

The Seventh Stony Brook Summer Festival on
Game Theory
International Conference on Game Theory
July 14 to Jul 18, 1996

Book of Abstracts

A Value for Games with n Players and r Alternatives: Potential and Consistency

M. Josune Albizuri Irigoien*
(joint w/J.C. Santos and J.M. Zarzuelo)

Abstract

Bolger (1993) introduced a special class of games in partition function form. More precisely, there is a set N of players and r alternatives and each player chooses one alternative. In this way it is obtained an ordered partition or *arrangement* $\Gamma = (\Gamma_1, \dots, \Gamma_r)$ of N . Each pair (Γ_i, Γ) is called an *embedded coalition*. With each embedded coalition (Γ_i, Γ) there is associated a real number $v(\Gamma_i, \Gamma)$ representing the ‘worth’ of coalition Γ_i if the players arrange themselves according to Γ . Bolger (1993) provided several examples of economic as well as political situations to which these games could be applied.

For this class of games this author defined and characterized a *jvalue* (depending on alternative j) that might be seen as a ‘natural extension’ of the Shapley value to these games. In the definition of this value it is implicitly assumed that in the end all the players will choose the same alternative, namely j . In addition, Bolger (1993) defined a value for the case in which in the end the players did not choose necessarily the same alternative.

The object of this work is to redefine and study some of the properties of the value associated with a final arrangement. Of course, the j -value is the particular case in which the final arrangement is that in which all the players have selected alternative j . We provide three different characterizations of this value, the first two are similar to the classical of Shapley (1953) and the third is similar to that of Young (1985). As a result of the third characterization we have obtained that the axioms used by Bolger (1993) to characterize the j -value are not independent. We have also established a relationship between the value associated with an arrangement of a game of the new class and the Shapley value of a particular game with side-payments derived from the former game. On the other hand, we define a potential for these games and, as Bolger (1993) did for the j -value, we also give a

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characterization of the value associated with an arrangement by means of a property of balanced contributions and efficiency (Myerson, 1980); as a consequence of our result we have found again that in the similar characterization of Bolger the axioms are not independent. Finally we have also studied the consistency of this value.

**On the Existence of Core Allocations
in a Large Economy
with Incentive-Compatibility Constraints**

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Abstract

For an atomless exchange economy with finitely many states of the world, possibly asymmetric initial information, and suitably dispersed initial endowment vectors for (almost) every state-dependent utility function, the (NTU) incentive-compatible core is nonempty, where (ex ante) blocking allocations must satisfy incentive-compatibility conditions. Such incentive-compatible core allocations are obtained by demonstrating the existence of “competitive equilibria” despite the non-convexities in agents’ consumption sets induced by the presence of incentive-compatibility considerations and then observing that the “equilibrium” allocations belong to the core.

The Robustness of a Sophisticated Mutant in an Evolutionary Model of Cooperation

Erwin Amann* (joint w/C.-L. Yang[†])

Abstract

In a formal model the effect of mutation in a prisoners' dilemma game is analyzed. It is shown that in an evolutionary model if information entails fitness costs cooperation can persist in a symbiotic equilibrium in the long run. Moreover, this result is robust against further mutation.

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One-Way Spillovers, Endogenous Innovator/Imitator Roles and RJV Performance

Rabah Amir* (joint w/J. Wooders†)

Abstract

We consider a two-period duopoly characterized by a one-way spillover structure in process R&D and a very broad specification of product market competition. We show that *a priori* identical firms always engage in different levels of R&D, at equilibrium, thus giving rise to an innovator/imitator configuration and ending up with different sizes. In view of this endogenous firm heterogeneity, the social benefits of, and the firms' incentives for, research joint ventures are somewhat different from the case of *ex post* firm symmetry. The key properties of the game are submodularity (R&D decisions are strategic substitutes) and lack of global concavity.

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Cyclical Cooperation in Finitely Repeated Games

Ivan Arribas (joint w/A. Urbano)

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Abstract

Several recent papers have addressed the problem of sustaining cooperation in finitely repeated games of complete information (Radner (1980), Benoit and Krishna (1985), Friedman (1985), among others). As is well known, every game possessing a unique Nash equilibrium gives rise to a unique subgame perfect equilibrium in finite repetitions, consisting of the repeated static solution -attempts to establish collusion “unravel” from the terminal period. However, games possessing a multiplicity of Nash equilibria give rise to a host of other outcomes; indeed Benoit and Krishna establish under relatively weak conditions that, as in the infinite horizon case, every individually rational outcome can be obtained in some subgame perfect equilibrium. Of course, certain outcomes are often supported by punishment phases which, while subgame perfect, penalize all participants. When players have opportunities to communicate throughout the game, these punishments require the group to behave in a dynamically inconsistent fashion.

The notion of a *consistent equilibrium* for finitely repeated games has been developed by Bernheim and Ray (1989). The notion also appears under different names in van Damme (1989), and Farrell and Maskin (1989). Bernheim *et al.* (1987) noted that this notion may not be entirely satisfactory for games involving more than two players, in that the above papers have restricted attention to renegotiation by the set of all players. Bernheim *et al.* notion of a perfectly coalition proof equilibrium coincides with consistency in two players, finite horizon games. A related concept is that of Asheim (1991).

The purpose of our paper is to isolate subgame perfect equilibria of particular interest. More precisely, when consistency isolates cyclical equilibria despite the fact that the games may also admit noncyclical subgame perfect equilibria. For a particular kind of two-players games, perfectly coalition-proof equilibria have a peculiar and striking problem: for identifiable interest rates, play necessarily cycles between cooperation and a static noncooperative outcome. In fact, one may induce cyclical cooperation of any periodicity as the unique consequence of perfectly coalition-proof behavior by selecting the discount factor appropriately. Further the periodicity increases as the discount factor increases.

Admissibility and Common Knowledge

Geir B. Asheim* (joint w/M. Dufwenberg[†])

Abstract

The implications of assuming that it is commonly known that players consider only admissible best responses are investigated. A procedure, where strategy sets are iteratively eliminated, is formalized in terms of an increasing order of mutual knowledge. This is done within a framework where players can have knowledge of strategy sets for the opponents such that, for each opponent, the choice of any strategy outside her set is deemed infinitely less likely than the choice of any strategy contained in her set. It is illustrated how concepts that do not allow the players to have such knowledge may admit incautious behavior. On the other hand, the procedure of iterated admissibility effectively imposes such knowledge, but does not adequately explain how this is a consequence of an increasing order of mutual knowledge.

The framework consists of a states-of-the-world model, with a partition of the state space for each player, and a function for each player assigning a subset of that player's strategies to each state. It is assumed to be commonly known that each player's strategy set is the set of admissible best responses given a probability distribution that does not assign positive probability to vectors of strategy sets for his opponents known by the player to be impossible. This assumption corresponds to a procedure where strategy sets are iteratively eliminated. A strategy set that survives the iterative elimination is called a fully permissible set. For this concept, general existence is established, a characterization is offered, and a finite algorithm is provided.

It is established that any strategy in a fully permissible set is both rationalizable and survives the Dekel-Fudenberg procedure, while the converse does not hold. The "Battle-of-the-sexes-with-outside-option" and "Burning Money" games are used to show how the forward induction outcome results from an assumption of it being commonly known that each player's strategy set is the set of admissible best responses. In the latter example, burning need not be interpreted as a signal,

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implying that our analysis is robust against a critique commonly leveled at the usual forward induction argument in this game. Finally, a new perspective on the backward induction paradox is discussed in the context of the “Take-it-or-leave-it” game, in which there is for each player a fully permissible set that contains more than the backward induction strategy.

The concept of fully permissible sets is based on both lexicographic optimization and a full support restriction on first-order conjectures. It is argued that the concept of fully permissible sets captures common knowledge of admissibility in the most reasonable way.

Business Cycles, Thin Resale Markets, and Darwinian Competition

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Abstract

This paper explores the entry and exit decisions of firms over the business cycle, detailing the joint evolution of the distributions of firm productivities, firm sizes, prices and profits. The driving force for the economy is a persistent stochastic demand process (so that high demand (price) in one period makes high demand in the succeeding period more likely).

A firm is characterized by its capital stock (size) and technology index. The distribution of firms is given as a joint distribution over capital and technology and this distribution, together with an aggregate shock parameter, describes the state of the system at any point in time. Firms, technologies evolve stochastically and the evolution of the capital stock depends on investment and depreciation.

Existence of equilibrium is guaranteed by results of Bergin and Bernhardt (1995) and in certain circumstances equilibrium can be characterized in terms of a solution to a social planner problem (discussed in the work of Lucas and Prescott and more recently by Hopenhayn). In that case, equilibria are unique and markov on a minimal state space.

Within this framework we explain the relationships between the timing and magnitude of output fluctuations, both in aggregate and at the firm level, bankruptcy (exit) and productivity rates. The value of exit is endogenized in a non-trivial way: the opportunity cost to a firm of using its specialized resources in production is that it could exit the market and sell its resources to a new entrant which can better employ them. The value both of remaining in production and of exiting the market vary over the business cycle and we detail the consequences for exit and hence the distribution of firm productivities. An active firm is modeled as one with a technology with control over input resources. The productivity of the firm's technology evolves according to a firm specific persistent stochastic process. This paper explicitly characterizes the option to exit. Each period an active firm has the option of continuing to produce or of ceasing production and attempting to sell its resources to a potentially more efficient entrepreneur. Such an

entrepreneur lacks other access to input resources. That is, we take seriously resource constraints on new entrants: entrants must obtain “storefront space” from existing firms before entering the market. This extreme assumption captures the fact that it may be quite costly for entrepreneurs without resources to start from scratch in an undeveloped area; it is less costly to enter by purchasing resources.

From the game theoretic perspective, the paper provides a partial synthesis of two different approaches to anonymous sequential games: the social planner formulation and the game theory approach to these games. Furthermore, it illustrates a methodology that should have wide application in other areas of games theory – such as evolutionary game theory.

Hart and Mas-Colell Potential for Restricted Games

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Abstract

The purpose of this paper is to generalize the notion of graph-restricted games or communication games. In this model, the feasible coalitions are those belonging to a *partition system*. First, we study a recursive procedure for computing the Hart and Mas-Colell potential of these games. For special classes of set systems — *partition convex geometries* \mathcal{L} —, we prove a formula for the *convex Shapley value* in terms of the original game.

Communication, Risk, and Efficiency in Games

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Abstract

This paper studies the evolution of effective preplay communication in games where a single communication round precedes a simultaneous-move, complete-information game. The paper identifies stable outcomes under population learning dynamics in which individuals with some probability replace their current strategy with a best reply against beliefs supported on a sample of currently used strategies. It is shown that under these conditions the effectiveness of one-sided preplay communication is inversely related to risk in the underlying game, and to the size of the message space. Multi-sided communication is more effective than one-sided communication, i.e. risk and the size of the message space play no role, if all players communicate, have the same preferred equilibrium and messages have some small a priori information content that identifies message profiles that signal agreement on a strict equilibrium in the underlying game.

Backward Induction Is Not Robust: The Parity Problem and the Uncertainty Problem

Steven J. Brams* (joint w/D.M. Kilgour†)

Abstract

A cornerstone of game theory is backward induction, whereby players reason backward from the end of a game in extensive form to the beginning to determine what choices are rational at each stage of play. Truels, or three-person duels, are used to illustrate how the outcome can depend on the evenness/oddness of the number of rounds (*the parity problem*) and on uncertainty about the endpoint of the game (*the uncertainty problem*). Since there is no known endpoint in the latter case, an extension of the idea of backward induction is used to determine the outcome.

