13th coalition theory network workshop

13th CTN Workshop

Integration and Cooperation in Socio Economic Networks and Coalitions

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SCIENTIFIC REPORT

The broad topic of this year's workshop was "segregation, integration and cooperation in social and environmental networks". In this spirit, the invited talks focused on various aspects of social networks and on environmental cooperation issues.

Plenary Sessions

Fernando Vega Redondo's paper has dealt with networks as organizational structures. The problems faced here is the optimal rate of change of the organizational structure in response to a volatile environment. The paper provides a very stylized model by which the main trade offs between adaptability of the organization and its structural stability. In very simple terms, adaptability enhances the ability of organizational members to redirect their search for other complementary members in the organizations when the environment changes; stability enhances the performance of the organization by allowing it to exploit the accumulated knowledge. The idea of accumulation is formally introduced in the model by assuming that redrawn organizational links (the outcome of adaptability) take time before being usable to convey information. The results of the paper are quite stark and, in a sense, paradoxical. First, organizations should either be very rigid or very flexible, depending on the volatility of the environment. Second, and more surprisingly, flexible organizations are optimal in very stable environments, while rigid organizations should be adopted when the environment is very volatile.

Social networks, in the specific form of friendship networks, were the topic of **Yves Zenou**'s invited talk. Zenous's paper focuses on some interesting patters of intra- and inter-racial friendship formation. Agents draw utility from both direct and indirect friendships. The cost of having a friend depends on its homophilous attitude, so that the more homophilous one is, the more costly is for agents with different race to link to her. The paper shows that the pattern of oppositional identities (i.e. some blacks have most of their friends who are blacks while others have mainly white friends) tend not to emerge when the cost of linking within groups is low, despite the existence of stable links across racial groups. In contrast, when linking costs are high, then oppositional identities are more likely to exist in equilibrium because once blacks connect to whites, they become more attractive and hence can form new links more easily with the other community. Finally, when the attractiveness to own race agents decreases with the number of other race friends one has, then oppositional identity becomes easier to occur, since the consequence of a cross-race link are even stronger in terms of attractiveness to own-race agents.

Rachel Kranton's paper looked at networks as structures of bilateral insurance arrangements. The paper is motivated by established empirical observations of incomplete (and therefore apparently inefficient) insurance at the village-level in rural communities. Kranton proposes a model of voluntary network formation, where links represent commitment to share income after some state of the world has realized (in short, insurance contracts). The main finding of the paper is that incomplete insurance at the village-level may occur as a result of strategic behaviour of families

and individuals when cross-village insurance is allowed. In particular, those that cover risk across villages end up better off, while those that do not operate across village do not get full insurance within their village and are therefore worse off. The incentives that drive incomplete insurance are complex, but can be roughly summarised by saying that those who insure across village can cover against aggregate risk, and their benefit decreases when more individual in their own village are allowed to do it. For this reason, they do not form a link with such individuals and preclude full insurance.

Michael Finus' contribution turned the focus on international environmental cooperation. The problem addressed here is the regulation of high seas fisheries by means of regional fisheries management organizations (RFMO's). The cooperative problem is studied by means of a partition function game, whose partition function is derived using the classical Gordon-Schaefer bioeconomic model. The prospects of success of RFMO's is shown to be strictly related to the biological aspects of the problem, embodied in the specification of the equations of the Gordon-Schaefer bioeconomic model. In particular, it is shown that the possibilities of success increase when costs of harvesting become asymmetric – probably a direct effect of a shift of total costs on low cost members, coupled with an appropriate redistribution of profits.

Session 1: Commons

The first paper by **Hideo Konishi** studies the problem of public good contribution taking a political economy perspective, in a model where a lobby forms in order to influence the government in its provision of a public good. Industry protection is one possible example of such situations. Once the lobby has formed, it proposes a menu of possible contributions schemes, among which the government chooses, taking into account production costs. The main questions of the paper are which lobby would form in equilibrium, and what level of public good is produced. The model employs at the second stage the Coalition Proof Equilibrium concept, which deals with coordination problems and the typical multiplicity of equilibrium of menu-offer games. The main theoretical result employed here is the equivalence between the set of CPEa and the core of a derived cooperative game (Laussel and Le Breton (2001)). Once the CPEa of the second stage are identified with the free-riding proof core, the analysis of the dynamic game becomes standard. The most interesting result seems to be that in equilibrium lobbies are not necessarily formed by the agents with highest willingness to pay, nor are they consecutive in this respect. A more expected result is that public good contribution is inefficiently low.

