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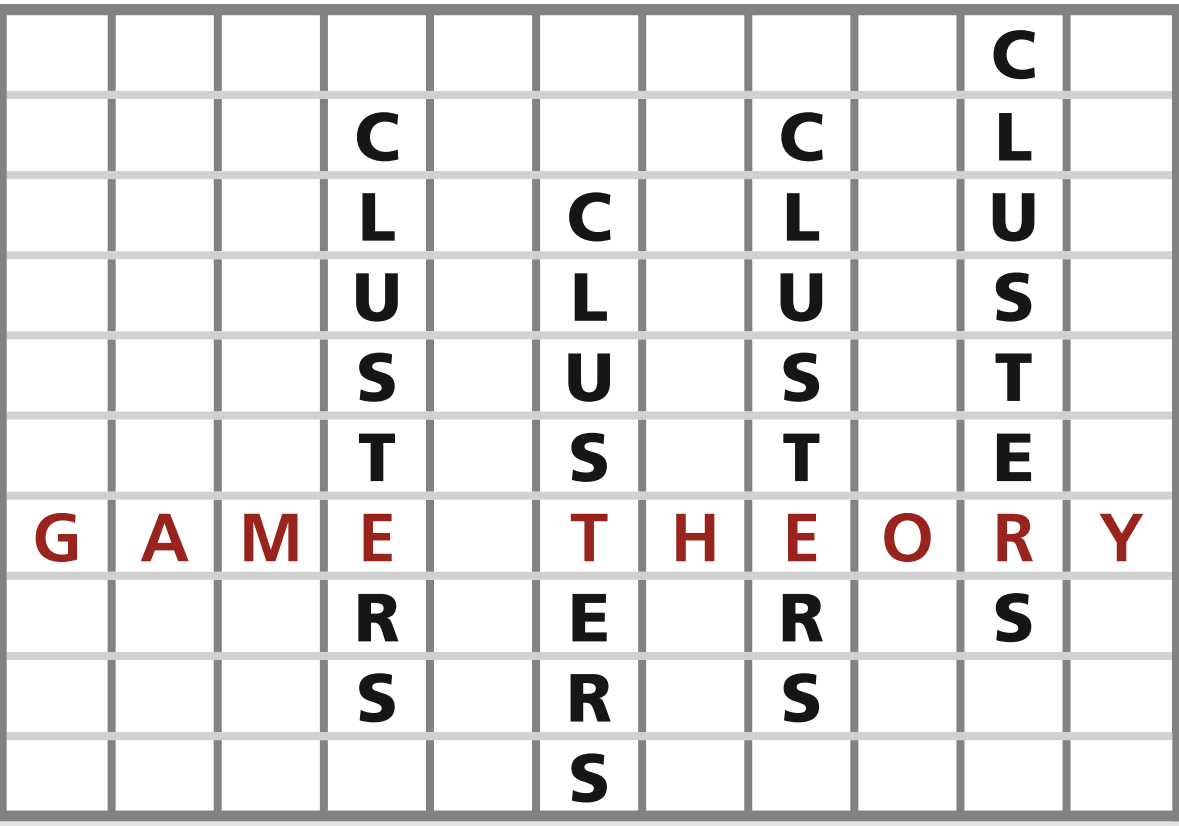

Cluster Games

A Novel, Game Theory-Based Approach to Better Understand Incentives and Stability in Clusters

Endre Gedai, László Á. Kóczy, Zita Zombori

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Authors
Endre Gedai
László Á. Kóczy
Zita Zombori

Editors
Gerd Meier zu Köcker,
Institute for Innovation and Technology, iit (Berlin)

Thomas A. Christensen
Danish Ministry for Science, Technology and Innovation,
DASTI (Copenhagen)

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Executive summary

Countries all over the world look for ways to increase their competitiveness. The contribution of cooperating companies in the form of clusters is rather substantial and therefore, for example, the European Union and its member states have long been supporting these cooperative efforts. This support may take the form of a more entrepreneur-friendly legal environment, initiate cooperation, but it may also mean non-returnable financial contribution.

This paper does not want to discuss the optimal channels to support clusters, and in particular it does not want to study the ways financial contributions are distributed among clusters. Rather, the contribution is an entirely novel way to look at the forces that keep some clusters on track while destruct others.