The parity problem highlights the lack of robustness of backward induction, but it poses no conflict between two foundational principles of rational choice and, hence, does not seem paradoxical. On the other hand, two conflicting views of the world underlie the uncertainty problem, depending on whether the number of rounds, which is assumed to be finite, is bounded or unbounded. While in the bounded case the players invariably shoot from the start, in the unbounded case they may all cooperate and never shoot, despite the fact that the truel will end with near certainty – and therefore be *effectively* bounded – after only a few rounds. Some real-life examples, in which destructive behavior sometimes occurred and sometimes did not, are used to illustrate these differences.

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What Price Coordination? Auctioning the Right to Play as a Form of Preplay Communication

Bruno Broseta* (joint w/V.P. Crawford†)

Abstract

The paper proposes a model to explain the experimental results in Van Huyck, Battalio and Beil's (1993) "Asset Markets as an Equilibrium Selection Mechanism: Coordination Failure, Game Form Auctions and Tacit Communication" (*Games and Economic Behavior*, 5, 485-504). In their experimental design, subjects repeatedly played a simple coordination game, with the right to play allocated by auction each period. Subjects invariably bid the market-clearing price to a level recoverable only in the most efficient equilibrium and then converged to that equilibrium, even though subjects playing the game without auctions always converged to an inefficient equilibrium.

In the first part of the paper, we develop an adaptive model which explains these experimental results by showing how strategic uncertainty interacts with the learning dynamics. A convergence result shows that the learning dynamics generate a prior probability distribution over coordination outcomes. The efficiency-enhancing effects of auctioning the right to play is then qualitatively assessed through a comparative dynamics analysis. We find that it can be attributed to both an "optimist subjects" effect and to players' forward induction inferences.

In the second part of the paper, we estimate the learning model using Van Huyck, Battalio and Beil's (1993) experimental data. We specify the econometric model as a discrete-choice dynamic process with heteroskedastic disturbances, endogenous sample selection and missing regressors. Finally, we simulate the learning model -using the parameter estimates- and test its explanatory power by comparing the prior probability distribution over outcomes it generates with the experimental results.

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Forward Induction in a Repeated Wage Negotiation

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Abstract

We present a finitely repeated bargaining game with complete information. The stage game is a simultaneous demand game with a fallback position for both parties, in which we allow one party (say, the union) to establish credible commitments to strike if it is not offered a determined wage. In this stage game there is a multiplicity of strict Nash Equilibria (NE), and in the repeated game there is also a severe multiplicity problem.

We try to refine the equilibrium set of the repeated game using a formulation of Forward Induction related with proposals suggested in the previous literature on repeated games with finite horizon (Osborne (1989), Ponsard (1991), Al-Najjar (1995)).

In particular, we say that a path of NE in the repeated game is consistent with forward induction (CFI) if for all periods t the cost of deviation (if it is strictly positive) in that period is greater or equal than the maximal net gain if CFI paths with $t - 1$ horizon.

Learning to Cooperate in Repeated Games

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Abstract

We investigate the learning behavior in a two person infinitely repeated game. In contrast to the existing literature on learning in games (e.g., Fudenberg and Kreps [1993]), each player is maximizing his long run payoff subject to his belief about the opponent's repeated game strategy. Each player "economizes" the estimation of the opponent's strategy and the selection of the best response by assuming a linear strategy (Cho [1995]) drives the opponent's action and by minimizing the complexity of the best response (Rubinstein [1986] and Cho and Li [1995]). We assume that a player updates the estimator according to the stochastic gradient method (Marcet and Sargent [1989] and Woodford [1990]) with a slowly disappearing random noise to ensure sufficiently frequent experiments as in a simulated annealing process (cf. Kushner [1987]).

By using a stochastic approximation technique (Kushner [1981]), we prove that in any symmetric 2×2 infinitely repeated game, the learning dynamics converge with probability 1. The long run outcome of the game is sustained by a Nash equilibrium in linear strategies, where each player is "imitating" the opponent's strategy. The actions of the two players are perfectly coordinated, and each outcome is realized with positive frequency. In the prisoner's dilemma game, for example, the players must cooperate with positive frequency in the limit.

Exchange Economy with Production Modelled as a Strategic Game

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Abstract

Let (A, \mathcal{A}, μ) be a measure space. A represents the set of players, \mathcal{A} the σ -algebra of subsets of A . A contains a continuum of players (consumers) and a finite number (n) of “managers”, each runs a firm. So, we require;

$$A = A_1 \cup A_2, \quad \text{where}$$

A_1 is the set of consumers and A_2 the set of managers, and

$$\mu(A_1) = \mu(A) > 0$$

$$|A_2| = n, \quad \mu(A_2) = 0.$$

Also, we require $(A_1, \mathcal{A}_1, \mu)$ to be an atomless measure space, where \mathcal{A}_1 is the σ -algebra of subsets of A intersected with A_1 . Without loss of generality, we may take $(A_1, \mathcal{A}_1, \mu)$ to be $([0, 1], \beta, \lambda)$ where β is a Borel σ -algebra and λ is a Lebesgue measure. There are m commodities under exchange and a commodity money is used as a mean of exchange of goods. We classify these m commodities as “input” and “output” for the production: The first m_1 goods are “raw (input) materials”, and the last m_2 are “consumable (output) goods”, where $m_1 + m_2 = m$. The money in this model is very close to the money we know: It has certain intrinsic value in itself, and it only serves as a mean of exchange. The choice of commodity money would avoid the insolvency problem which could result when consumers are allowed to create as much “paper” money they wish and come short at the end of the game. Also, the total amount of any goods, including the money, present in the model will be kept finite, so that allocation functions (see below) will be integrable. The money is formulated as the $m + 1$ st commodity.

We wish to establish existence of active Nash Equilibrium of this game: In particular, we wish to establish the following

Theorem: Suppose that for each consumable good $j, j = m_1 + 1, \dots, m$, there are non-null set of consumers S_j who are monied and desire the good j , and suppose that for each raw material $k, k = 1, \dots, m_1$, there are at least 2 firms which desire the raw material k . Then there is an active Nash Equilibrium.

Games and Economies with Crowding Types

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Abstract

We develop a new model of an economy with public goods and differentiated crowding. In such an economy agents form groups for the purpose of collective consumption of public goods and the externalities generated by group members. Our model has the new feature that a distinction is made between the crowding effects of an agent and his tastes. Crowding effects are assumed to be observable while tastes are not. In the standard model, agents are affected by the “types” of other agents where the “type” of an agent encompasses his taste type. The crowding types model enables us to obtain a number of new results and address new questions.

Copying Fidelity

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Abstract

This paper considers the evolutionary stability of a population of players choosing finite automata to play the infinitely repeated prisoners' dilemma. Players attempt to imitate automata that have proved successful in previous generations in such a way that population proportions follow the replicator dynamics. This imitation may be imperfect, as they do not observe the structure of automata directly, only the action sequences the automata generate. It is shown that when automata are deterministic, the problem of copying fidelity prevents a utilitarian equilibrium. However, if players occasionally make operating mistakes when using their automata, they may be copied faithfully and a utilitarian equilibrium is possible. Imitation is particularly easy in populations of stochastic automata with no more than two internal states. In such populations, automata that perform the 'PAVLOV' strategy do particularly well.

Committee Decisions and Contracting

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Abstract

A committee (i.e., a group of principals) signs a contract with an individual (i.e., an agent) for the agent to produce a commodity for the committee. First, the committee determines a contract and then offers it to the agent. Second, the agent either accepts or rejects the contract. If the agent accepts she produces the commodity, and the relationship ends if the agent rejects the contract. After the commodity is delivered to the committee, the committee acts in accordance to the contract. The contract has several important features.

The commodity x has k characteristics. That is, $x \in \mathbb{R}_+^k$. Each characteristic is observable by the agent and the committee. Only $j < k$ of the characteristics are verifiable by a third party (such as the courts). Thus, any contractual terms can specify only the j verifiable characteristics, and compensation may be a function of only the j verifiable characteristics.

After the commodity is produced, the committee votes by majority rule whether to accept the commodity and pay the contracted fees. If the committee rejects the commodity, it must make a severance payment. (This feature of the contract is like a take-or-pay option contract.)

In this model, the agent's decision is straightforward. We derive a best response function for the agent that states the characteristics of the produced commodity as a function of the contract. The focus of our paper is the committee decision.

That fact that the committee is able to contract on only a subset of the characteristics adds a complicating dimension to the committee's contracting problem. We examine a complete information model, and the agent knows that each committee member has strictly monotone and strictly convex preferences. Hence, if a committee member places a minimum requirement on one of the characteristics, then the agent may decrease the quantity of a nonverifiable characteristic and still receive a majority approval by the committee. While the committee can directly affect the verifiable characteristics of the commodity that the agent delivers,

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the committee cannot directly affect the agent's production of the nonverifiable characteristics.

One interesting question is: Does a Strong Nash equilibrium exist to the committee contract offer game (given the agent's best response function). To answer this question we characterize preference profiles for which Strong equilibria exist and ones for which strong equilibria do not exist. Roughly, if the agent has a strong preference to produce the characteristics on which the parties can contract, then a strong equilibrium exists, else not. By addressing the existence of strong equilibrium we intend to determine whether stable committee decisions exist to this problem.

Keeping Up With the Joneses: Aspirations and Experiments Without Random Matching

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Abstract

This paper considers a model where agents play in pairs on separate islands. They have an aspiration level which is determined by the average payoff of all agents in all islands. If their own profit level falls below their aspiration level, then they randomly choose a strategy from the available set. There is thus a population dynamic generated by the impact of population profits on individual aspiration levels, and hence on the experimentation of individual agents. Agents remain on the same island: there is no random matching. The results are very clear cut. Given a very weak condition, the global attractor is the (set of) cooperative outcome(s).

Core Equivalence Theorems for Infinite Convex Games

Ezra Einy* (joint w/R. Holzman[†], D. Monderer[‡],
and B. Shitovitz[§])

Abstract

We show that the core of a continuous convex game on a measurable space of players is a von Neumann-Morgenstern stable set. We also extend the definition of the Mas-Colell bargaining set to games with a measurable space of players, and show that for continuous convex games the core may be strictly included in the bargaining set but it coincides with the set of all countably additive payoff measures in the bargaining set. We provide examples which show that the continuity assumption is essential to our results.

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Incentive Monotonicity and Equilibrium Selection in Binary Choice Games

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Abstract

In this paper I develop a model of equilibrium selection for binary choice games with complete information. It relies on the successive application of two refinements of the Nash equilibrium concept. It is shown that the solutions are payoff monotonous and invariant with respect to isomorphisms, but not best reply invariant. For some special classes I compute and compare the solution with the risk-dominant Nash equilibrium.

Commonly Assumed Rationality

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Abstract

Iterated strict dominance is a well-established procedure that delivers the implications of common knowledge of rationality in normal-form games. Many attempts have been made to devise an analogous concept that is based on weak dominance or admissibility. Serious foundational issues seem to make a good theory impossible. This paper approaches the problem from a new perspective. Using first-order predicate logic, we model the players' ability (or inability) to derive theorems from a given set of assumptions. Under *commonly assumed rationality*, the strategy sets decompose into three categories: irrationalizable strategies, rationalizable strategies, and others. The theory provides a framework that helps to judge and interpret the sometimes surprisingly strong results of iterated weak dominance. Examples are given. Moreover, standard normal-form rationalizability is shown to be the consequence of *commonly assumed Bayesian rationality*.

