GEM: Game Theory – Economics and Mathematics

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Hosted by	Department of Business and Economics
Organizers	Lone Grønbæk (lg@sam.sdu.dk)
	Andrés Salamanca (salamanca@sam.sdu.dk)
	Rafael Treibich (rtr@sam.sdu.dk)
	Peter Sudhölter (psu@sam.sdu.dk)
Financially supported by	FAIRCARE
	Department of Business and Economics
	Faculty of Business and Social Sciences
	University of Southern Denmark

Preface

Game theory is a branch of applied mathematics that is mainly used in economics, political science, psychology, logic, computer science, and evolutionary biology. The international GEM workshop gathers scientists predominantly from economics and mathematics departments for scientific presentations and discussions of mathematical foundations of game theory as well as of applications of game theory in economics, particularly in microeconomics.

Abstracts

Sibilla di Guida (SDU), Thu 16:15–16:45

Plasticity of strategic sophistication in interactive decision-making

Abstract Most human decision-making happens in interactive situations, in which the decision outcome for an agent depends upon the decision of one or more other agents. The ability of accurately guessing the other agents' moves, commonly referred to as strategic reasoning, is therefore fundamental for obtaining better decision outcomes. The depth of an individual's strategic reasoning, often summarized as the level of strategic sophistication, has been shown to be stable across different interactive decision situations and strongly associated with stable individual traits such as cognitive ability. This could suggest that the level of strategic sophistication is a stable trait in individuals. We cast doubts on this statement, testing whether and to what extent experience affects strategic sophistication. In a controlled behavioral lab experiment, we collect and analyze choice and ocular data to evaluate the effect of different kinds of repeated interactive decisions with immediate feedback on the participants' strategic sophistication. We show that such repeated experience can dramatically affect participants' level of strategic sophistication, and that newly acquired strategic sophistication is generalized to cope with different, more complex interactive decisions. Our results show that strategic sophistication is plastic, with important implications for the development of theoretical economic modeling, cognitive training schemes, and artificial intelligence.

Luc Doyen (Université de Bordeaux), Fr 12:00–12:45

The Tragedy of Open Ecosystems

This paper investigates the role played by cooperation for the sustainable harvesting of an ecosystem. To achieve this, a bio-economic model based on a multi-species dynamics with interspecific relationships and multi-agent catches is considered. A comparison between the non-cooperative and cooperative optimal strategies is carried out. Revisiting the Tragedy of Open Access and over-exploitation issues, it is first proved analytically how harvesting pressure is larger in the non-cooperative case for every species. Then it is examined to what extent gains from cooperation can also be derived for the state of the ecosystem. It turns out that cooperation clearly promotes the conservation of every species when the number of agents is high. When the number of agents remains limited, results are more complicated, especially if a species-by-species viewpoint is adopted. However, we identify two metrics involving the state of every species and accounting for their ecological interactions which exhibit gains from cooperation

at the ecosystem scale in the general case. Numerical examples illustrate the mathematical findings.

Michel Grabisch (University Paris 1 Panthéon-Sorbonne, Paris School of Economics), Thu 11:00–11:45

Diffusion on large networks

We investigate the phenomenon of diffusion in a countably infinite society of individuals interacting with their neighbors in a network. At a given time, each individual is either active or inactive. The diffusion is driven by two characteristics: the network structure and the diffusion mechanism represented by an aggregation function. We distinguish between two diffusion mechanisms (probabilistic, deterministic) and focus on two types of aggregation functions (strict, Boolean). Under strict aggregation functions, polarization of the society cannot happen, and its state evolves towards a mixture of infinitely many active and infinitely many inactive agents, or towards a homogeneous society. Under Boolean aggregation functions, the diffusion process becomes deterministic and the contagion model of Morris (2000) becomes a particular case of our framework. Polarization can then happen. Our dynamics also allows for cycles in both cases. The network structure is not relevant for these questions, but is important for establishing irreducibility, at the price of a richness assumption: the network should contain infinitely many complex stars and have enough space for storing local configurations.

Joint work with **A. Rusinowska** and **X. Venel**.