Longstanding cooperation between companies forms a special complex process hierarchy in clusters. The main businesses of the cluster is driven by the actors' interests in staying competitive, improving competitiveness and obtaining high profits both as a cluster, but especially as an individual company. Cooperation and the actors' selfish interests should be kept in balance or else the success of the cluster is in jeopardy and its actors can lose both joint and individual profits. Organic relationships and cooperation among companies or a favourable business environment is, by no means a guarantee for a working and successful cluster. Clusters operating at industrial concentration points, having a critical mass, supporting environment, and a successful cluster manager may nevertheless lack success. On the other hand other clusters operating in suboptimal circumstances in theory, flourish and produce a high extra profit in practice. This puzzle cries for new models, new approaches for a better understanding of the opportunities and decisions that drive the clusters and their actors.

This paper introduces an entirely novel way to study clusters by looking at the selfish, profit-seeking interests of the entrepreneurs, the actors of clusters. The approach, using game theory provides an exact, mathematical framework to study the conflict between the fruitful cooperation represented by the cluster and the selfish ways of the actors to follow their own – possibly short term – interests. The game theoretic approach makes it possible to identify not only good or bad clusters, provide recipes for solutions in some of the bad clusters, but also to define golden rules that do not only facilitate the evaluation of existing clusters, but help future cluster managers to create better, more stable clusters.

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1 Clusters and game theory

Today the formation of clusters – the collaboration of companies with each other and with the research sector – is seen as a possibility to renew the economy and the society. Clusters have been proven as a very promising tool to strengthen the competitiveness of companies all over the world. Competitiveness significantly increases among cluster actors which are closely located within a region and willing to do joint research, development as well as to jointly create innovations. Clusters offer a favourable and dynamic business environment (ecosystem) where innovative companies can flourish by interacting with different innovation actors and across sectoral boundaries. Recognizing these positive roles the development of clusters is actively supported by policy makers worldwide.

I.1 Cooperation of the companies

History proves that humanity is ready for cooperation and it needs cooperation. To put it simply, the modern enterprise is a typical product of modern people's cooperation and the relations between the enterprises and other organizations mean a more advanced stage in the cooperation's hierarchy.

Alfred Marshall in his book – Principles of Economics (Marshall, 1890) – shed light on the positive effect of the concentration of specialized industries in a particular area.

His concept was based on a pattern of organization that was common in late nineteenth century Britain in which companies concentrating on the manufacture of certain products were geographically clustered. Comments made by Marshall (1890, Book 4, Chapter 10) have been used by economists and economic geographers to discuss this phenomenon. The two dominant characteristics of a Marshallian industrial district are high degrees of vertical and horizontal specialisation and a very heavy reliance on market mechanism for exchange. Companies tend to be small and to focus on a single function in the production chain. Companies located in industrial districts are highly competitive in the neoclassical sense, and in many cases there is little product differentiation. The major advantages of Marshallian industrial districts arise from simple propinquity of companies, which allows easier recruitment of skilled labour and rapid exchanges of commercial and technical information through informal channels. They illustrate competitive capitalism at its most efficient, with transaction costs reduced to a practical minimum; but they are feasible only when economic of scale are limited. (Wikipedia contributors, 2012; Zaratiegui, 2002)

Without being absorbed in a form and content analysis of the companies and the institutions in contact with them, it is necessary to mention the classification made by Jacobs and De Man. They define clusters in a three-fold manner as either being regionally located, as possessing a vertical production and supply chain process or third, as businesses that are related by some form of narrowly-focused specialization. Links the cluster definitions to the development of industrial policy in The Netherlands, and from the discussion compiles a menu of possible policies and strategies that can be utilized by both industry and government for the furtherance of industrial policy. (Jacobs & De Man, 1996)

In conclusion our opinion is that longstanding cooperation between companies forms a special process making complex hierarchy which main business motives basically are driven by the ideas of staying alive and being competitive and strengthening this competitiveness as well as maximizing the profit.

The fact that the forms of companies' cooperation are continuously developing and this cooperation has a special evolution progress – the successful solutions will be commonly used and the less successful initiatives will die – is noteworthy as well.

I.2 Clusters

Moving on to the particular subject of the concept paper, it would be worth beginning with a definition which clarifies the concept of cluster, with one, which is fully accepted by the community. In the literature many alternative, overlapping definitions are used, but there is no commonly accepted standard.

Actually, the most known definition of cluster had become public as a result of Michael E. Porter's work. In the 80's Porter studied the factors of competitiveness. In connection with this research he clarified the positive effect on the competitiveness of the regional and sectoral cooperation.

The four factors of Porter's diamond model (company strategy, structure and rivalry; factor conditions; demand conditions; related and supporting industries) interact with each other to create conditions where innovation and improved competitiveness occur (Porter, 1990).