Weighted Discounted Stochastic Games with Perfect Information

Eugene A. Feinberg* (joint w/E. Altman[†], and A. Shwartz[‡])

Abstract

We consider a two-person zero-sum stochastic game with an infinite time horizon. The payoff is a linear combination of expected total discounted rewards with different discount factors. For a model with a countable state space and compact action sets, we characterize the set of persistently optimal policies. For a model with finite state and action sets and with perfect information, we prove the existence of an optimal pure Markov policy, which is stationary from some epoch onward, and we describe an algorithm to compute such a policy. We provide an example which shows that an optimal policy, which is stationary after some step, may not exist for weighted discounted sequential games with finite state and action sets and without the perfect information assumption.

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Evolving Landscapes in Population Games

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Abstract

We consider adjustment processes, including learning, in population games in which the action spaces are the unit interval $[0, 1]$. Such processes arise from a three-dimensional “landscape” of an underlying payoff function. We use gradient dynamics, in which each player increases or decreases his action at a speed proportional to the gradient of the expected payoff. The distribution of actions is described by a class of nonlinear partial-differential-integro equations. We derive gradient processes as constrained optima, given certain information and adjustment technologies. Limiting distributions for generalized gradient processes are characterized for a class of payoff functions that result in pure Nash equilibria, and for another class that results in totally mixed Nash equilibria. Sample simulations and analytically tractable examples are exhibited. We discuss connections with the learning in games literature, Sonnenschein (1982) dynamics on the circle, replicator dynamics and other biological models. Economic and other social science applications are suggested.

On a Market for Coalitions with Indivisible Agents and Lotteries

Rod Garratt (joint w/C.-Z. Qin)

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Abstract

In this paper we define a new class of games called totally L -balanced games. These are games whose subgames are all balanced with respect to the balancing coefficients that are generated by joint lotteries over partitions of agents. We show that total L -balancedness is necessary and sufficient for the game to be generated from a direct lottery market. Total L -balancedness is a weaker condition than total balancedness. Indeed, all simple majority voting games are totally L -balanced, though they are not even balanced when the number of players is greater than two. Thus the analysis expands the class of market games. The paper also considers the relationship between the core outcomes of a game and the competitive outcomes of the direct lottery market. It is shown that the core of a totally L -balanced game coincides with the set of lottery equilibrium utility vectors of the direct lottery market.

Market Institutions and Allocations

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Abstract

Interpreting market institutions and market processes as noncooperative games, we ask why any given noncooperative game is played in a market rather than some other noncooperative game. The assumption that individuals will use market institutions that are not payoff dominated by any other set of market institutions implies restrictions on the allocations that should be observed. The analysis is based on an adaptation of the mathematical structure of the dynamic matching problems introduced by Roger B. Myerson (1995) to a setting in which all outcomes are obtained in Nash equilibria of noncooperative games. We show for a general class of market environments that there exist allocations that cannot be improved upon by allocations that are obtainable in the Nash equilibria of alternative noncooperative games. We take account of the fact that, in such alternative games, individuals will draw inferences about others' types when they participate in the alternative game.

Asymptotically Finite Repetition of Rubinstein's Bargaining Game

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Abstract

This paper studies the infinite repetition of Rubinstein's alternating offers bargaining game. It is shown by Muthoo (1995) that for this game, the folk theorem holds under weak conditions on the discount factor between stage games. Furthermore it is shown by Bernheim and Dasgupta (1995) that for a broad class of strategic form stage games the folk theorem holds even with a variable discount factor converging to zero. In this paper we extend the analysis in these two papers, showing that for the repeated bargaining game the folk theorem breaks down if discounting between stages converges to zero.

Perfect Graphs, Normal Hypergraphs, Stable Families of Coalitions, and Effectivity Functions

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Abstract

A family of coalitions k is called stable if k -core is “always” not empty. More accurately, k is TU-stable if $C(k, v)$ is not empty for any superadditive characteristic function v ; k is NTU-stable if $C(k, V)$ is not empty for any superadditive and compact generalized characteristic function V ; k is NF-stable if $C(k, g, u)$ is not empty for any normal form game (g, u) where g is a game form and u is a utility function.

Theorem 1. k is NTU-stable iff k as a hypergraph is normal.

Theorem 2. k is NF-stable iff k as a hypergraph is normal.

Theorem 3. k is TU-stable iff k as a hypergraph is partitionable, that is, any integer balanced weighting of k is a sum of partitions.

The last theorem was proved by Le Breton, Owen, and Weber (1992), and then independently by Kuipers (1994), Boros, and Gurvich (1994). All the proofs are based on Bondareva-Shapley Theorem. Theorems 1 and 2 are based on Scarf Theorem.

Let G be a simple graph. Let us assign a player to any maximal clique of G and an outcome to any maximal independent set of G . For any vertex v in G let us denote by $K(v)$ and $B(v)$ the coalition of players and the block of outcomes generated by all the maximal cliques and respectively independent sets which contain vertex v . Let us define an effectivity function (EFF) $E = E(G)$ by formula

$$E(K, B) = 1 \quad \text{iff} \quad K = K(v) \quad \text{and} \quad B = B(v) \quad \text{for some vertex } v.$$

Theorem 4. For any graph G the EFF $E(G)$ is playing-minor, that is $E(G)$ is majorized by an EFF $E(g)$ implemented by a game form g .

This theorem can be derived from Moulin-Peleg’s characterization of EFFs implementable by game forms as monotone and superadditive.

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Theorem 5. EFF $E(G)$ is stable iff graph G is kernel solvable.

Theorems 2 and 5 enable us to prove that perfect graphs are kernel solvable, as it was conjectured by Berge and Duchet (1983). Thus some problems of perfect graph theory are in fact special cases of a game theoretic problem: to characterize stable EFFS.

We also assign to any EFF a pair of hypergraphs and give a sufficient condition for stability in terms of perfect graph theory. At last, using this technique we prove Theorem 6. It is NP-hard to recognize stability of an EFF.

Theorem 7. It is NP-hard to check that an EFF is playing-minor.

Repeated Within-Group Games with Discounting in a Multi-Group Environment

Kjell Hausken

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Abstract

The article analyzes how a technology of conflict between groups, such as litigation, confiscation, robbery, theft, combat, and between-group competition for an external rent affect strategic behavior within groups in a repeated game with discounting. The static analysis shows that the requirement for the external rent E to facilitate within-group cooperation increases with the number of groups, the number of agents in each group, and the cost of cooperation, and decreases with the amount of resources produced by one cooperative act. The dynamic analysis combining the between-group conflict technology with the Folk Theorem shows how a positive external rent can compensate for a too small discount factor, and how a negative rent in the sense of hardship can be tolerated if the discount factor is above a certain minimum value.

Linear and Symmetric Values for Partially Defined Cooperative Games

David Housman

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Abstract

There is a growing literature on the applications of cooperative game theory to the allocation of costs or benefits of a joint endeavor. This paper is motivated by such applications; when the determination of all coalitional worths is prohibitively expensive. For example, each coalitional worth may require an extensive engineering or accounting study, and the number of such studies increases exponentially with the number of players. The purpose of this paper is to present axiomatic rationales for allocation methods when not all coalitional worths are known. The results extend Shapley's (1953) and Young's (1985) characterizations of the Shapley Value for "fully defined" cooperative games and Wilson's (1993) characterization of the reduced Shapley Value for "partially defined" cooperative games.

The Time Factors to Patent Litigation and Licensing

Jin-Li Hu* (joint w/R. Aoki†)

Abstract

We incorporate patent licensing, litigation, damage reward, and time factors into a single model. The settlement of a patent lawsuit is more likely to be achieved as it takes longer time to reach a verdict or the length of the patent is shorter. The administration and the court can affect the settlement rate of patent lawsuits by changing these time-spans. When the time to imitate is short, the patentee willing to settle or without incentive to litigate will license to a potential infringer. The legal system which prevents the patent infringement from taking place maximizes the patentee's realized payoff. Yet a legal system's inducing licensing agreement before the patent infringement maximizes the realized social surplus. We also demonstrate how the price of an intangible asset like a patent is determined by the time factors, in addition to the legal, market, and technological factors.

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On Compactness of the Core of Nonatomic Convex σ -Continuous Measure Games

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Abstract

Let (Ω, A) be a measurable space isomorphic to $([0, 1], \beta)$, where β is the collection of all Borel measurable sets in $[0, 1]$. By cooperative game we mean a nonnegative function on A , satisfying $v(\Omega) = 0$. v is convex if

$$v(A) + v(B) \leq v(A \cap B) + v(A \cup B)$$

for all $A, B \in A$. v is nonatomic if $v(\Omega) = v(\Omega - w)$ for any $w \in \Omega$, and σ -continuous if for any $S \in A$ and any monotonic sequence S_n converging to S , $v(S_n)$ converges monotonically to $v(S)$ as n goes to infinity.

The core of a game v , denoted by $C(v)$ is defined as the set of measures on (Ω, A) satisfying

$$\mu(\Omega) = v(\Omega), \quad \mu(S) \geq v(S), \quad \forall S \in A$$

The core of convex games has been extensively studied in the literature. Shapley (1971) proved that the core of any convex game with finite number of players is always not empty. Moreover, he obtained a representation of the all the vertices of the core. Soon after that Delbaen (1974) generalized the result to infinite games and studied the weak compactness and projection properties of the core, providing a theoretical basis for the study of infinite convex games. Recently, Sharky (1982) studied the core of finite convex games based on a new idea and found that the core of such games is not only nonempty but also large in some sense. The result has been generalized to the infinite case by the present author (1987). According to studies of Schmeidler (1973) and Delbaen (1974), the core of any nonatomic σ -continuous convex game is not empty and all measures in the core are nonatomic.

Let μ be a nonatomic measure on (Ω, A) and f be a continuous convex function over the interval $[0, \mu(\Omega)]$, satisfying $f(0) = 0$. $f(\Omega)$ is obviously a nonatomic

σ -continuous convex game, and is known as convex measure game, which plays an important role in the theory of nonatomic games.

The purpose of this paper is to consider the compactness of the core of convex measure games under the norm topology. It turns out that the core is not compact for nontrivial games, showing the largeness of the core of such games in a sense other than defined by Sharky for the finite case.

Bounds to Memory Loss

Hans Krogh Hvide

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Abstract

If we express our knowledge in sentences, we will find that these sentences are intertwined in complex patterns governed by our observations and our inferences from these observations. These inferences are to a large extent driven by logical rules. I ask whether the structure logic imposes on our knowledge may restrict what we forget and what we remember. The model is a two period S5 logic, where I define a memory loss operator. It is true to say that the agent forgets a sentence p iff he knows p at time 1 and he does not know p at time 2. Equipped with the operator, I prove theorems on the relation between knowledge and memory loss. Then I show that there are some formulas an S5 rational agent must forget and there are some formulas he cannot forget. A welcomed feature is that the results also hold in the S4 logic. I interpret the results as illustrating bounds on memory loss, and thus on bounded rationality. I apply the model on single-agent conventions: conventions made between an agent and himself I show a sufficient condition for such conventions to be successful: ‘commonly known’ between former and future selves.

**A Generalization of the Bankruptcy Game:
Financial Cooperative Games**

Josep M. Izquierdo (joint w/C. Rafels)

Universitat de Barcelona, Spain

Abstract

A new class of games called Financial games is defined. These games are market games and it is showed that they become a generalization of Bankruptcy games. The algebraic structure of this class of games is studied and necessary conditions for a game to be financial are stated. The proportional distribution is analyzed and two different axiomatic characterizations of this solution are given.

Dynamic Efficiency and Implementation in Markets with Repeated Pairwise Matching

Matthew O. Jackson* (joint w/T.R. Palfrey†)

Abstract

We examine implementation in a simple bargaining setting, where heterogeneous buyers and sellers are repeatedly matched with each other. This places a natural “individual rationality” constraint on the implementation: no buyer or seller should consummate an agreement which leaves them worse off than the discounted expected value of their future rematching in the market. Buyers and Sellers are impatient, and in equilibrium trade off the value of current trades versus the potential of being rematched to someone with whom a more valuable trade could be arranged. We begin by characterizing the efficient allocations of a simple static world. We then examine the dynamic implementability of the efficient allocations, when mechanisms allow agents to opt for rematching.