Carlos Hervés-Beloso (Universidade de Vigo), Fr 9:30–10:14

On equilibria and cores for production economies with externalities and tradable licenses

Carlos Hervés-Beloso
ECOBAS. Universidad de Vigo.
e-mail: cherves@uvigo.es

Emma Moreno-García
Universidad de Salamanca.
e-mail: emmam@usal.es

Abstract. We consider a general equilibrium scenario, where there are externalities that come from either the consumption of some goods or their use in the production process. We show that quantity regulation presents problem of equilibrium existence. Then, we consider a cap and trade system, with rights or permissions that are initially allocated among consumers, can be costless traded and are required to get consumption bundles. We obtain existence of equilibrium and prove that it may be inefficient. Moreover, we define different core solutions and we find conditions on the requirement of rights ensuring that any equilibrium allocation is in the core and, in particular, it is efficient.

Keywords: cap-and-trade program, Coase theorem, competitive equilibrium, externalities, tradable licenses.

JEL Classification: D51, D00, D62.

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1 Introduction

In many situations, the individual preferences derived from the use or production of some goods depend not only upon the individual quantity consumed, but also upon the other individuals' consumption. If it is the case, we say that preferences are interdependent. One famous quotation from 165 a.C., by the latin playwright Terence, reads: *Homo sum, humani nihil a me alienum puto.*[1] Although we may find many interpretations of this sentence, one of them is that the behavior of others affects us. That is, the idea of considering our utility functions depending on the consumption of the others is far to be new.

In economic theory, the consideration of interdependent preferences is a way of formalizing externalities, which typically give rise to inefficiency problems. Indeed, with the objective of diminishing the inefficiencies originated by externalities several regulation systems have been proposed and analyzed in the literature.

In this manuscript, we aim to analyze both market equilibria and the core for production economies with externalities that, in general, represent marker failure situations. To illustrate the kind of externalities and problems we focus on, we may think about, for instance, the use roads, parking, swimming pools, university libraries, gyms, fitness centers, lakes, rivers, ... We may also think of pollution, traffic congestion, water pollution, the common resources involving the problem of overuse, ...

Despite the variety of regulations to respond to externalities, basically there are two main types, namely, command and control regulation and market-based policies. The former regulate behavior directly whereas the latter try to incentivize private decision makers to change their own behavior. In this paper, we follow a *cap and trade* mechanism which is market-based; a set of licenses or rights are allocated among the agents and these permissions can subsequently be traded.

Our approach is stated within a general equilibrium framework. When we have externalities prices do not gather in all the information. Since externalities are fundamentally about individual facing "wrong" prices for their actions, they are naturally a general equilibrium issue. In fact, the analysis of the price mechanism

[1] *I am human, I consider nothing human alien to me. This comes from his play Heauton Timorumenos.*

within a general equilibrium model may give some additional insights explaining how the prices can fail to incorporate "external" effects.

For our purposes, we first describe a production economy where consumers have interdependent preferences. Then, we show not only that the market equilibrium may be not efficient but also that a quantity regulation may result in non-existence of equilibrium. These circumstances lead us to address the problems arising from externalities by establishing rights, which are initially distributed among consumers, are required for the consumption or production of certain commodities and can be traded. It should be noted that the establishment of rights has implications regarding the feasibility of assignments. In fact, the set of feasible allocations is determined not only by the endowments and production set but also by the specification of the system of permissions that is required. Along with it, we obtain a result of equilibrium existence for our economy with production, externalities and tradable rights. In this way, we extend the work by Hervés-Beloso, Martínez and Rivera (2012) from exchange to production economies.

Once we have existence of a market equilibrium, and attempting to get a version of the first welfare theorem for our model, we focus on the following questions: What's about efficiency? What's about the core? We stress that to provide some answer, we face a conceptual difficulty which is the definition of the core. Given that preferences depend on others' consumption choices, how should we evaluate the actions of agents outside of a coalition once the coalition forms? This problem does not arise in the classical case when the preferences of each agent depend only on their consumption, but it raises important issues in our context. In fact, for economic environments with externalities, there can be many definitions of the core. This is because after a deviation, the payoff of the deviating group depends on what the complementary coalition does. Thus, one has to make assumptions about what a deviating coalition conjectures concerning the reaction of the others while defining the core (see, for instance, Makarov and Vasil'ev, 1984, Florenzano, 1989, 1990, and Dufwenberg *et al.*, 2010).