The problem of public goods provision in the form of abatement of polluting emissions is the topic of **Henry Tulkens**' paper. Here, two strands of literature on coalition formation are put to a comparative test: the literature based on traditional cooperative game theory and, in particular, on the extension of the concept of core to game with externalities, and the literature based on the dominant group theory of industrial organization, employing a stability notion based on individual deviations (the internal and external stability notions). The paper proceeds by applying the two stability notions to the integrated assessment CWS model. The conclusion is that while the grand coalition is indeed stable in the "gamma-core" sense for appropriate transfers, none of the largest coalitions is stable in the internal-external stability sense. Smaller coalitions are instead stable in this second sense, provided appropriate transfers are permitted.

Session 2: R&D Networks

There is a growing body of literature exploring R&D collaborations between agents within a network theory perspective. Starting from the literature strand which examines networks of collaborations resulting from research projects, the paper by **David Frachisse** focuses on R&D networks resulting from the EU Sixth Framework Programme for Research and Technological Development. The paper is an interesting contribution to assess one of the objectives of the 6th FP, namely to implement the European Research Area (ERA) initiative. One contention in the literature

is that networks of collaboration may influence, for instance, competitions, technological diffusions, etc., and that network analysis can be an important tool to understand these forces. Comparing two different representations of the network emerging from collaboration in projects within the 6th FP, the authors conclude that network representation influences in important ways the results of network analysis. In particular, the authors show that the identification of the central nodes is sensitive to the chosen representation. Furthermore, the nodes forming the core of the network vary according to the representation.

Exploring R&D collaboration from a different perspective, **Vasileios Zikos** investigates bilateral incentives for network formation on R&D collaboration in a mixed oligopoly. Mixed oligopoly is a very common form of market in Europe and in the former Soviet Bloc countries, following the introduction of competition into traditional state monopolies. The aim of the paper is therefore to explore the role of public firms in influencing the structure of collaboration, looking at whether the presence of public firms affects the incentives to form collaboration. One of the key results of the literature is that investment in R&D will be below efficient levels due to a lack of full appropriability of the returns to R&D. In this paper, the authors explore in a more comprehensive manner incentives to cooperate using network theory. The main result of the paper is that the complete network – where all firms collaborate with all the others – is stable and efficient, and that state-owned firms may be used as a policy instrument to bridge the potential gap between individual and collective incentives for R&D collaboration. A future promising research direction is to empirically investigate the relationship between network architectures and the presence of state-owned firms.

Session 3: Segregation in social networks

This session was addressing one of the main issues on which the conference focused: segregation in social networks. The four contributions are examples of different angles from which the problem can be treated, that confirm a growing interest for the topic of heterogeneity in social networks.

The first paper by **Sergio Currarini** is a stylized model of friendship formation, applied to data on high school friendships in the U.S. The model aims to explain the observed patterns of friendship formation by means of an economics model, in which the incentives are generated by preferences on formed friendships and on their racial mix. Meetings are random, and agents decide how long to search for friends. In equilibrium, agents' decisions affect the proportion of various races in the matching pool, and these affect agent's decisions through preferences. Three observed trends are captured by the model: larger groups have more friends per capita; large groups have more same type friends and less different type friends per capita; all groups tend to be homophilous, with higher levels for middle sized groups. In order to match all three patterns, the model need ingredients of both racial bias in preferences and bias in the meeting process (such as race segregated clubs, academic tracking,…).

Similar issues are addressed in the paper by **Paolo Pin**, but with different methodology. The problem is again to distinguish between choice and opportunity in generating the observed behaviour in social networks where racial attributed may be important in determining the pattern of ties. The paper looks at two different dataset, concerning friendships in US high schools and marriages in the US. The idea is to estimate the contribution of choice and opportunity by looking at the behaviour of very small groups, for which it is possible to obtain an analytical expression of expected behaviour. The results are then generalized to all groups in a sort of inference argument. The authors reach two conclusions: choice is a main determinant of observed behaviour in marriages, while it is much less so in adolescent friendships.