Based on this theory he introduced the concept of clusters: 'A cluster is a geographically proximate group of interconnected

companies and associated institutions in a particular field linked by commonalities and complementarities'. (Porter, 1998)

Ketels (2004) draws four critical characteristics to our attention which is proximity, linkages, interactions and critical mass. Understanding the importance of these four dimensions is much more important than defining specific benchmarks along them that a group of companies and institutions have to meet to be called a cluster.

'The geographic scope of clusters can vary from a single city, state or region to a network of companies across state or even country borders. There are various clustering forms that may ensue to optimise competitive advantage. Clustering can be formal or informal, in the public or private sector; horizontal or vertical; physical; and even sometimes virtual. In horizontal clustering companies within the same industry sector are co-located in a particular geographic area and might share an industrial or technological base, operate within a common market and use a common purchasing and/or distribution channel (Michael, 2003). Vertical networks include horizontal cluster participants as well as supply chain members such as suppliers, consumers and related services (Boekholt, 1997). Diagonal clustering refers to the concentration of complementary or symbiotic activities, whereby each company adds value to the other.' (Braun, McRae-Williams, & Lowe, 2005)

The changes and the improvements of the cluster definition were induced by the realization of the influence of the organizations and institutions working in interaction in the market on the competitiveness and by the realization of the various forms of cooperation of the cluster's framework.

'Comparing the diversity of cluster definitions and approaches throughout the literature, three common elements emerge: geographic, economic integration, and social elements. In the literature, these elements are further divided into a number of dimensions (Bryant & Wells, 1998; Enright, 2000; Harrison, 1992; Jacobs & De Man, 1996; Rosenfeld, 1997, 2001; Verbeek, 1999), such as geographic localisation, vertical and horizontal aggregation, innovation, critical mass, and social networks.' (McRae-Williams, 2004)

We consider it important to mention that the essence of clusters is based on empirical examinations and on a bottom up procedure. Funding and/or organizing a cluster is an organic instrument of the member companies to increase their competitiveness, which has a (back) positive effect on geographical and economic circumstances of a cluster as well. Moreover cluster is an economic device in the competitiveness development, with which effective utilisation of a region's resources it is possible to realize higher profit than the total profit of the cluster actors. From the point of view of this concept paper it is important to emphasize the observation implemented in cluster definitions – cooperation and competition… both of them are characteristic for the cluster actors at the same time. But these two opposite attitudes should be kept in balance among the cluster actors under any circumstances, otherwise either overweight could jeopardize the success of the cluster.

I.3 Cluster development

Thanks to the work of Porter the positive impact of the clusters on the regional economy has become well known fast for policy makers responsible for economic development. Taking the advantage of this theory numerous economic strategies have tried to get the benefit of the clusters' operation. The successful clusters can integrate the regional capacities with the special knowledge in their own value chain, which result is an advantage that is hardly reached by others. The cluster itself is a favourable business environment for the SME's and it helps them (directly and indirectly as well), to easy connect to the international economic trends. We can say that the clusters can be ready to be the heart not only of the well-working companies but of the regional development as well, thus if the cooperation-culture becomes general and is widely used in a region, the development of a favourable business environment is only a child's play.

Cluster development programmes based on economic political decisions proved that without (strong) base or a suitable approach there is no success, there are no successful initiatives. Examples for such failures are PANAC (Hungary) or IT Öresund (Sweden and Denmark).

Nowadays it is a fact that the cluster itself can be a useful instrument in the economic development, but if the cluster funding itself has become the central goal for the cluster actors and/or for the economic leaders, then the cluster can miss lose his basis basically needed to success. Clusters have to be considered as tools not as an objective.

Regarding the cluster development our starting-point is that the clusters are 'the product' of a long term evolutionary process and at the same time they are a successful instrument of the companies' struggle for survival and of obtaining (high) profit. One must therefore pay attention to the cluster fundamentals, and the cluster's motivations when evaluating a cluster's plan of operation.

I.4 Cluster policies and cluster-based economic development

Studies about the companies' cooperation have outlined the role of geographical concentration of different activities and the conurbational benefits coming from it. From the point of view of the development of the cluster it is essential that potential actors are present in ample number in geographical area, exceeding the critical mass. Therefore if statistical evidence suggests that in a given geographical area the companies, which are willing to join a cluster, are present in higher than the average density and their number, size and economic importance achieve the critical mass, an industrial cluster organisation can be founded or the formation is already in progress. This method was adopted by Ketels & Sölvell (2004) in order to map the new member states' cluster organisations.

