclusions are directly taken from PSCG.

but not payoff dominance.

Again, somewhat, similar results as obtained in Phase II random match could also be observed in the fixed match protocol..

Conclusion 7: Some support is found for the pairwise research hypotheses based on risk dominance, but not payoff dominance.

As expected, however, reputation plays a more important role in the decision process than did social history in the random match protocol case:

Conclusion 8: The frequency of play of A observed by an individual during Phase I has a significant impact on his/her likelihood to play A in Phase II.

Given those results one of the major findings of the paper is not only that risk dominance plays an important role in determining the outcome of coordination games but also that risk considerations can be decreased by moving from a one-shot game towards a face-to-face environment. In order to compare both the random match and the fixed match protocol a simple efficiency measure is developed:

$$((A,A)/(B,B))*100 = \text{overall efficiency} \qquad [4]$$

Using this measure efficiencies are substantially higher in the fixed match protocol for both Phase I and II (even though they vary depending on the game structure). Averaging across all games, the fixed match protocol has an efficiency that is 9 percentage points higher than the equivalent Phase in the random match protocol. In Phase II the difference is 11 percentage points.

Conclusion 9: Overall, efficiencies observed under the Fixed Match Protocol are somewhat greater than with the Random Match Protocol, but the impact of protocol varies considerably with game structure.

Summary:

Risk dominance consistently played a role in equilibrium selection in the experiments conducted. This does not imply that concerns about risk dominance always outweigh concerns about payoff dominance and thereby reversing the lexicographic ordering presented in the Harsanyi and Selten's approach. It simply means that risk and payoff dominance are both taken into account by rational deductively reasoning players. In addition to this deductive reasoning, players seemed to use inductive reasoning. They inferred future potential outcomes from their past experience. This inference was the more important in the calculation, the bigger its reliability was (reliability was assumed to be greater in the fixed match protocol). Even though the authors find evidence for both inductive and deductive reasoning, they still find an average inability to coordinate ranging from 20% to 40% after 7 rounds of experience.

As a result the authors conclude that risk dominance as well as payoff dominance are important concepts to explain behavior in coordination games. A crucial factor in obtaining better coordination results, however, remains repetition.