Finally, social segregation is analyzed in its consequences for job market outcomes in the paper by Marco **Van der Leij**. Here, the author addresses the problem of how agents of different social groups (race or gender) choose to segregate as a result of educational, friendship and occupation choices. More precisely, the paper studies a model in which agents first choose a field of education, which grants access in a given occupational sector. Then agents form friendships,

though which job contacts will be found. Then, agents look for a job and consume private goods. Equilibria with complete segregation are shown to exist, together with equilibria in which one groups segregates in the high productivity sector, and one groups mixes between good and bad sectors. The group in the good sector receives higher wages and has a lower unemployment rate.

In this same session, **Andrea Galeotti** presented a very interesting paper on information transmission in networks. This paper can be viewed as generalizing previous work on public good provision on networks to the case of an endogenous network structure. The paper can also be viewed as a theoretical treatment of the empirically relevant observation that in many social situations, information is acquired, processed and transmitted by a small set of agents, that act as a dense center of a core-periphery structure (the so called "law of the few"). Since these central agents do not appear different in terms of exogenous characteristics from the other agents, it could be guessed that the difference in their positions in the network may be due to strategic equilibrium behaviour. In the formal model of Galeotti, agents can either acquire information at some cost, or link to informed agents at a lower cost. In all strict Nash equilibria, it shown that agents acquire the same aggregate amount of information. This, together with the observation that uninformed individuals will always link to informed one, and only to such agents, is shown to imply that all strict equilibria display the core-periphery structure described above.

Session 4: network games 1

The so called "Tragedy of The Commons" occurs when the individual users ignore the cost their activity imposes on the rest of the community. **Ilkilic**'s paper studies a particular case of this phenomenon: if the sources and users are interconnected, the exploitation of each user from each source will depend on the structure of the connections and importantly on the centrality of the links connecting the source to the users. The author decomposes the network into regions: each region consumes only from its sources. The sources are distributed between regions, so that the less resourceful ones are assigned to the most possible number of sources. When players have concave valuations, these amounts depend on the whole network. The socially efficient outcomes are characterized.

In reality, impatient economic agents frequently form a network whose structure may delay information flow. In many industries, such as the car industry, big producers are at the centre of a large network of suppliers, which may be linked among themselves. **Kinateder** models delayed perfect monitoring by allocating players, that play an infinitely repeated discounted game, to a connected and undirected network. Usually, it is possible to sustain equilibria that do not arise in a one-shot game by repeating it. Under the assumption of truth telling, the Folk Theorem extends to the delayed perfect monitoring model, that is, any feasible and strictly individually rational payoff vector can be supported by a sequential equilibrium strategy profile when the players are sufficiently patient. This paper contributes to the network literature, which so far emphasized the importance of the clustering coefficient for cooperation to be sustainable in a network.

A finitely repeated prisoner's dilemma game has a unique, defective Nash equilibrium. **Ule**'s paper shows that, in contrast, cooperation can be achieved in a subgame-perfect Nash equilibrium of a *finitely* repeated prisoner's dilemma game when players can choose their partners. The author assumes that finitely repeated network dilemma games are played by rational players with perfect foresight and show that cooperation can be sustained in a subgame-perfect equilibrium through strategic linking behaviour. In this game to achieve cooperation it may be necessary that there is some competition for partners: either players are strictly constrained in the number of links, or linking is costly and the cost function is convex. Cooperation can be sustained solely via exclusion of defectors if the number of all players is substantially larger than the number of links that players can or are willing to support. Nonetheless, introducing endogenous network formation itself is not sufficient for cooperation, but assuming very weak constraints on the number of links or linking costs may be sufficient.

In a roommate market, a finite set of agents has to be partitioned into pairs (roommates) and singletons. Thus, for roommate markets coalition formation is restricted to coalitions of at most two agents, a matching can be interpreted as an extension of a so-called marriage market. In **Klaus**' paper it is shown that for any roommate market the set of stochastically stable matchings coincides with the set of absorbing matchings. While the core for a marriage market is always nonempty, the core of a roommate market can be empty. As a consequence, roommate markets can be considered an important benchmark for the development of solution concepts for matching, network and coalition formation models that may exhibit an empty core or set of stable matchings, network or coalition structures. The main result is a very strong structural result for roommate markets that cannot easily be extended to more general markets.