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Learning in Sequential Auctions

Thomas David Jeitschko

Texas A&M University

Abstract

The importance of information is studied in a model of a sequential auction in which bidders have independent private values. In the course of the auction information about the bidders' values becomes available, as winning bids are revealed. From this bidders learn about their opponents' types. A more subtle effect of information is that bidders anticipate the generation of information and take this into account in the first auction.

The equilibrium in this model is contrasted to a scenario in which bidders are unaware of informational effects. It is shown that bidders who are aware of informational effects have higher payoffs. However, a static auction, in which informational effects are absent, yields the same expected final allocation as the equilibrium. Finally, properties of the equilibrium price path are studied. Regardless of the outcome of the first auction, the second price is expected to be equal to the first price. Despite this, the probability of a decreasing price sequence depends on the information generated in the first auction.

The Classification of Continuation Probabilities

Michael A. Jones

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Abstract

The only subgame perfect equilibrium for finitely repeated Prisoner's Dilemma games consists of "defecting" in every round. Finitely repeated games are only representatives of a class of indefinitely repeated games where the sole subgame perfect equilibrium is noncooperative. This broader class of repeated games with "quasifinite" continuation probabilities is defined and examined.

A matrix inequality is recalled that when solved by a cooperation vector, induces a subgame perfect equilibrium. A condition for continuation probabilities indicates when this matrix inequality can be satisfied at equality by a cooperation vector. The associated strategy is a cooperative subgame perfect equilibrium.

**Repeated Games with Imperfect Private Monitoring: Recent
Developments and Open Questions**

Michihiro Kandori

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Abstract

A repeated game has imperfect private monitoring if (1) each player's action is not observable and (2) players privately observe *different* noisy signals about each other's actions. This class of games have important economic applications such as secret price cutting and exchange of goods with uncertain quality, but the structure of equilibria has not been fully characterized. I will survey the recent developments in this topic and point out some remaining open questions.

Defaults, Bidding, and Participation in the Rotating Credit Association: An Equilibrium Analysis

Ping-Sing Kuo

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Abstract

Rotating credit associations (RCAS) are a type of informal financial institution, they are very important in some countries. Their members finance each other in turn, and bidding is a conventional method for deciding the order of receiving finance. The financial gains and the default risks are two major concerns for a participant in an RCA, and this paper addresses the issues of default risks: What kinds of defaults are there? When do defaults occur? How do defaults alter the equilibrium bidding strategy? In what magnitude or direction can they change the expected payoff, and affect the participation decision?

To answer these questions, a game tree is given to depict the possible actions of players. The paper shows that a long-term relationship between organizer and other members is the key factor for the sustenance of an RCA. Equilibrium bidding strategies with and without risks are solved. They, show that members will bid higher in response to a higher perceived default risk. Interim and ex ante expected payoffs are also solved. The expected payoffs will be negative if the perceived risk is big enough, which hinders a candidate from joining; if the expected payoff is positive, the increase of risk will reduce the expected payoff.

Price Competition in a Distorted Price System Leads to Output Collapse in Transition Economies

Chun-wah Liu

University of Wisconsin

Abstract

I present a game-theoretic general equilibrium input-output model of economic transition based upon observed microscopic institutions in Central and East European Countries (CEECs), the former Soviet Union (FSU) and China. In socialist regimes goods are underpriced and in shortage, whereas at the beginning of transition, prices skyrocket and output collapses. I argue that these phenomena are closely related. I show that optimal planning with asymmetric information between the planner and state enterprises in a socialist economy results in underpricing and shortages. At official prices lower than the market clearing prices, a two-tier price system during transition without enforcing input delivery *may* lead to a diversion of inputs away from state firms. If, in addition, state enterprises compete in prices in consumption good markets and behave as Bertrand firms, the result *must* be a surge in market prices of consumption goods and a collapse in aggregate output with zero input. This set of institutional structures is *critical and sufficient* for the result obtained.

**The Invariance of Best Reply
Correspondences in Two-Player Games**

Luchuan Andy Liu

City University of Hong Kong

Abstract

In this paper the invariant properties of best reply correspondence in two-player games are studied. We demonstrate necessary and sufficient conditions for a pair of two-player games in strategic form to have the same best reply correspondence through characterizing transformation between those payoff functions.

Economic Natural Selection and a Double Auction Market: The Market as a Filtering Process of Information

Guo Ying Luo

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Abstract

Even when participants know very little about their environment, the market, itself, by serving as a filtering process of information, promotes an efficient aggregate outcome. This is illustrated using a double auction dynamic commodity futures market. To emphasize the role of the market and the importance of natural selection, rather than the strategic actions of participants, an evolutionary model is presented, in which there is a continual inflow of traders who are unresponsive to past market experiences. Futures contracts are one-period in length and the spot price consists of the fundamental value (predetermined at the beginning of each time period but unknown to all traders) plus a random shock (realized at the end of the time period). Two contrasting versions of this model are described. In the first version, where traders have no information about the fundamental value, the long run futures price does not converge to the fundamental value. In the second version, where differences in information are reflected in different predetermined distributions of prediction errors with respect to the fundamental value, the market does act as a filtering process, that constantly shifts wealth from traders with less accurate information to those with more accurate information. Consequently, with probability one, as the volatility of the random shock gets sufficiently small and as time gets sufficiently large, the proportion of time, that the futures price is arbitrarily close to the fundamental value, converges to one. Furthermore, the width of the interval containing the fundamental value, where the futures price eventually lies, increases as the volatility of the underlying spot market increases.

Relative Performance Evaluation and Collusion

Annalisa Luporini

Università di Trieste, Italy

Abstract

This paper examines the consequences of collusion on the form of the optimal incentive scheme in a principal two-agent model in which the agents, who operate in correlated environments, have *ex ante* private information. In the absence of side contracting, the principal should insert in the contracts relative performance evaluation clauses that make the compensation of each agent depend not only on his own output but also on the output of the other. We analyze side contracting in the form of a collusion game in which an agent makes a take-it-or-leave-it offer to the other. We show that, if the agents can engage in side contracting, it is not possible to design an interdependent incentive scheme that is not dominated by independent contracts, i.e. relative performance evaluation is never optimal.

Competitive Equilibrium with Indivisibilities: Price Discrimination and Manipulation

Jinpeng Ma

Rutgers University

Abstract

This paper studies an exchange economy with indivisibilities. Each agent is initially endowed with a finite number of indivisible commodities and has interdependent reservation values over bundles of indivisible commodities in the economy. In this broad framework, our major concern is the competitive equilibrium with price discrimination. Such a price system is common at auctions because different bidders often have different bids. It is shown that Kelso and Crawford's (1982) gross substitute condition is sufficient for the existence of competitive equilibrium with price discrimination in the bilateral exchange and the exchange economies. A necessary and sufficient condition on *agents'* preferences is derived for the existence in the bilateral exchange economy. A weaker sufficient condition is obtained for the exchange economy.

It is also shown that there does not exist any competitive mechanism that is also individually or coalitionally *nonmanipulable*, even if the reservation values satisfy the gross substitute condition and no side payments are allowed.

Monotonicity Properties of the Nucleolus of a Tree Game

Michael Maschler* (joint w/J. Potters[†] and H. Reijnierse[‡])

Abstract

It is well known that the nucleolus of a game does not behave monotonically when some parameters of the game change. It is therefore of interest to know that monotonicity properties do hold for large classes of games.

We show that the nucleolus of a tree game has the PMAS property; namely that if a few players leave the game and the rest have still to cover the cost of the tree, then each of the remaining players has to pay more. This generalizes a result of Sönmez [1994], who recently proved a similar result for the airport game.

To get our result as well as other monotonicity properties of the nucleolus, we develop yet another algorithm for computing the nucleolus of a tree game. This algorithm has the advantage that it can be described in plain words. Comparison of this algorithm with those of Megiddo [1978] and Granot [1995] is given.

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Semivalues of Nonatomic Games with Coalition Structures

Richard P. McLean

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Abstract

Nonatomic games have proved to be a very powerful tool in the analysis of economic and political problems where large numbers of players are present. In this paper, we study games with coalition structures. A coalition structure is a partition of the player set that arises when players organize themselves into groups for the purpose of bargaining. A coalition structure (CS) value is a solution concept for TU games that resolves the bargaining problem at the “intercoalitional” level and the “intracoalitional” level. For finite games, the CS value was defined by Owen and alternative axiomatic characterizations have been provided by Owen and by Hart and Kurz. In a previous paper, the author extended the notion of CS value to nonatomic games with from the axiomatic and asymptotic viewpoints. In this paper, we study semivalues of nonatomic games with coalition structures. Semivalues are operators that satisfy all of the axioms characterizing the Shapley value except efficiency. The axiomatic treatment of semivalues on spaces of finite games and on PNA was presented in Dubey, Neyman, and Weber (1981).

We present the axioms that will characterize the coalition structure semivalues on certain subspaces of BV. In the statements of the axioms, $\Pi = \{B_1, \dots, B_m\}$ is a coalition structure, Q is a Π -symmetric subspace of BV and $\psi : Q \rightarrow FA$ is a function.

- A.1:** (Linearity) ψ is a linear mapping of Q into FA .
- A.2:** (Monotonicity) ψv is monotonic whenever v is monotonic.
- A.3:** (Intracoalitional Symmetry) For all $v \in Q$, $\psi(\Theta_* v) = \Theta_*(\psi v)$ whenever $\Theta \in \mathcal{G}_n$.
- A.4:** (Intercoalitional Symmetry) If B_k and B_ℓ are substitutes in v_Π , then $\psi v(B_k) = \psi v(B_\ell)$.
- A.5:** (Projection) If $v \in Q \cap FA$, then $\psi v = v$.

A.6: (Efficiency) For each $v \in Q$, $(\psi v)(I) = v(I)$.

Axioms A.1, A.2 and A.6 are standard in the value theory of nonatomic games of Aumann and Shapley. Axiom A.3 says that the names of players belonging to the same coalition in Π do not matter. If $\Pi = \{I\}$ (so that $\mathcal{G}_\Pi = \mathcal{G}$), then A.3 is precisely the symmetry axiom of Aumann and Shapley. Axiom A.4 states that two coalitions that affect the game between coalitions in the same way will receive the same coalitional payoff under ψ while A.5 is a weak form of the dummy player axiom. Given a coalition structure Π and a Π -symmetric subspace Q of BV , a Π -CS semivalue is a function $\psi : Q \rightarrow FA$ satisfying axioms A.1-A.5. A Π -CS semivalue satisfying A.6 is a Π -CS value. In a previous paper, we proved the following coalition structure extension of Theorem H in Aumann and Shapley.

In this paper, we also study $\Pi - CS$ probabilistic values from the axiomatic viewpoint. In addition, we apply the machinery developed for the nonatomic case to the case of mixed games i.e. games with a player set consisting of a nonatomic “ocean” as well as atoms. These results allow us to treat coalition structure semivalues for finite and nonatomic games in a unified manner.

Dynamic Externalities and Policy Coordination

Len J. Mirman* (joint w/M. Datta†)

Abstract

We introduce the possibility of trade in dynamic models with externalities and evaluate the consequences on the capital accumulation process, the market-clearing prices and policy making. We consider mixed economies characterized by a blend of strategic and nonstrategic sectors. An equilibrium exists in the bilateral monopoly game because the strategic planner incorporates the future utility of the country and the presence of a nonstrategic sector in its decision making. Capital externality is one source of interdependence. Equilibrium price, a function of both outputs, is another. Policy coordination is advantageous *only* when preferences are dissimilar and an externality is present.