In this paper, based on Aumann's (1964) work, we define the strong, prudent and weak veto mechanisms leading to the cooperative solutions that we refer to as pessimistic, cautious and optimistic core, respectively. In addition, by considering that coalitions only take into account the consumption of their members when blocking an allocation, we state a concept that we call coalitional selfish-

ness core. All the aforementioned veto system coincide for the big coalition and then we have the same notion of efficiency provided that a feasible allocation is efficient if it is not blocked by the coalition formed by all the participants in the economy.

To see if our market equilibrium is efficient or, more generally, if it belongs to some core, we assume the presence of a positive level below which the externality is negligible. Even in this case, we state an example showing that the assignment of rights is not enough to get efficiency. This inefficiency at equilibrium is basically due to the fact that the aggregate equilibrium consumption of a commodity is above the cap from which the externality appears and at the same time it is lower than the total endowment of such a commodity since the total amount of rights does not allow market clearing of this commodity. Therefore, additional assumptions have to be required to get a version of the first welfare theorem for this setting. Indeed, we find properties on the requirements of rights that allow us to obtain a strong version of the first welfare theorem. More precisely, the sufficient condition is that the rule defining the required rights implements as feasible assignments those that are within the set where the externalities become negligible. Thus, we show that the equilibrium belongs to every of the core we define and, in particular, is efficient. We emphasize that our results provide a help for understanding and revisiting, within a general equilibrium framework, the so-called Coase theorem.

Marco LiCalzi (Universitá Ca' Foscari Venezia), Thu 10:00-10:45

Learning across Prisoners' and Hunters' Games[1]

Marco LiCalzi [licalzi@unive.it]
Roland Mühlenbernd [roland.muhlenbernd@unive.it]
Department of Management, Università Ca' Foscari Venezia

Extended abstract

May 2019

Introduction. This paper studies agents who face a stream of similar (but not identical) 2×2 games. We are interested in modeling the empirical evidence about which actions agents play and how their choices change over time across similar games. The key ideas in our approach are four: 1) agents categorize games into two sets, one per each pure action, and play the corresponding action; 2) the choice of the category is stochastic; 3) the categorizing propensities are proportional to linear functions of three game features; 4) the functions weights change over time in response to the observed play. We test the model across a wide set of laboratory experiments from the literature and find a very good fit for the main stylized facts.

Game descriptors and individual motivations. Given a 2×2 game, consider the payoff matrix for the row player:

	C	D
C	a	b
D	c	d

The actions are conventionally labelled C (cooperation) and D (defection). A Prisoners' Dilemma (PD) and a Stag Hung are characterized by the preference order $c > a > d > b$ and $a > c \geq d > b$, respectively.

In a meta-study of 96 laboratory experiments on the Prisoners' Dilemmas (PD), published or carried out between 1967 and 2014, Mengel (2018) identifies three key variables for predicting cooperation in PDs that she calls them temptation (TEMPT), risk (RISK) and efficiency (EFF). Each of these descriptors takes values in $[0, 1]$. They pertain to the game under play: we say that they are *extrinsic*. We use a similar set of three extrinsic descriptors, but slightly generalize her definition of TEMPT to encompass the SH games in a unified treatment:

TEMPT : $T = \dfrac{|c - a|}{\max(a, c)}$ is the percentage gain when playing the best reply against C;

[1]This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 732942.

RISK: $R = \dfrac{d-b}{d}$ is the percentage loss when cooperating against D;

EFF: $E = \dfrac{a-d}{a}$ is the percentage gain from coordinating on C versus D.

We assume that, when agents evaluate a strategic decision in a PD or SH game, they are influenced by the strength of three individual motivations:

fear: an impulse to avoid the lowest individual payoff of the game, given by b;
greed: an impulse to achieve the highest individual payoff of the game, given by c in PD and a in SH;
harmony: an impulse to coordinate on the highest common payoff, given by a.

The relative strength of each impulse is denoted by f, g, h, whereby $0 \leq f, g, h \leq 1$ and $f + g + h = 1$. The three impulses pertain to the individual agent: we say that they are *intrinsic*.