Session 5: International Environmental Agreements

Global environmental problem requires international agreements. Since costs and benefits from the agreement are different among countries and each country may have an incentive to free-ride, the stability of an international environmental agreement (IEA) has been tackled in substantial literature. While most studies on non-cooperative games and self-enforcing agreement use a static framework, **Michèle Breton**, Sbragia, and Zaccour develop a dynamic model to analyse how countries join environmental agreements based on a non-cooperative point of view. They study the formation and stability of IEAs when a stock externality is considered, and membership is allowed to change endogenously over time, which is a more realistic situation. Under the assumption that signatory countries punish non-signatory counties at a cost for both groups, they show that partial or full cooperation in a stable IEA can be obtained either by using the "stick", that is, increasing the punishment to non-signatories, or the "carrot", that is reducing, the cost of punishing for the signatories.

By introducing asymmetric countries, transfers between coalition members, and renegotiations of the agreement into an open membership cartel formation game, **Weikard** and Dellink show that there are options to stabilise successful international climate agreements (ICAs), in contrast to earlier findings that find only small stable coalitions consisting of no more than two or three players. To study the effects of optimally designed sharing rules in an empirical setting and to illustrate their impacts, they examine the stability of ICAs using the STACO model. They show that a well-designed transfer scheme increases the incentives to join the coalition, and is therefore able to stabilise larger coalitions.

Session 6: Multiple Memberships

This session presents a series of contribution to what seems to be a promising line of development of coalition theory, and actually lies at the border between coalition and network theory. The general idea is to consider general "covers" of a set of agents, allowing therefore agents to belong to more than one coalition at the same time. I feel personally obliged to remember some very early and unpublished work in this direction by our colleague Murat Sertel, who explored this issue in the context of cooperative games.

The first paper by **Alexei Savvateev** uses this new framework to further explore the issue of secession stable partitions, previously analyzed in a series of papers, some of which co-authored by Alexei. One important and "negative" result of such paper is that when agents are concerned about a public good to be produced in the country they belong to, and about the contribution to such production in terms of a private consumption good, then a stable *partition* may fail to exist, by this meaning a partition of the set of agents into countries such that no connected subset of agents would like to form a new country on their own. In the present paper, this result is shown to crucially depend on the assumption that membership in countries is exclusive. Once each country (or region) can be simultaneously part of several regions, then a stable structure is shown to exist under very general conditions.

The following paper by **Edith Elkind** addresses the related optic of overlapping coalition formation. Here, agents can belong to more than one coalition at the same time, and share a limited amount of resources among these. So, the idea of a partition is generalized accordingly by that of a cover. The paper takes a few first steps in this generalization of cooperative game theory to covers. First, a notion of "core" is defined, that accounts for the limited resources constraint. Then, the notion of convexity of the characteristic function is also extended to this new setting. Finally, it is shown that, as in the classical analysis, all convex games have a nonempty core (which maximizes social welfare).

Session 7: coalitions and groups

The concept of corewise stability and of von Neumann-Morgenstern stable set are myopic notions, since individual and coalition deviations cannot be countered by subsequent deviations. In her contribution, **Ana Mauleon** develops and characterises the notion of von Neumann-Morgenstern far-sightedly stable sets in one-to-one matching problems: a set of matchings is a von Neumann-Morgenstern far-sightedly stable set if and only if it is a singleton set and its element is a corewise stable matching. Thus, contrary to the von Neumann-Morgenstern (myopically) stable sets, von Neumann-Morgenstern far-sightedly stable sets cannot include matchings that are not corewise stable.

Challenging the prevailing focus of cooperative game theory with transferable utilities (TU), **Jingang Zhao** explores whether it is always rational to split the grand coalition's payoff, or whether there are other sub-groupings or sequence of sub-groupings which generates a higher payoff. Such exploration leads to the maximum of generated payoffs (mgp) for coalitional TU games, which is used to establish a new theorem: the TU (transferable utility) core is empty if and only if the maximum of generated payoffs (mgp) is greater than the grand coalition's payoff v(N), or if and only if it is irrational to split v(N). The contributions provides important insights into some of the key questions of cooperative game theory, namely what payoffs to split, how to split the payoff, what coalitions to form, and how long each of the coalitions will be formed by rational players in coalitional TU games. Furthermore, similar results can be obtained for cooperative games with non-transferable utilities, even though, because of the generality of NTU games, some results are weaker than the corresponding TU results.