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Evolving Aspirations and Cooperation

Dilip Mookherjee*

(joint w/R. Karandikar[†], D. Ray[‡], and F. Vega-Redondo[§])

Abstract

A model of “satisficing” behavior in the repeated Prisoners Dilemma is studied. Each player has an aspiration at each date, and takes an action. She switches from the action played in the previous period only if the achieved payoff fell below the aspiration level (with a probability that depends on the shortfall). Aspirations are updated in each period, according to payoff experience in the previous period. In addition, aspirations are subjected to random perturbations around the going level, with a small “tremble” probability. For sufficiently slow updating of aspirations, and small tremble probability it is shown that in the long run both players cooperate most of the time.

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Payoff Distribution in Coalitional Games

Massimo Morelli

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Abstract

In this paper we modify Core Theory in order to form predictions about the distribution of payoffs in coalition formation games. Traditional Core Theory cannot be used directly, because many relevant distributive games have an empty Core. We propose a solution concept that keeps the spirit of Core-like competition (reflecting individual rationality as well as group rationality), but differs from the Core by restricting the admissibility of objections: objections where agents of the same type receive different treatment (when working in a productive coalition) are not considered admissible; a consistency requirement, derived from the one underlying the von-Neumann- Morgenstern Stable Set, is also imposed.

Our solution concept allows us to obtain a unique prediction about which payoff distribution must prevail in majority games. The prediction contrasts with the previous results in the literature, taking more explicitly into account the different bargaining power, or commitment power, that agents with different endowments have when they bargain on their share of the total coalitional outcome. Every agent should receive a payoff share equal to her relative contribution.

Higher Order Beliefs in Game Theory

Stephen Morris

University of Pennsylvania

Abstract

The talk will survey recent research which relates players' higher order beliefs about payoffs and the equilibria of games. The relationship between refinements and higher order beliefs will be discussed.

Strategy-Proof Cost (or Surplus) Sharing

Hervé Moulin

Duke University

Abstract

Traditional Clarke Groves mechanisms achieve an efficient outcome at the cost of budget balance. An alternative, less traveled, route explores budget balanced and strategy-proof mechanisms (that do not choose the efficient production outcome). Several classes of these mechanisms have been recently uncovered, that offer palatable resolutions for a few important cases of the general cost sharing problem. Examples include submodular access charges, excludable public goods, and supermodular and increasing marginal costs.

Cooperation in R & D: The Case of Patent Infringement Agreements

Arijit Mukherjee* (joint w/S. Marjit[†] and H. Shi[‡])

Abstract

The paper attempts to provide a strategic rationale behind patent infringement agreements (PIA), PIA is to be viewed as a form of “cooperation” in an otherwise noncooperative environment. In this paper, we develop a symmetric duopolistic structure where firms initially hold certain patents and invest for further R & D. In the process of R & D, firms face a positive probability of infringing the patents held by the other. Once infringement takes place, the infringing firm has to pay a compensation to the patent holder. The PIA scheme generates a binding contract suggesting that such infringements would go unpunished. We prove that (a) If the infringement probability is not too “low,” firms would have incentives to sign a PIA and sacrifice the monopoly option. In case the infringement occurs with certainty, PIA dominates the non-cooperative outcome; (b) For relatively low and high probabilities of infringement, PIA dominates state-contingent PIA; and (c) The likelihood of signing PIA will also increase with the probability of failure in R & D.

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The Stable Standard of Behavior in the Prisoner's Dilemma

Shigeo Muto* (joint w/A. Suzuki†)

Abstract

This paper studies the stable standard of behavior or the von Neumann/Morgenstern stable set due to von Neumann/Morgenstern and Greenberg in the prisoner's dilemma. Using a two-person strategic form game, the authors introduce a chain (or indirect) domination due to Harsanyi to find $vN - M$ stable sets. Conditions for inclusion in stable sets are found under various domination assumptions and a sort of folk theorem holds w.r.t. these stable sets. Further results include that to surely attain the cooperation-cooperation pair, the two players' joint moves are indispensable.

*Tokyo Metropolitan University, Japan

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Strategic Entropy and Complexity in Repeated Games

Abraham Neyman* (joint w/D. Okada†)

Abstract

We study repeated two-person zero-sum games in which one of the players has a restricted set of strategies. Restriction is imposed directly on the set of mixed strategies. To this end, we introduce a notion of entropy for mixed and behavioral strategies as the means of bounding strategies available to a player.

We derive a relation between the two types of strategies in terms of entropy. Using this relation together with certain properties of entropy, we show that if the number of repetitions grows faster than the entropy bound, then an unrestricted player can asymptotically hold a restricted player's payoff down to his maximum level in pure actions of the stage game.

We consider implications of this result concerning the number of repetitions needed so that an unrestricted player can take full advantage of finite automata or bounded recall strategies.

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Potential Competition and Coordination in a Market Entry Game

Kofi O. Nti

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Abstract

When there are too many potential competitors available to exploit a new market opportunity, a problem arises regarding the effectiveness of potential competition. Competition may not be served if entry occurs spontaneously. This paper employs a contest or rent seeking game to coordinate entry and shows that some competitive benefits may be realized. Specifically, probability of entry and consumer surplus increase with potential competition but expected profit per firm decreases. Although welfare decreases with potential competition when the number of competitors is large, welfare can increase with potential competition for some contest designs if the number of competitors is small. Market performance deteriorates with increasing coordination failure when the number of competitors is fixed.

The Indirect Evolutionary Approach To Explaining Fair Allocations

Jörg Oechssler (joint w/S. Huck)

Humboldt University, Berlin

Abstract

Experimental results on the ultimatum game show clearly that (1) large fractions of players offer a ‘fair’ allocation and (2) that unfair (but positive) offers are systematically rejected. We offer an explanation of this behavior using the ‘indirect evolutionary approach’ which is based on the assumption that players behave rationally for given preferences but that their preferences change through an evolutionary process. We prove that despite anonymous interaction a preference for punishing unfair offers is an evolutionarily successful strategy if players interact in groups. This leads players to split the resource equally almost always. However, the equal split is not due to ‘true fairness’ (or ‘altruism’) but is entirely caused by the (justified) fear that unfair offers might be rejected. Our result can be interpreted as presenting an evolutionary foundation for the emergence of social norms.

A New Approach of a Prekernel for NTU Games

Gooni Orshan (joint w/J.M. Zarzuelo)

The Basque Country University, Spain

Abstract

The *consistency property (reduced game property)*, with respect to the reduced games of Davis and Maschler (1965), stands as the main axiom in the characterization of the prekernel (Peleg 1986) in the following sense: of a solution concept coincides with the Nash solution for all 2-person TU games (as the prekernel does), the *bilateral consistency* (i.e., only the 2-person reduced games are taken into account) implies that its extension for each multi-person TU game is contained in the prekernel. Generalizing this approach to the case of NTU games yields a solution concept that unfortunately specifies an empty set for too many games. Therefore, we use here a weaker version of bilateral consistency to obtain an NTU solution concept. This version, refers to the reduced game of Hart and Mas-Colell (1989), was used by Maschler and Owen (1989) to characterize the consistent Shapley value for the class of hyperplane games. In this work we study the properties of the new solution concept and provide existence theorems.

Social Learning and Competition

Marco Ottaviani (joint w/G. Moscarini)

Massachusetts Institute of Technology

Abstract

This paper analyzes equilibrium prices in a model of quality differentiated duopoly, selling to a sequence of buyers who learn from each other. The introduction of competition between producers allows us to extend the theory of rational social learning to consider the effect of prices on the decisions of the buyers and the incentives of the sellers to induce herding of buyers on their own good. Competition is shown to reduce the occurrence of informational cascades.

Simple Divide the Money Game with Bribing

Vesna Pasetta

Belgrade University

Abstract

This paper addresses an extension of a well-known divide the money game due to externalities, that take the particular form of bribing transfers. Theory of operator algebras in dynamical systems and theory of unbounded derivations are applied to get an insight into economic phenomena, embodying a bribing process, that arise by this setting of the model.

Note on Two Excess Functions for Cooperative Games Without Side Payments

Sergei Pechersky

St. Petersburg Institute of Economic and Mathematics, Russia

Abstract

Michael Maschler (1992) noted that “Research concerning the extension of the kernel and the nucleolus to games without side payments is still scarce.... the main issue is to decide what the analogue of the excess functions should be.” We introduce two more excess functions and discuss some of their properties.

The definitions depend on the specification of the excess function. Though there are several notions of excess function for NTU-games, there is no generally accepted notion of excess function for those games, and we define two more excess functions. It can be shown that both excess functions defined are excess functions in Kalai’s sense (Kalai (1975)). Moreover both excess functions are continuous and concave, and we list some of their properties (for more properties see Kalai (1975)).

A Formal Approach to Nash's Program

Bezalel Peleg

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Abstract

We provide a formal framework which allows for a precise formulation of the Nash program for n -person decision problems (i.e., n -person cooperative games). Two classes of decision problems are investigated: Finite decision problems (i.e., decision problems that may be resolved by means of finite extensive games), and decision problems that lead to multistage games with observed actions. In both cases certain assumptions imply the rejection of Nash's program. We suggest to replace Nash's program by the following weaker assumption.

The weak program of Nash: Let N be a set of n rational decision makers, $n \geq 2$, and let δ be a decision problem for N . Then there is a nonempty set Γ of n -person noncooperative extensive games that may resolve δ . The choice of a game from Γ , in order to solve δ , is left to nature.

We should emphasize that we only show that, in our model, there exist some families of cooperative games for which Nash's program fails. Certainly, other cooperative games may be resolved by the Nash Program.

Characterization of Fully Consistent Assessments in Extensive Form Games

Andres Perea y Monsuwé (joint w/M. Jansen and H. Peters)

University of Maastricht, The Netherlands

Abstract

In an extensive form game, a combination of a behavior strategy profile and a belief system is called an assessment. Such an assessment is a sequential equilibrium if it satisfies sequential rationality and full consistency. The first condition means that at every information set the corresponding player maximizes his expected payoff, given his beliefs at this information set and given the local strategies at other information sets. This condition is equivalent to a system of polynomial inequalities and is therefore straightforward to check. Full consistency is a condition which relies totally on the graphical structure of the game. An assessment is called fully consistent if it can be approximated by a sequence of assessments in which every action is played with positive probability and the beliefs are obtained by Bayesian updating. In contrast to the first condition, full consistency is (in general) hard to check because the definition requires sequences of assessments.

In this paper we develop a purely algebraic characterization of fully consistent assessments without making use of sequences and limits. This characterization is used for three different purposes. (1) If the extensive form game is not too big, it enables us to check rather quickly whether a given assessment is fully consistent, or not. (2) The characterization can be used to develop an efficient algorithm which computes the set of fully consistent assessments in a given extensive form game. (3) The characterization makes it possible to give a geometrical description of the set of fully consistent assessments.

An Analysis of a Learning Dynamic: Learning to Play an “Egalitarian” Equilibrium

Alexandre Possajennikov

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Abstract

In the paper I analyse the dynamics proposed in the paper of Roth and Erev (1995). The dynamics can be interpreted as a learning dynamics with a fixed aspiration level and all payoffs are more than this aspiration level, therefore all strategies are reinforcing. I start the analysis with the simple case of a one-agent decision problem and show that the dynamics converge in expectations to the optimal strategy. However, the convergence is very slow, so for economic relevant time period the results can differ from the very long run predictions. The analysis of the dynamics for games is more difficult and I present only the results of computer simulations for several simple games. The simulations show that the dynamics do not necessarily converge even to a Nash equilibrium in the medium run. The other feature of dynamics is that it converges to the perfect Nash equilibrium in games where the equilibria are “extreme” in the sense that one of the players receives almost all payoffs there. However, if the game possesses an (imperfect) equilibrium with more equal distribution of payoffs, such an equilibrium is chosen in the medium run more often than the perfect one.