In the recent years the European Union and some member states have rightly committed considerable effort and resource to the deeper understanding of clusters. Looking at the European cluster landscape it becomes clear that some clusters are more successful than others. Which clusters will likely be successful? Which of these is it worth investing in?

'In order to facilitate the discussion about cluster policy through further insights into the characteristics of clusters and cluster policy intervention, the Danish Ministry of Research, Innovation and Higher Education, supported by the German Federal Ministry of Economics and Technology and its national cluster program Initiative Kompetenznetze Deutschland, the Nordic Council of Ministers and the Nordic Innovation Centre (NICe), have initiated the project 'NGPExcellence – Cluster Excellence in the Nordic Countries, Germany and Poland'. The overall objective of this project is to contribute to the development of outstanding clusters through excellent management and excellent cluster programs. … This project pays particular attention on characteristics of cluster management organizations and their effects on cluster development. … As many cluster management organizations are supported through national funding programs the project also analyzed 16 cluster programs from nine countries in a benchmarking exercise to facilitate a better understanding of successful strategies and mutual learning between the program owners. The project, … , addressed two target groups: On the one hand, managers and staff of the cluster and network organizations from the participating countries, and on the other hand, program owners and policy makers responsible for national cluster and network programs and policies.' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, pp 10–11)

The examination of 16 different cluster programs in Europe gave the authors a unique opportunity to describe the characteristics of these programs. Let us summarize the most important findings:

- 'Common to all programs is their rationale of increasing the competitiveness of the national economy through the facilitation of collaboration between companies and research stakeholders.' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, p 34) But there are different types of the 16 cluster programs which serve different purposes. The analysis of the objectives and strategies of the different cluster program reveals the following main types of cluster programs:

I) Cluster programs that focus on regional economic development
II) Cluster programs that focus on the development of national industries
III) Cluster programs that focus on the commercial exploitation of the R&D potential of a country's economy

- 'Network programs to support the competitiveness of national industries.' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, pp 44–45) 'Most programs support both the establishment of new cluster management organizations and the future development of already existing matured cluster management organizations. Only a few programs concentrate either on the establishment of new cluster organizations or the further development of already existing matured cluster organizations.' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, p 35) e. g. Competence Network Germany, Cluster Offensive Bayern, Norwegian Centres of Expertise, Arena and Strategic Research Program for Centres of Excellence and Research Clusters.
- 'Most programs do not have particular strategic objectives in terms of actors of clusters that are funded, restrictions on thematic areas and coverage of the most important business sectors.' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, p 37) Only Innovation Networks Denmark, the Norwegian Centres of Expertise Program and the Cluster Policy Strategy of the Free and Hanseatic City of Hamburg concentrate their efforts on the most important business sectors of the economy.
- 'Grant funding is the main instrument of nearly all cluster programs, while technical assistance for capacity development of cluster management organizations and its members is applied by only half of the programs.' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, p 39) 'The most programs co-fund initiatives to 50 or 75 per cent of the total project budget' (Lämmer-Gamp, Meier zu Köcker, & Christensen, 2011, p 41) and a number of cases there is no maximum funding period for a project or maximum amount of funding an applicant can apply for.

Looking at the European cluster policy landscape it becomes obvious that there are similarities but there is no common 'recipe' for cluster policies, moreover there is no common 'recipe' for the success, just there are recommendations. The most important ones were given by the European Cluster Policy Group issued in 2011. Building on them the INNO-Net project, the TACTICS Reflection Group – the objective of which is to assist the TACTICS' partners to analyse, develop and propose new cluster policy actions and methods of implementation in a number of predefined topics such as channelling RDI funding through excellent clusters or user-driven excellent clusters, among others – will issue in 2012 two handbooks on Cluster internationalisation and Cluster marketing & branding.

Is it worth supporting clusters and if yes, how? – such questions raise a heated debate. As we mentioned before, different solutions are adopted. Which one of these is the best? Should we give alternative possibilities for the subsidies for the cluster managers or for the cluster organizations or for the common cluster actors' projects or just for developing a favourable business environment? The success of the cluster development policies can be measured only after years. And the next question this entails: How is it appropriate to measure the effects and impacts of clusters? The evaluation targets could be the target policy or the cluster program or the cluster organization itself or the cluster management. The kind of the evaluation could be ex-post, ex-ante, formative, impact evaluation or benchmarking or quality labelling. (Meier zu Köcker & Kind, 2012). More analyses were born even in the last few months (e. g. Joenneum Research – Policies Graz or The SLIM Project in Sweden). It can be seen that Europe and the member states are different and not unified. Taking the national characteristics, the ways and the methods of the national developments into consideration, companies with different conditions and structures, and then cooperative and competitive economics have developed… there are regions where it is worth to strengthen the ideas of cluster initiatives with any kind of support and thereby stimulating the development of the cooperation's culture and speeding up the infrastructure development of cluster organisations and generating the joint investment projects of the cluster actors. Parallel to it we have to say that there are regions where the direct subsidies for the cluster organisations are not necessary at all because the main aim and motivation of the cluster actors are the realizable certain and high profit through their cooperation.