The paper of **Kempf** and von Thadden sets up a simple, generic framework for the analysis of strategic interactions among independent but interdependent players in order to account for the broad range of findings on the (ir)relevance of cooperation and commitment in the recent literature. The paper introduces two concepts: "coalition structure" and "commitment pattern". The former is to characterize cooperative behaviour between particular groups of players, and the latter is to characterize a particular order of moves of players. They prove that games characterized by different commitment and cooperation schemes may admit the same equilibrium outcome if certain spillover effects vanish at the common solution of these games. Finally, they explain the driving forces behind seemingly contradictory results from a number of recent contributions on the nature of policy interactions both within monetary unions and among fully sovereign nations.

An interesting contribution links landscape theory, first developed by Axelrod and Bennett in 1993, can be useful to analyze a wide variety of aggregation problems, such as international alignments, social networks, social cleavages in democracies, etc. According to this theory the propensity of States to collaborate or conflict with each other and the frustration index as a measure of the distances with partners had been interestingly modelled in the alignment problem in World War II.

Michel Le Breton, Ortuño-Ortin, and Weber examine the explicit connection between landscape theory and the theory of games and extend the model to include a more comprehensive class of coalitional environments. They introduce a non binary set of policy options and pairwise hedonic heterogeneity and assume that actors are impacted by the size of the coalition to which they

belong. Using the theory of potential games, they show that a global maximum of the potential game is a Nash equilibrium, thus establishing a bridge between landscapes and potential games.

Session 8: Network Games

This last session presented recent models of games played on networks.

The paper by **Frédéric Deroïan** explores a related and complementary issue to the one studied in Gameotti's paper. Here, agents face incentives to produce information which non excludable along the paths of the network. However, information efforts are strategic complements, as they generate synergies among agents. So, information is obtained from all agents in a connected components, with some decay. The paper obtains characterization results for the line network, for which it shows conditions under which central agents provide more effort.

The paper by **Christian Ghiglino** addresses the wide and mostly unexplored area of general equilibrium when agents' interaction is modelled as a network. Here, social interaction takes the form of consumption externalities among neighbours. Very interesting issues arise in such setting: how do prices and allocations depend on the network architecture? How does consumption and welfare depend on the position of an agent in the network? What changes can we expect when the network becomes denser? The paper answers these questions in a Cobb Douglas example with two goods, one of which is subject to these local consumption externalities. The very sharp result obtained here is that prices and allocations are related to a centrality measure of agents in an affine way. In particular, the relative price of the commodity with externalities is shown to increase with the aggregate centrality of the network, while individual consumption grows linearly with the centrality of an agent. So, as the network becomes more connected, the price increases, as does the consumption of the agents responsible of the new connections. The pap also shows that results may change when both goods are subject to externalities.

The paper by **Giacomo Pasini** also looks at markets where agents are embedded in a network. Here, buyers and sellers are linked, with each seller having information only on the number of potential buyers, and on the probability with which these buyers put this seller in competition with "k" other sellers, for each possible number of rivals "k". So, sellers and buyers play a game of incomplete information. The paper shows that equilibrium in pure strategies might not exist, while symmetric equilibrium in mixed strategies always exists.

Finally the paper by **Bhaskar Dutta** addresses an old and unresolved issue in cooperative game theory. When externalities across coalitions are present, the traditional tools of cooperative game theory (the characteristic function) is not apt at representing payoff possibilities. The partition function solves the problem of representation, but leaves open the problem of applying the main classical solution concepts (the core, the Shapley Value, etc…) to situations with externalities. This paper develops a technique, based on Hart and Mas-Colell potential, to derive a value for such games. The approach is axiomatic. First it is shown that a simple axiom – "path independence" – is sufficient to generate a unique potential function for all games in partition function - This axioms only requires that the order in which players are removed to generate restrictions of a game does not matter. This is a notable results, since there is a number of different restrictions that are consistent with such axiom, but all these are shown to generate the same potential. Then, additional consistency axioms, of the type used to characterize the Shapley Value in games without externalities, are introduced to restrict the set of possible game restrictions which are consistence with path independence.

Sergio Currarini with the contribution of Masako Ikefuji, Luca Marazzi, and Alessandra Sgobbi