The Benefits From Digging Holes and Filling Them Up

Rohit Prasad* (joint w/P. Dubey[†] and J. Geanakopolos[‡])

Abstract

We consider a finite horizon general equilibrium economy, with fiat money, and public goods. The government finances its production of public goods, (i.e. fiscal policy), by printing money, (i.e. deficit financing), and issuing bonds/bank loans, (i.e. open market operations). Its debt on bonds/bank loans is repaid in full by levying taxes. Furthermore, it may raise the levels of bank money available in the economy, (i.e. undertake monetary policy). The government can choose its policy variables freely, with one of the variables determined residually by the condition that the government balance its budget. We show that for any policy of the government, competitive equilibria always exist, (in which private agents view the government actions as fixed), and are generically finite. This enables us to carry out comparative statics as government policy is varied. Certain qualitative features of optimal government policy are highlighted via robust examples.

- Using both deficit financing, and open market operations maybe better, (in the Pareto sense), than using just one or the other.
- Even in the absence of public goods, with the government therefore totally unproductive, fiscal policy may be beneficial. (The equilibrium without government intervention may be inefficient on account of positive interest rates). Indeed, situations can arise when the government can bring about a Pareto improvement by simply employing people to ‘dig holes and fill them up’.
- If the initial level of bank money is low relative to privately held money, then the most efficient Pareto-improving trajectory involves the initial use of monetary policy, followed by fiscal policy.

We also pinpoint general circumstances under which hyperinflation can occur in the economy.

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Efficient Mechanisms for Cooperation Games

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Abstract

G is a Cooperation Game if the utility of every player is a monotonous function of the strategies of other players. Such games are very prominent in economic theory. G is a Simple Cooperation Game if every player has only two actions available. Standard solutions of cooperation games in general will not be efficient. However economic and political conflicts usually are not one shot strictly non-cooperative games. In this paper we shall study mechanisms leading to efficient outcomes for Simple Cooperation Games. An oral descending auction is a good candidate for such a mechanism. We define stable outcomes for such auctions and show that all stable solutions are indeed efficient. Interpretations in terms of extensive form games and those of the theory of social situations are also indicated.

Equilibrium Play and Adaptive Learning in Two-Person Bargaining

Amnon Rapoport

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Abstract

Can the Bayesian-Nash equilibrium solution account for the experimental outcomes of bilateral bargaining under the sealed-bid double auction mechanism? In response to this question we report the results of two experiments on bilateral bargaining under the sealed-bid double auction mechanism where theory calls for decidedly strategic play. The observed individual sellers' ask functions and buyers' bid functions, each based on 50 rounds of bargaining, are shown to be in good agreement with the piecewise linear equilibrium solution of Chatterjee and Samuelson (1983). Although the game is played "against the field", with random matching of traders on each round, both sellers and buyers change their behavior over time. We propose a simple adaptive learning model postulating round-to-round changes in the bid/ask functions which are proportional to the actual gain, if a deal was struck, or to the opportunity loss, if no agreement was reached on the previous round. The model incorporates major findings in the psychological study of learning. It captures the major features of the observed mean bid/ask functions and accounts for most of the variability in the individual choices.

Wage Bargaining: “Voice” and Organization Costs May Lead to Social Partnership

Arno Riedl

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Abstract

This paper analyzes a wage bargaining situation where gains from cooperation – due to the so called “voice/response effects” of unionization – are possible. The workers have to bear organization costs. If the union is formed the bargaining power of the workers is increased in the sense that they are able to participate in a bargaining process with the firm. If workers don’t organize they have to accept an ultimatum wage offer made by the firm. At a first stage the firm has the possibility to influence the unions organization costs directly, i.e. possible management opposition against unionization is explicitly taken into account. The bargaining part is modeled as a non cooperative bargaining game. Existence of subgame perfect equilibria in the bargaining subgame is derived. In general the equilibrium is not unique. For low organization costs multiplicity arises because of the non-(log)concavity of the firm’s profit function. For higher cost levels multiple equilibria come into play because the workers have to decide after a rejection if they want to continue the bargaining process. The negotiated wage depends on the costs the workers have to bear and is, in general, higher than the workers reservation wage. At the first stage, the firm will not decide to choose prohibitively high costs, since in this case bargaining never takes place. But even if the firm sets cost levels in a range where the gains from cooperation are going to be exploited the firm does not always have an incentive to choose the highest possible costs within this range. This behavior is independent of the equilibrium played in the bargaining subgame. The result that the firm decides not to use an aggressive strategy can be interpreted as a kind of “social partnership”. That is, firms do not try to prevent workers from organizing with all possible means.

A Principal-Agent Model with Incomplete Preferences and Inertia

Luca Rigotti

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Abstract

In some principal-agent settings, the agent's preferences may be incomplete, and thus, he may have multiple, or 'imprecise,' beliefs. This imprecision arises because the agent is not confident in his assessments about the possible consequences of his actions, I find the optimal incentive scheme in such settings, and discuss its characteristics. Furthermore, I explore the implications of this model for the robustness and simplicity of optimal contracts.

The model illustrates principal-agent relationships where the agent is an outsider who is not familiar with all the details of the production process. In contrast, the principal is an insider, more familiar with these details. The principal is at an informational disadvantage because she cannot observe the agent's effort choice, but the agent is entering a new environment, and cannot *ex-ante* precisely evaluate the consequences of his work. The standard principal-agent model, however, neglects this possibility. It assumes both parties can precisely evaluate the stochastic consequences of the agent's action. In our setting, however, there is a natural candidate for the status quo, namely, the agent's outside option.

I consider a two-state, two-action moral hazard model. A risk-neutral principal has to design an incentive scheme for a risk-neutral agent who has imprecise beliefs over output outcomes. These beliefs are represented by sets of probability distributions, one set for each action. The principal cannot observe what action the agent chooses. She wants to implement, at the lowest possible cost, the action that makes the good state more likely. This action corresponds to high effort, and is relatively expensive for the agent.

Cooperation, Corporate Culture, and Incentive Intensity in Organizations

Rafael Rob* (joint w/P. Zemsky[†])

Abstract

We offer an alternative to the standard risk-sharing theory of incentive intensity and an exploration of culture-based performance differences across firms. We study a multi-agent, multi-task, multi-period principal-agent problem. Employees (agents) allocate their effort between individual production and tasks that involve cooperating with other employees. Employees have endogenously determined tastes for cooperating, which depend on past levels of cooperation in the organization. These history dependent preferences create a dynamic process in which the firm's control variable is the incentive intensity and the state variable is the level of cooperation among employees. We define corporate culture as the interdependent collection of behaviors, experiences, and values of a firm's workforce. We show that there may be multiple possible stable cultures for a given production technology. We also show that even with risk-neutral employees, the firm reduces incentive intensity below the first best level. It does this to encourage cooperation and to manage the evolution of its culture.

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Experimentation, Imitation, and Stochastic Stability

Robert W. Rosenthal (joint w/D. Gale)

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Abstract

In complex situations, substantive rationality is a very strong assumption; so it is interesting to ask whether boundedly rational agents could learn over time to play an equilibrium strategy. In this paper we model the dynamic interaction of two types of agents, experimenters and imitators, whose behavior is characterized by simple rules of thumb. The agents repeatedly play a one-shot game in which the agents' actions are strategic substitutes. The system is *stable in the large*: it converges globally and with probability one to a compact neighborhood of the unique and symmetric equilibrium. On the other hand, the equilibrium is *unstable in the small*: the system leaves a small neighborhood of the equilibrium with probability one in finite time. However, the equilibrium is *not too unstable*: the probability of the system being in any given neighborhood of the equilibrium at t converges to one as t approaches ∞ . The properties of stability in the large and instability in the small appear to be robust and may be factors in macroeconomic cycles.

**Imitation Dynamics in the Repeated Prisoners' Dilemma: An
Exploratory Example**

Christopher S. Ruebeck

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Abstract

This paper investigates a deterministic evolutionary process governing the adoption of strategies for playing the infinitely repeated Prisoners' Dilemma. Agents playing unsuccessful strategies attempt to imitate the strategies of successful agents. However, agents' strategies are assumed not to be directly observable, so must instead be inferred from a memory of pairwise play and a knowledge of the strategy space. The result is that all agents adopt "always defect" in the long run.

Why Isn't It Enough to be Coherent?

Dov Samet (joint w/A. Heifetz)

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Abstract

Players' beliefs, in a game with incomplete information, can be constructed explicitly: first, their beliefs about the parameters of the game, then their beliefs about these beliefs and so on. Such beliefs should be coherent in the sense that higher order beliefs should agree with lower order ones. Mertens and Zamir (1985) have shown that when the initial set of the parameters of the game sense that higher order beliefs should agree with lower order ones. Mertens and Zamir (1985) have shown that when the initial set of the parameters of the game is a topological compact space, then all coherent beliefs form a universal belief space. We show that this is not necessarily the case when the set of parameters of the game is a measurable space. Nevertheless, we show that even in such cases there exists a universal belief space.

Aggregation of Preferences in Social Choice and Voting

Norman Schofield

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Abstract

Suppose p is a smooth preference profile (for society N) belonging to a domain P^N . Let σ be a voting rule, and $\sigma(p)(x)$ be the set of alternatives preferred to x . The equilibrium $E(\sigma(p))$ is the set such that $\sigma(p)(x)$ is empty. A sufficient condition for existence of $E(\sigma(p))$ when p is convex is that a “dual”, or generalized gradient, $d\sigma(p)(x)$ is non-empty at all x . Under certain conditions $d\sigma(p)$ admits a “social gradient” $\Gamma(p)$. Γ is called an “aggregator” on the domain P^N if Γ is continuous on P^N . The paper shows that the “minimax” voting rule, σ , admits an aggregator when P^N is the set of convex preference profiles (on a compact, convex topological vector, W) and P^N is endowed with a C^1 -topology. An aggregator can also be constructed on a domain of non-convex preferences when W is the compact interval. The construction of an aggregator for a general political economy is also discussed. Some remarks are addressed to the relationship between these results and the Chichilnisky-Heal theorem on the non-existence of a preference aggregator when P^N is not contractible.

The Core of a Production Economy with Asymmetric Information

Ulrich Schwalbe

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Abstract

This paper studies the core of a production economy with asymmetric information. The information of an agent is modeled as a partition of a finite set of states of nature. If the information is incomplete, it restricts the actions an agent can take: Only those transactions that are compatible with the information an agent has at his disposal can be carried out. However, if he joins a coalition, his information changes according to an exogenously given information rule, a concept introduced by Allen (1991). The transactions the members of a coalition can make depend on this modified information. In addition to a reallocation of its members endowments, a coalition is also able to produce. The production possibilities of a coalition are described by a technology set and an information that the coalition can employ in production. This information depends on the information of the coalition members and is also described by an information rule. Given that the technology sets satisfy some regularity conditions, a production economy with asymmetric information generates a well-defined cooperative game. It is shown that the core of this game and thus the core of the underlying economy is nonempty provided that the technology sets satisfy a balancedness condition. This result holds independently of the given information rules. This result is illustrated by a simple example that demonstrates that asymmetric information could be an incentive for the decentralization of production. Some possible extensions of the model are discussed.