The three extrinsic descriptors (RISK, TEMPT, EFF) and the three intrinsic impulses (fear, greed, harmony) interact in ordered pairs: RISK with fear, TEMPT with greed, and EFF with harmony. We model their pairwise complementarity using a simple product operator. Each product generates a *disposition* in $[0, 1]$:

$d_R = f \cdot R$ is the disposition to avoid the lowest individual payoff;
$d_T = g \cdot T$ is the disposition to achieve the highest individual payoff;
$d_E = h \cdot E$ is the disposition to coordinate on the highest common payoff.

Individual choice over a game. An agent confronting a game has to decide whether to play C or D. Following Erev and Roth (1998), our descriptive model for the laboratory evidence attempts to predict the probability of choice for each action, and compares predicted and observed behavior by computing the mean squared deviation (MSE).

We posit that the agent's attraction to either choice depends on the three dispositions aroused by the game. The attraction towards C is increasing in d_E and decreasing in d_R for both PD and SH. On the other hand, the attraction towards C is decreasing in d_T for PD but increasing for SH.[1] Then the probability $P_i(C)$ that an agent i with weights $(f, g, h)_i$ chooses C in a game G with descriptors $(T, R, E)_G$ is proportional to d_E in a PD and to $d_E + d_T$ in a SH. Clearly, the probability $P_i(D) = 1 - P_i(C)$ that the agent makes the opposite choice is proportional to $d_R + d_T$ in a PD and to d_R in a SH. In short,

$$P_i(C) = \begin{cases} \dfrac{d_E}{d_E + d_T + d_R} & \text{if G is a PD game} \\ \\ \dfrac{d_E + d_T}{d_E + d_T + d_R} & \text{if G is a SH game} \end{cases}$$

[1] A different way to view this is to remove the absolute value from the definition of T and note its change in sign across these two classes of games.

Reinforcement learning. This rule of probabilistic choice applies for an agent facing a game G at a given period. Our model let intrinsic motivations change over time in accordance with observed past play (over the same game or over similar games). We model this updating process using reinforcement learning.

The update rule is based on three elements, common to both PD and SH games. First, after a recent history of defecting opponents, the agent becomes more concerned about avoiding the lowest payoff and thus we increase the weight f for fear. Second, after a recent history of cooperating opponents, the agent feels more tempted to achieve the highest payoff and thus we increase the weight g for greed. Third, after a recent history of inconclusive evidence (some opponents defected, other cooperated), the agent experiences more strategic uncertainty: because there seems to be no settled convention yet, the common payoffs on the main diagonal provide some guidance about the relative benefits of coordinating on one.

Our implementation of these ideas aims for simplicity and robustness, not for accuracy. We assume that an agent estimates opponents' behavior using only the last two rounds of interaction with them. Given a (PD or SH) game G with descriptors $(T, R, E)_G$ and the last two observed opponents' actions (s^{t-1}, s^t), the vector of impulse strengths $(f, g, h)_i$ for player i is updated to a new vector $(f', g', h')_i$ using the rule:

$$(f', g', h')_i = \begin{cases} \left(f + \gamma R,\ g - \dfrac{\gamma R}{2},\ h - \dfrac{\gamma R}{2}\right)_i & \text{if } s^{t-1} = s^t = D \\ \left(f - \dfrac{\gamma F}{2},\ g + \gamma F,\ h - \dfrac{\gamma R}{2}\right)_i & \text{if } s^{t-1} = s^t = C \\ \left(f - \dfrac{\gamma E}{2},\ g - \dfrac{\gamma E}{2},\ h + \gamma E\right)_i & \text{otherwise} \end{cases}$$

This update rule ensures that the revised weights always sum to 1, but allow single weights to become negative. Our implementation ensures that this cannot occur, but for the sake of readability we omit details.

PD: Experiments and results. We test our learning model for PD against the laboratory evidence collected by others. We use the 28 games collected in Mengel (2018) that are based on the random matching protocol, where agents play the same game over several periods against randomly chosen opponents. The main stylized fact is that the initial cooperation rate is relatively high, but it declines over time.

We calibrate the initial weights for the stochastic choice rule to match the available evidence on the initial cooperation rate, by minimizing the mean squared error (MSE) between observations and predictions. Then we apply the update rule with a (non-calibrated) learning rate $\gamma = 0.2$.