Efficiency in Repeated Prisoner's Dilemma with Private Monitoring

Tadashi Sekiguchi

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Abstract

This paper analyzes repeated games with private monitoring, where in each period each player receives a signal of the other players' actions in the previous period, and that information is private information. Previous literature on repeated games with private monitoring has not shown whether or not (nearly) efficient equilibria exist. For a repeated prisoner's dilemma satisfying a certain assumption regarding stage game payoffs, we show that there exists a nearly efficient sequential equilibrium, provided that imperfectness of signals is small and players are patient.

Mixed Strategy Play and the Minimax Hypothesis

Jason Shachat

University of Arizona

Abstract

This paper reports on a set of experiments designed to discriminate among the possible sources of the failure of the minimax hypothesis' predictions in the unique mixed strategy minimax equilibrium of the O'Neill (1987) game. First, the experimental design allows one to identify the causes of the serial correlation in subjects' action choices. Second, the design allows one to discriminate among, a set of mixed strategies which generate distributions over actions and wins similar to the distributions generated by the minimax strategy. This is accomplished by introducing a new methodology for eliciting mixed strategies, which overcomes some of the difficulties with previous experimental attempts to directly observe mixed strategies. The results clearly show that subjects' choices do not coincide with their minimax strategies, and that players' intended behavior is not minimax. Analysis of the data also reveals that subjects adopt a wide variety of strategies. It is shown that this heterogeneity can rationalize some of the features of the aggregate data that are consistent with the predictions made by the minimax hypothesis.

Nash-Equilibrium and Pareto Optimality

Lloyd S. Shapley

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Abstract

An equivalence relation is defined on strategic-form n -person games, such that all or most of the apparatus of Nash equilibrium theory remains invariant. But the Pareto sets are not preserved. The implications of this observation for the study of the efficiency of Nash equilibria will be discussed.

Can Pre-Arranged Matches be Avoided in Two-Sided Matching Markets?

Tayfun Sonmez

University of Michigan

Abstract

We study manipulation via pre-arranged matches in the context of two-sided matching markets. We show that the mechanism that is used to match the hospitals and medical residents in the U.S., namely the hospital-optimal stable rule is manipulable in this way. Unfortunately this is a more general problem and we show that there is no mechanism that is both stable and non-manipulable. We then analyze the conditions under which such manipulations are possible for stable mechanisms and show that it is more serious of a threat for the hospital-optimal stable rule than its main competitor, the student-optimal stable rule. Our results suggest that the market participation is likely to increase while the instabilities due to such manipulations are likely to decrease if the student-optimal stable rule is adopted.

Herding as Experimentation Déjà Vu

Peter Sorensen* (joint w/L. Smith†)

Abstract

We prove that the recently proposed herding models are special cases of a standard single person experimentation model with myopia. Relying on this mapping, we interpret the pathological outcomes of observational learning as well-known pathological phenomena from the experimentation literature. Furthermore, we obtain a natural model for the analysis of social optima in social learning models. Results for that model are immediately obtained from the experimentation literature.

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Computation of Equilibria in Extensive and Normal Form Games

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Abstract

Economists and game theorists using non-trivial games in their modeling should have good computational tools at their disposal for solving these games. We give a survey of algorithms for computing Nash equilibria in games that are specified in normal form or extensive form. Such a game is usually converted to an optimization problem, in the simplest case a linear program, which is then solved by iterative methods. For two-person games, ‘combinatorial’ algorithms suffice, which inspect only a finite number of possibilities. Pivoting methods, like the simplex algorithm for linear programming, are of this kind. In order to be practically feasible, the number of variables of the optimization problem should be kept small. For extensive games, this has recently been achieved by avoiding the conversion to normal form with its large (exponential) number of strategies, using sequences of moves instead of strategies. We will also discuss computational aspects of equilibrium refinements, like perfect or sequential Nash equilibria.

Tracing Equilibria in Extensive Games by Complementary Pivoting

Bernhard von Stengel*
(joint w/A. van den Elzen[†] and D. Talman[‡])

Abstract

An algorithm for solving a game should be efficient, simple, robust, compute “useful” solutions, allow an interpretation if possible, and have the potential to be extendable to wider classes of games. We present an algorithm with all these properties for the following problem: Find an equilibrium of an extensive two-person game with perfect recall.

Our algorithm is efficient and simple. Our method is robust and computes an equilibrium with many useful properties that allow a game-theoretic interpretation. It defines a piecewise linear path in the strategy space leading from a given prior to the equilibrium. Each strategy pair on that path is an equilibrium of a restricted game where the prior is played with some minimum probability that is initially one and decreased to zero (with possible intermittent increases). Up to projection, this mimics the tracing procedure by Harsanyi and Selten (1988) to determine an equilibrium starting from the given prior. As a drawback, this is the (linear) tracing procedure for the normal form of the game, not the extensive form.

Finally, the prior as an arbitrary starting point allows the method to be used as a subroutine for solving multiplayer games. This problem is intrinsically nonlinear, but an iterated approximation by linear methods is desirable. Such an iteration requires the possibility to restart the method at an arbitrary point. This is possible with our method, but not with the Lemke-Howson method, for example.

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Equilibrium Existence for Infinite Games: The Nearly Compact and Continuous Case

Maxwell B. Stinchcombe* (joint w/C.J. Harris[†] and W. Zame[‡])

Abstract

For games satisfying an algebraic condition on strategies and utilities, equilibria exist, depend upper hemicontinuously on the specification of the game, and are exactly the limits of approximate equilibria on large finite approximations. These games are called nearly compact and continuous (NCC) because they can be understood as dense subgames of larger, compact games with continuous payoffs. The equilibria of NCC games have equivalent representations as equilibria in finitely additive mixtures.

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Beliefs, Competition, and Bank Runs

Theodosios Temzelides* (joint w/B. Adao[†])

Abstract

Within the framework of Diamond-Dybvig, the optimal (run free) outcome is shown to be the unique forward induction equilibrium. In a version of the model that posits Bertrand competition among banks, there are sequential equilibria that imply positive profits. However, the zero-profit contract is supported as the unique equilibrium outcome if the agents' beliefs are restricted to the space of beliefs consistent with the forward induction refinement.

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Bertrand Price Competition in a Social Environment

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Abstract

We consider the behavior of agents in a social environment. In most papers on this subject these kind of economic problems are dealt with from a pure economic perspective (e.g. Young, Kandori, Ellison). In this paper we look at the problem from a more sociological point of view. We drop the assumption that the agents are rational and replace this assumption by specifying an adaption process for the strategies played by the agents, taken from the sociological literature (e.g. Liebrand & Messick). By specifying such an adaption process, we prescribe the agents what to do in every situation they might encounter. In this way an evolutionary process is specified. This leads to results that differ substantially from the results achieved by, for instance, Young & Foster.

The social environment is constructed as a torus of agents. Each agent has a limited set of agents with whom he can interact, his set of neighbors. We make the (common) assumption that the set of neighbors is much smaller than the total population. An agent doesn't perceive what is going on outside his set of neighbors. The agents are producers of a heterogeneous product and their other features (market opportunities, size and so on) are all equal. They play a symmetric Bertrand-price competition game with heterogeneous products. In this context a strategy consists of a price at which an agent sells his product. The agents can only name a fixed number of prices varying from the pure Nash-equilibrium price to the pure cooperative-equilibrium (cartel) price of the game. In every stage of the model an agent from the social environment is randomly selected. The agent will compete against the agent in his set of neighbors with the lowest price at that moment. Since the cartel-price is always higher than the Nash-price, this will be the agent with the most 'Nashlike' price, the agent playing the strategy with the lowest degree of cooperation of all neighbors. Since the opponent with the lowest price is bound to draw away the most consumers from the producer, this 'matching rule' implies that a producer always plays Bertrand-competition with his most aggressive opponent.

In our model it is shown that the population of agents converges to a quasi-stable state. In this state the individual agents still change their strategy, but the fraction of agents that plays a certain strategy is fixed. In the quasi-stable state of the population a great deal of cooperative behavior is observed. When the population is in the quasi-stable state, after a stochastic time a trigger event will occur, after which the quasi-stable state will be left. More competitive ('Nash-like') behavior evolves rapidly. After some time however there will again be convergence to the same quasi-stable state of the population. We show that (and why) the occurrence of the trigger event is very rare.

Corruption and Political Institution

Shyh-Fang Ueng

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Abstract

This paper uses a model of two-stage bargaining with coalition structure value allocation to show that, given the same culture, a political institution with veto players to its multi-party legislature is more corruptible than the one without veto players to its multi-party legislature. Corruption is defined as the amount of bribe which a legislative coalition can extract from an interest group in exchange for passing the law desired by the interest group. The political institution with veto players to its legislature represents the presidential system; while the one without represents the parliamentary system.

A Shapley Value Representation of Potential Games

Takashi Ui

Stanford University

Abstract

Potential games, considered by Monderer and Shapley, are games with potentials, functions of strategy profiles such that the difference induced by a single deviation is equal to that of the deviator's payoff function. We provide a representation theorem for potential games in terms of the Shapley value. Our result states that a game has a potential if and only if its payoff functions coincide with the Shapley value of a particular class of cooperative games indexed by the set of strategy profiles, and that its potential also coincides with a potential of the cooperative game that is defined by Hart and Mas-Colell.

Output Communication and Leadership

Amparo Urbano (joint w/D. Alepuz and R. Moner)

University of València, Spain

Abstract

We investigate whether, in a homogeneous market, duopolists have an incentive for sharing information about their equilibrium outputs. We isolate the conditions under which the exchange of information among firms is the subgame perfect equilibrium of a three stage noncooperative game.

Our game consists of two production stages preceded by an initial one in which the duopolists decide on whether or not to communicate their equilibrium outputs in the first production stage. This comprises two potential production periods, with the proviso that a firm can produce in either period but not in both. Thus, the decision for each firm in this subgame consists of whether to produce in period one (specifying the quantity to be produced) or to wait. Finally, the second production stage, where firms play Cournot, provides the incentive for information manipulation (signal-jamming). Two effects are in play: an incentive to communicate when the rival does not, if communicating involves a “first mover advantage,” and a threat of not being better off if it is the rival who communicates instead.

The Leximin Stable Allocation

José Ramón Uriarte* (joint w/J. Arin and E. Iñarra)†

Abstract

We shall be dealing with a society in which every member believes to a certain extent in equality as a social value. Those personal beliefs are not neatly represented by a profile of individual inequality preorders as in Lebreton, Trannoy, and Uriarte (1985). But somehow, the aggregation of ethical beliefs has already been done and we face an equality oriented society. Nevertheless, the selfish preferences or “the preferences as they actually are” generate a social conflict that is studied by a means of a cooperative n -person transferable utility game in characteristic function form. Thus, our framework is similar to that of Dutta and Ray (1989), although there are some differences that should be mentioned. We shall be dealing with an allocation rule that satisfies: fairness, universality, and core stability.

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Inductive Belief Updating, Mutual Knowledge and Equilibrium

Peter Vanderschraaf

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Abstract

This paper explores the properties of certain rules for *inductive belief updating* in noncooperative games, which one can use to account for both Nash equilibrium play and elements of the mutual knowledge implicit in the Nash equilibrium concept. Standard models of *fictitious play dynamics* in noncooperative game theory have players update their beliefs, quantified as probability distributions, over each others' strategies recursively, until these beliefs converge. The usual interpretation of the fictitious play process is that the players mentally simulate a sequence of successive plays by computing one another's expected utilities at each stage of deliberation, noting which strategy maximizes expected utility for each player, and updating their probabilities as a function of the relative frequencies that their opponents would have followed a particular strategy profile. If the players' belief distributions satisfy probabilistic independence over their opponents' strategies, then the limit of a sequence of fictitious plays is a Nash equilibrium of the game (Brown 1951).