The initial calibration considers the average initial cooperation rate over the 28 PD games. We compute a triple (f^*, g^*, h^*) that minimizes the mean squared error between the observed average cooperation rate π_G and the cooperation probability $P_G(C)$ predicted by the model across 28 games. We find that the optimal initial weights are $f^* = 0.36, g^* = 0.28$, and

$h_i^* = 0.36$. Using these weights entails an average squared error of 0.0218, with a Pearson correlation of 0.691 across the 28 games.

Experiment I concerns the PD games. We first ran 100 simulations for each of the 28 games, over the same number of periods used in the original experiment. (The number of periods ranges between 2 and 100.) Each simulation started with the optimal initial weights (f^*, g^*, h^*) for PD games and a learning rate $\gamma = 0.2$. We computed the average cooperation rates for each game across time (averaged across simulations) and we compared it against the average cooperation rate (averaged across players) in the original experiments: the Pearson correlation is 0.566.

We also computed the trend in weights. Generally speaking, the weight for fear increases over time, while the weights for greed and harmony decrease. This implies that the cooperation rate decreases over time, matching the main stylized fact. Intuitively, people learn to focus more on the motivation associated with the opponent's defection as players defect more and more.

Finally, we repeated the simulation assuming that each game is played 1,000 times. We found that the cooperation rate decreases for 25 of the 28 games, confirming the short-term trend. For the other three games, characterized by a very low value for RISK, the cooperation rate may increase or decrease, pointing to path-dependence: when the motives for fear are weak, an initial stream of cooperating choices may sometimes cement mutual cooperation.

SH: Experiments and results. We tested our model for SH against a database of 22 games from experimental studies conducted between 1995 and 2008. The database contains 22 games but only 17 are different with respect to payoffs, because 5 of them were used twice in different studies.

Using the same methodology, we calibrate the initial weights for the stochastic choice rule over SH by minimizing the mean squared error (MSE) between observations and predictions. The optimal initial weights for SH games are $f_i^* = 0.22, g_i^* = 0.13$, and $h_i^* = 0.65$. Using these weights entails an average squared error of 0.0234, with a Pearson correlation of 0.597 across the 22 games.

Experiment II concerns the SH games. We ran 100 simulations for each of the 22 games, over the same number of periods as in the original experiment. (The number of periods ranges between 8 and 75.) Each simulation started with the optimal initial weights (f^*, g^*, h^*) for SH games and a learning rate $\gamma = 0.2$. We computed the final c ooperation r ate for each game (averaged across simulations) and we compared it against the final cooperation rate (average across players) in the original experiments: the Pearson correlation is 0.835. Generally speaking, the trend in weights is that harmony always decreases while either fear or greed increases, depending on whether agents learn to cooperate or defect; see van Huyck (2008) for a similar observation. Intuitively, people learn to focus less on harmony and more on the motivation associated with the opponent's emerging convention.

Finally, we compared the trend of cooperation over time with the results from the laboratory experiments. These latter include SH games where participants always learn to cooperate, other SH games where they always learn to defect, and other SH games where the evidence is mixed. Our simulation produces trends that exactly match the empirical trends

in 13 of all 22 games (59%) and are compatible with them in other 7 games (32%).

References

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Emma Moreno-García (Universidad de Salamanca), Fr 11:15-12:00

On the private provision and use of public goods

Marta Faias and Emma Moreno-García.

In the classical paper "The pure theory of public expenditure", Samuelson (1954) referred to a public good as a collective consumption good and he defined it as follows:

"... *which all enjoy in common in the sense that each individual's consumption of such a good leads to no subtractions from any other individual's consumption of that good...*"

Since then, we say that a public good is characterized by the properties of non-rivalry and non-excludability. However, the fact that it is impossible to exclude any individuals from consuming a good does not imply that all individuals make the same use of it. That is, in spite of the non-excludability properties of the collective commodity, since its use is not fixed and compulsory, consumers may vary their degree of utilization.

Thus, we focus our attention on a non-cooperative model where individuals not only contribute privately to the provision of a public good but also decide their use. We argue that distributions of the intensity of utilization of public goods matter and that, together with private contributions, confer objective properties on the good in question that can be relevant and affect the individual preferences and the welfare of the society.

In this paper, the aforementioned ideas lead us to provide a strategic approach to the provision of public goods, where agents decide simultaneously not only their private contribution for the production of the public goods but also a new variable that capture their level of utilization which may differ among individuals. In this way, we extend the original model by Bergstrom, Blume and Varian (1986) to an scenario where individuals are free to modify their own use of a collective consumption commodity.

After showing existence of equilibrium for our non-cooperative game, we establish how the approach we propose leads us to the study of a variety of issues that include altruistic behavior, congestion problems, free-riding, neutrality results and further externalities captured within our framework.

Marina Núñez (Universitat de Barcelona), Thu 11:45–12:30

Valuation monotonicity, fairness and stability in assignment problems

In two-sided assignment markets with transferable utility we ask which monotonicity properties are compatible with stability and which allocation rules they characterize. We consider a finite set of buyers and a finite set of sellers, each seller owns only one good and each buyer values each of the goods in the market and wants to acquire at most one of them.

It is well-known that pairwise monotonicity, which states that when one buyer increases the valuation of an object neither this buyer nor the owner of the object can receive a lower payoff, is compatible with stability. Several stable rules, such as the buyers-optimal stable rules, the sellers-optimal stable rules and the fair division rules are pairwise monotonic. The Shapley value is not a stable rule but is also pairwise monotonic. Hence, pairwise monotonicity does not individualize any stable rule.

Our paper is motivated by Kojima and Manea (2010), where, for the setting of two-sided markets without money, the deferred acceptance rule is shown to be the only stable rule that satisfies weak Maskin monotonicity.

We introduce two related monotonicity properties for allocation rules defined in two-sided assignment markets with transferable utility. A rule satisfies buyer-valuation monotonicity if when a buyer weakly decreases his valuation of all objects, and this fact does not modify which object he is assigned to by the rule, then this buyer cannot receive a higher payoff by the rule. Similarly, object-valuation antimonotonicity states that when all buyers weakly decrease their valuation of a given object, and this object remains assigned by the rule to the same buyer as before, then this buyer cannot receive a lower payoff.

We prove that the buyers-optimal stable rules, those defined by the buyers-optimal stable payoff and a compatible matching, are the only stable rules that satisfy buyers-valuation monotonicity. Similarly, the sellers-optimal stable rules are the only stable rules that satisfy object-valuation antimonotonicity.

The same optimal stable rules are characterized on the domain of all allocation rules, without imposing stability. The buyers-optimal stable rules are the only ones that satisfy derived consistency and buyer-valuation monotonicity. The sellers-optimal stable rules are the only allocation rules that satisfy derived consistency and object-valuation monotonicity.

We would like to characterize the fair division rule, that assigns to each buyer-seller market the fair-division payoff, which is the midpoint between the buyers-optimal and the sellers-optimal stable payoffs.

Valuation fairness requires that changing the valuation of a buyer for the object of a seller leads to equal changes in the payoffs of this buyer and seller. Van den Brink and Pintr (2015) show that, together with submarket efficiency, valuation fairness characterizes the Shapley value on

the domain of assignment games. Since all stable rules satisfy submarket efficiency, and the Shapley value may not be a stable payoff vector, it is easy to conclude that no stable rule satisfies valuation fairness.
We then introduce weak valuation fairness that requires that changing the valuation of a buyer for the object of a seller leads to equal changes in the payoffs of this buyer and seller if this buyer-seller pair were matched both before and after the change of the valuation. This property is compatible with stability since it is satisfied by the fair division rules.

Joint work with **R. van den Brink** and **F. Robles**.

Trine Tornøe Platz (Copenhagen Business School), Thu 14:30–15:15

QALY, DALY, HYE and more: a unified approach

The ability to asses the effect on a population of specific health interventions is crucial for decisions of priority and financing in the health care sector, and several proposed methods to (quantitatively) measure the health status of a population exist. Two of the most widely known and applied measures are the Quality Adjusted Life Years (QALY) and aggregated Disability Adjusted Life Years (DALY). Whereas the normative foundations of basic families of QALY-based measures of population health have been established, a normative foundation for DALY-based measures, or more broadly, models taking a health deficit approach to measuring population health, is lacking.