This paper considers models of dynamic belief updating which, while closely related to fictitious play, have a different underlying interpretation. In these models of *matched player inductive dynamics*, a finite population of individuals update their probabilities over their opponents' strategies over time. In an n -player game, at each stage of the updating process n individuals in the population are selected and assigned one-to-one at random to the pure strategy sets and payoff vectors which define the game. Each selected individual plays a strategy which is a best response, given her current beliefs regarding her opponents. At the end of a round of play, all members of the population revise their beliefs given what they can observe, and then new individuals are selected who repeat the process given their updated beliefs. As in fictitious play, in matched player inductive dynamics, each player's beliefs are a mixture of his priors and the relative frequency of observed plays. However, the assumptions needed to justify matched player inductive dynamics regarding the players' knowledge of their situation are

much weaker than those of the standard interpretation of fictitious play. Given the interpretation of fictitious play as a sequence of mentally simulated plays, the players are assumed to have common knowledge of the payoff structure of the game, of their Bayesian rationality, of their prior probability distributions *and* of the fact that they all update their beliefs according to the recursive fictitious play formula. In matched player inductive dynamics, at the start of the updating process each player is assumed at the onset to know only the game and her private prior over her opponents' strategies. Assuming that the players' probability distributions are uncorrelated, the limit of this process is a Nash equilibrium of the game. It is shown that for a class of *coordination games*, this dynamics converges almost surely to a *strict* Nash equilibrium of the game. This dynamical adjustment process might be facetiously called "nonfictitious fictitious play", because it is a mathematical generalization of the fictitious play process but is best interpreted as a sequence of actual repeated plays of a game.

The motivation for introducing matched player inductive dynamics is twofold: (1) Like most of the dynamical adjustment process in the literature, this process gives an account of how players starting at an initial state of indecision can settle upon a Nash equilibrium of a game. However, as hinted already, matched player inductive dynamics gives an explanation of the "spontaneous" emergence of equilibrium play which relies upon weaker assumptions than fictitious play and most of the generalizations of fictitious play. In particular, matched player inductive dynamics does *not* presuppose that all agents engaged in the game have a common prior, or even that they can deduce the priors of their opponents. (2) Matched player inductive dynamics can be used to account for players' having the *mutual knowledge* which justifies their following a particular Nash equilibrium. In a set of remarkable results, Aumann and Brandenburger (1995) show that mutual knowledge of the game, of Bayesian rationality and of players' beliefs regarding each other is in general a necessary condition for justifying Nash equilibrium play, and that in the 2-player case, such mutual knowledge is also a sufficient condition. However, one cannot explain all cases of such mutual knowledge as the result of pre-play communication without making the explanation circular, since the ability to communicate successfully presupposes certain higher order mutual knowledge, such as mutual knowledge of the meanings of linguistic expressions. It is argued in this paper that players who initially have no mutual knowledge can come to have the mutual knowledge which underpins the Nash equilibrium concept for the 2-player case, and which is required for the n -player case, if they learn inductively about each other according to a process such as the matched player inductive

dynamics.

Bargaining with an Endogenous Deadline

Vincent Vannetelbosch

University of Louvain, Belgium

Abstract

We study a sequential bargaining game with a deadline from which the size of the cake decays. Two bargaining procedures are considered a model with alternating-offers and a model with iterated simultaneous demands. We show that the bargaining game with alternating-offers has a unique SPE outcome, while the game with iterated demands possesses a unique Pareto *robust*-SPE outcome. Then, we endogenize the choice of the deadline: the bargaining game with alternating-offers is characterized by a deadline effect, whereas the other game is not. That is, once we endogenize the deadline, the occurrence of a deadline effect depends on the bargaining procedure used. But as the bargaining period goes to zero, the unique SPE outcome of the game with alternating-offers approaches the unique Pareto robust-SPE outcome of the game with iterated demands.

Ex-ante Communication and Nash Equilibrium

Jose E. Vila (joint w/A. Urbano)

University of València, Spain

Abstract

A model is presented where players communicate prior to the play of a two player, complete information game. We, show the role of ex-ante, plain conversation as a coordination mechanism.

Our main result is formulated in terms of the correlated equilibrium concept. In particular, if G_0 is a 2-person game and x is a correlated equilibrium payoff of G_0 with rational valued underlying probability distribution, then there exists a direct communication game G extending G_0 (i.e. one where plain conversation is allowed before moving) such that x is a Nash equilibrium payoff of G . In other words, that no mediator is needed for the actual realization of a correlated equilibrium (when the distribution is rational).

Our scheme of plain conversation (protocol) assumes finite messages, but uses a different approach than that of Bárány. In particular, it entails public messages with private keys (for coding and decoding), following the Pohling-Hellman methodology. Also, we do not look for built-in checking protocols, or sure protocols, but for those protocols for which deviations are not ex-ante profitable.

A by-product of the analysis is that under our protocol any unilateral deviation from the rules is detected with probability $1 - \epsilon$. And also, any unilateral deviation by a player does not change the other player's marginal probability to play any given strategy.

An Experimental Test of Bayesian vs. Adaptive Learning in Normal Form Games

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Abstract

This paper reports on an experiment designed to test whether Bayesian models of learning or adaptive models such as best response and fictitious play provide a better description of actual disequilibrium behavior in strategic situations. The experiment is designed to make specific path predictions under each model, thus avoiding the need to estimate values of the models' parameters, and it is designed to maximize the separation between the two models' path predictions. Maximum-likelihood analysis of the resulting panel data set reveals that (a) subjects overwhelmingly used a few simple, cognitively coherent "rules of thumb," often even simpler than best response, and almost never Bayesian; (b) there was substantial heterogeneity across individual subjects in their use of these few rules; and (c) the heterogeneity is described remarkably well by a simple model of population equilibrium in the use of these rules.

Uniqueness of Equilibrium in Cost Sharing Games

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Abstract

A group of agents share a common production process transforming a given input into a given output. In a cost sharing game, each agent simultaneously demands an amount of output; the cost of producing this output is then divided by a given cost sharing mechanism. Examples of cost sharing games include: division of a common cost among different branches within a firm (Shubik [1962]); shared use of a service facility with user delay (Dewan and Mendelson [1990], Friedman [1996], and McLean, Pazgan, and Sharkey [1995]); shared use of a telephone system (Billers, Heath, and Raanan [1978]), computer network (Moulin and Shenker [1992]), or airport runway (Littlechild and Thompson [1977]).

Most of the literature on cost sharing games seeks to determine which cost sharing mechanisms meet certain axioms. However, one important property of such mechanisms is usually overlooked: that is which mechanisms generate a unique equilibrium for cost sharing games.

Uniqueness is needed for predicting a game's outcome; this knowledge is crucial for comparative analysis which allows one to find qualitative results without the use of an empirical study. In this paper, we seek to find the minimum restrictions that must be placed on a cost sharing mechanism in order to generate a unique equilibrium, given that each player's preferences meet certain assumptions (namely, preferences must be convex and bi-normal, meaning both the input and output are normal goods).

The current paper differs significantly from the previous general uniqueness results of Rosen [1965], Katarnardian [1969], and Gabay and Moulin [1980] in three ways. First, these previous papers prove uniqueness by way of a contraction argument, while we prove uniqueness by a method similar to a revealed preference argument. Second, these previous theorems give sufficient conditions for uniqueness, while we give both necessary and sufficient conditions for uniqueness in the two player case. Third, when these general results are applied to cost sharing

games, they place joint restrictions on preferences and the cost sharing mechanism, which makes the restrictions difficult to interpret. Alternatively, Theorem I places distinct conditions on preferences and the cost sharing mechanism. Theorem I gives the conditions necessary and sufficient for uniqueness for a two-player game.

The conditions necessary and sufficient for uniqueness are applied to five well-known cost sharing mechanisms: the average cost sharing mechanism of Mirman and Neyman [1982], Tauman [1988], and Watts [1996]; the serial cost sharing mechanism of Moulin and Shenker [1992] and Friedman and Moulin [1995]; the equal split mechanism; the Shapley-Shubik mechanism developed by Shapley [1953] and Shubik [1962]; and the marginal cost pricing mechanism with a break even requirement, see Samet and Tauman [1982] and Friedman and Moulin [1995]. Conditions are also given which are sufficient for uniqueness of the equilibrium in the n-player case.

Cost Sharing - Efficiency and Implementation

David Wettstein (joint w/T. Kaplan)

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Abstract

We study an environment where a production process is jointly shared by a finite group of agents. Both the input and output of the process are private goods that are desired by the agents. The agents start with positive endowments of the input good. The social decision involves the determination of input contribution and output distribution.

We show that a competitive specification of the ownership shares and consumption decisions leads to a Pareto optimal outcome. Since there is a finite number of agents, the competitive process is prone to manipulation. We construct a game form for which the set of Nash equilibria coincides with the set of competitive outcomes.

We discuss the differences between our game form and various cost sharing methods suggested in the literature: average cost sharing, marginal cost sharing, and serial cost sharing (Moulin and Shenker, 1992).

About Selectors of the Core in Dynamic Games

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Abstract

We consider cooperative games in characteristic function form where the players control a dynamic system and maximize integral payoff functions. Two problems are investigated here:

- What are sufficient conditions for the core, to be nonempty along the optimal path?
- What are sufficient conditions for the selector of the core to be time consistent?

Also we describe the sufficient conditions when vector Shapley, Kalai-Smorodinsky and Nash bargaining solutions are selectors of the core and time consistent.

We prove theorems that show conditions which guarantee nonemptiness and determine a selector of the core.

Furthermore, we will define conditions on IDP which yield dynamic stability and time consistency of the selectors mentioned above.

The Asymptotic Competitiveness in an Oligopolistic Market with Incomplete Information

Jianbo Zhang* (joint w/Z. Zhang[†])

Abstract

This paper examines the asymptotic competitiveness of an oligopolistic market in the classical Cournot and Stackelberg framework with incomplete information about the market demand. We find that if firms could pool their private information first, the asymptotic outcome of the oligopolistic market is always ex post efficient in terms of marginal cost pricing no matter what conjecture forms they have. However, if agents could not pool their private information, and private information could only be revealed through publicly observable actions, i.e. with information externality, then both Cournot and Stackelberg competition will be asymptotically inefficient with probability 1. That is, oligopolistic market asymptotically deviates from the competitive market outcome even as the number of firms go to infinity.

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What is the “Right” Desirability Relation for Coalitions, and Which Weakening of Weightedness Does It Characterize?

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Abstract

Part of the interest in desirability relations for simple games arises from their use in characterizing weak forms of weightedness. For example, the coalitional order $<_c$ [defined by $A <_c B \Leftrightarrow A \cup D$ is losing, and $B \cup D$ is winning, for some D disjoint from $A \cup B$] has no cycles iff the game $G = (N, W)$ bears a coalitional weight function $w : \mathcal{P}(N) \rightarrow \mathcal{R}$:

$$w(\chi_1) + w(\chi_2) \geq q \Leftrightarrow \chi_1 \cup \chi_2 \text{ is a winning coalition } (\clubsuit)$$

for any two disjoint coalitions χ_1 and χ_2 (If (\clubsuit) holds for k disjoint coalitions, then true weightedness is captured as $k \rightarrow \infty$.)

However, $<_c$ has some drawbacks; it behaves differently in G than in G 's dual (not the case for the desirability relation on individuals) and fails to distinguish between a winning coalition and its proper supersets. The “improved” version, defined by $A <_M B \Leftrightarrow [A - B] \cup D$ is losing and $[B - A] \cup D$ is winning, for some D disjoint from $[A - B] \cup [B - A]$, was studied by threshold logicians over 25 years ago. We prove a pseudo-weighting characterization (strictly stronger than (\clubsuit)) for acyclicity of $<_M$ and discuss the relationship between $<_c$, $<_M$, and a third relation, $<_T$, based on trading.