In this paper, we aim to fill this gap by investigating the normative principles underlying several models in which the health of a population is measured in terms of a deficit or health gap. We assume that society has preferences over distributions of (average) health states and lifetime combinations in a population, and we determine sets of normative principles - axioms - that characterize different models for the evaluation of population health, so-called Population Health Evaluation Functions (PHEFs). We depart from the existing literature by also allowing the preferences of society to take into account a reference age for each individual that indicates the potential age the individual could have expected to reach in the absence of premature death. This allows us to consider PHEFs concerned with the health deficit as well as those considering population health from an asset perspective. We characterize deficit-oriented PHEFs including the (time linear) DALY and a more general PHEF denoted the Years of Life Lost Equivalent. For completeness and comparison, we also provide corresponding characterizations of asset-oriented PHEFs, including the (time linear) QALY PHEF and the Healthy Years Equivalent.

Joint work with **L. P. Østerdal**.

Agnieszka Rusinowska (University Paris 1 Panthéon-Sorbonne, Paris School of Economics), Thu 13:45–14:30

Winning coalitions in plurality voting democracies

We study the issue of assigning weights to players that identify winning coalitions in plurality voting democracies. For this, we consider plurality games which are simple games in partition function form such that in every partition there is at least one winning coalition. Such a game is said to be precisely supportive if it is possible to assign weights to players in such a way that a coalition being winning in a partition implies that the combined weight of its members is maximal over all coalitions in the partition. A plurality game is decisive if in every partition there is exactly one winning coalition. We show that decisive plurality games with at most four players, majority games with an arbitrary number of players, and almost symmetric decisive plurality games with an arbitrary number of players are precisely supportive. Complete characterizations of a partition's winning coalitions are provided as well.

Joint work with **R. van den Brink** and **D. Dimitrov**.

Andrés Salamanca (SDU), Fr 10:15–11:00

Random Dictatorship and the Value in Cooperative Games with Incomplete Information

The value of a cooperative game is an a priori evaluation of the utility a player expects from the participation in the game. Maschler and Owen [The consistent Shapley value for hyperplane games. *Int. J. Game Theory*, 18, 1989, pp 389-407] have defined a *consistent value* for non-transferable utility (NTU) games. Their definition is based on a random order arrival procedure in which players successively enter the cooperation until the grand coalition is formed. In Hart [An axiomatization of the consistent non-transferable utility value. *Int. J. Game Theory*, 33, 2005, pp 355-366], it is shown that the consistent value may equivalently be expressed as the vector of expected marginal contributions of the players, once the marginal contributions have been appropriately defined. This alternative characterization of the consistent value can be interpreted by means of a recursive conditional random dictatorship procedure: a player i is picked at random, with all players having equal probabilities. Then, player i is given the power of dictatorship conditional on giving the other players in the coalition what they would get in the value of the subgame restricted to the subcoalitions not containing player i. In this paper, we elaborate on this *conditional random dictatorship procedure* to provide a generalization of the consistent value to cooperative games with incomplete information. When a player possessing private information is given all the bargaining ability to coordinate the actions inside a coalition, the choice of a feasible (state-contingent) allocation may signal part of her private information to

the other participants. With this new information, the members of the coalition may find new opportunities to strategically manipulate their private information or to refuse to cooperate. Myerson [Mechanism design by an informed principal. *Econometrica*, 51, 1983, pp. 1767-1797.] developed a theory of inscrutable mechanism selection by an informed individual with all the bargaining ability. We build on Myerson's approach to develop a generalization of the random dictatorship procedure. Our main results are individual rationality, incentive (second best) efficiency and existence of our cooperative solution. To obtain these results we restrict our analysis to cooperative games with stochastically independent types, private values and orthogonal coalitions.

Leanne Streekstra (SDU), Thu 15:30–16:15

Stable source connection and assignment problems as time-varying shortest path problems

We extend the familiar shortest path problem by supposing that agents have time-varying demands. This potentially allows agents to combine their paths if their demands are complementary; for instance if one agent only needs a connection to the source in the summer while the other requires it only in the winter.

We show that the resulting cost sharing problem always has a non-empty core, regardless of the number of agents and periods, the cost structure or the demand profile.

We then exploit the fact that the model encompasses many well-studied problems to obtain or reobtain non-vacuity results for the cores of source-connection problems, (m-sided) assignment problems and minimum coloring problems.

Joint work with **Christian Trudeau**.

José Zarzuelo (Basque University of Bilbao), Thu 9:15–10:00

Some solutions for bargaining problems with claims

A bankruptcy problem is an elementary allocation problem in which claimants have individual claims on a deficient estate. In a bankruptcy problem with transferable utility (ONeill, 1982), the estate and claims are of a monetary nature. On the other hand Chun and Thomson (1992) considered bankruptcy problems with nontransferable utility, where the estate can take a more general shape and corresponds to a set of utility allocations. Thus NTU-bankruptcy problems form a natural generalization of the traditional bankruptcy problems. These authors proposed the proportional solution for NTU-bankruptcy problems using an axiomatic approach. In this

paper we propose and characterize some solutions for NTU-bankruptcy problems that are closely related to the bargaining solutions proposed by Nash (1950), Kalai-Smorodinski (1975) and the proportional bargaining solutions (Kalai, 1977). Actually we propose two different axiomatic characterizations. The first one consists of the traditional axioms used by the mentioned authors together with a new axiom called Independence of Irrelevant Claims (IIC) , that requires that if the claims of all the agents decrease but the solution still remains below the new claims, then the solution will not change. In the second characterization we replace the IIC axiom by another axiom called Independence of Higher Claims (IHC). This axiom requires that if an a new situation some agents increased their claims, then an agent that already received his/her claim, will not be worse.

Joint work with **M. J. Albizuri** and **B. Dietzenbacher**.

Huanren Zhang (SDU), Thu 17:00-17:45

Cooperation under the shadow of inequality

Cooperation under the Shadow of Inequality: An Experimental Investigation

Existing studies on infinitely repeated prisoners dilemma have focused on homogeneous agents with symmetric payoff structures. This leaves a surprising gap in the literature because in many situations with repeated interactions, economic agents often differ in the benefits they derive from cooperation, and they face different outside options if they fail to reach cooperation. Exploring the extent to which inequality affects cooperation in infinitely repeated social dilemmas is a topic of obvious importance. However, theoretical prediction and benchmark become exceedingly more complicated to obtain in the presence of payoff inequality. While raising concerns for inequality, imposing payoff asymmetry inevitably changes incentives. Even if players do not care about inequality or do not directly respond to the changed incentives, payoff inequalities could still upset cooperation by changing beliefs on the opponents likely behavior. In addition, theoretical predictions vary greatly for the asymmetric games depending on how the incentives and beliefs of the two players are reconciled. The difference in preferences and beliefs, the mixture of motives, and the lack of common knowledge, all make it tricky to provide a theoretical benchmark.

To bypass the difficulty, we design an experiment that provides the counterfactual behaviors where the imposed inequality does not change incentives to cooperate. Our experimental design provides empirical benchmarks based on counterfactual behaviors where players face exactly the same monetary incentives. Our experiment has 10 treatments that vary (1) whether inequalities are present, (2) whether inequalities reinforce or undermine cooperate, and (3) the discount factor. The experimental results indicate that cooperation is undermined when mutual cooperation implies inequality, while the effect of inequality from mutual defection is not significant. We find

evidence that payoff inequality also affects the gains from increasing continuation probability: the beneficial effect of increasing continuation probability is abated when mutual cooperation implies inequality, while it is reinforced when mutual cooperation eliminates inequality.

Joint work with **James Bland, Olivier Bochet, Nikos Nikiforakis**.

Speakers

Sibilla di Guida	SDU (sidg@sam.sdu.dk)
Luc Doyen	Université de Bordeaux (luc.doyen@u-bordeaux.fr)
Michel Grabisch	University Paris 1 Panthéon-Sorbonne (michel.grabisch@univ-paris1.fr)
Carlos Hervés-Beloso	Universidade de Vigo (cherves@uvigo.es)
Marco LiCalzi	Università Ca' Foscari Venezia (licalzi@unive.it])
Emma Moreno-García	Universidad de Salamanca (emmam@usal.es)
Marina Núñez	Universitat de Barcelona (mnunez@ub.edu)
Trine Tornøe Platz	Copenhagen Business School (ttp.eco@cbs.dk)
Agnieszka Rusinowska	University Paris 1 Panthéon-Sorbonne (agnieszka.rusinowska@univ-paris1.fr)
Andrés Salamanca	SDU (salmanca@sam.sdu.dk)
Leanne Steekstra	SDU (leanne@sam.sdu.dk)
José M. Zarzuelo	Basque Country University of Bilbao (josemanuel.zarzuelo@ehu.eus)
Huanren Zhang	SDU (huanren@sam.sdu.dk)