As it was written in the Vienna Cluster Manifesto as well 'The Commission shall further support the statistical analyses of clusters as provided in the framework of the European Cluster Observatory. … Member states and regions should, with support from the Commission, continue their policy dialogue on cluster policy matters to further develop and adapt cluster policies to newly emerging needs and challenges and exchange knowledge and experience on the evaluation and impact assessment of cluster programmes.' (European Cluster Conference, 2012, p 3).

This concept paper does not deal directly with the question of the clusters' support, but it is even important from some point of view. We have to note though that the subsidies of the clusters do deform or could deform the organic (economic) process of a cluster development. It can happen that the prime motivation of the cluster will be the extra profit getting with the help of subsidies or simply the subsidies will become a real part of the profit. Therefore the cluster actors will get a false understanding of the cluster's operation and about its outcome. In any case – we should take these facts into account at the evaluation of a cluster's operation.

I.5 The cluster management organisation

The cluster management is the result of the conscious cluster development whose task is among others to stimulate the organic development of the cooperation within the cluster with the help of accelerating the information flow and the project generation and providing the necessary competences. Of course, the right cluster manager cannot even substitute the cooperation between the cluster actors and cannot replace the essential motives of the cluster's operation but it can really catalyze the cluster development not only with the realization of the above mentioned task but with right position of the marketing & branding and internationalization strategy and with solving the problems, debates, etc. The services offered by the cluster manager shall be colourful based on the demand and habit of the cluster actors and on the activity of the cluster. The most important thing is that the cluster manager shall not want to get the upper hand over the cluster. Moreover the cluster manager cannot lose sight of the fact that the cluster's success always depends on the actors and on their original aim – to achieve the maximum profit via cooperation.

I.6 Key elements – Trust and social capital

It must be mentioned that a 'program' cannot be successful if the interested parties do not trust each other, they do not co-operate or they are not committed to a long term, consistent strategy. 'The ability of people to work together for common purposes in groups and organizations is the social capital which is a capability that arises from the prevalence of trust in a

society or in certain parts of it' (Fukuyama, 1995). 'Further developed the social capital is the existence of a certain set of informal values or norms shared among members of a group that permit cooperation among them' (Fukuyama, 1999). It 'refers to the collective value of all social networks and the inclinations that arise from these networks to do things for each other' (Putnam, 2000) 'The literature has discussed social capital as a resource at the individual, organization, and community level' (Strauss, 2010). 'Social capital appears to be positively related to organizational effectiveness and to play a central role in reducing organizational transaction costs' (Fukuyama, 1995). 'It also facilitates coordinated action to achieve desired goals (Leana & Buren, 1999) justifies organizational commitment (Watson & Papamarcos, 2002), and results in a significant positive impact on product innovation' (Nahapiet & Ghoshal, 1998). But there are differences between the level of the trust and the social capital of the countries, and these differences could appear among the regions of a country as well.

From the point of view of this concept paper the trust and the social capital is significant with a view to the future profit of the trust and social capital. The return in the cooperation invested resources is always awaited just in the future.

The present value of the awaited profit is being decreased not only by the time-factors but by the risk of the distrust (e.g. changing of the economic regulation, deficiency of the cooperation-rules, the problems of exercising a right). The more risk is recognised by the cooperating partners the less but immediately provided advantage (profit) make them give up the cooperation.

I.7 "Cluster illnesses"

In the last decades extensive studies have been conducted to investigate and determine success-factors in clusters. During the examinations the characteristics of the clusters have been analyzed from a number of points of view. On the basis of these examinations we can theoretically and statistically specify the kinds of clusters to be funded. Such conditions can specify the optimal number of cluster actors or the ideal competences of the cluster managers . Theoretically it is also possible for each of us to found and build a successful operating cluster or catalyze the process.

Although the theoretical models have been proved in the practical life many times, the practical experience is not unanimous. What are the problems noticed during the last years and the policy makers are willing to hush up them?

1/ building up a cartel

There are forms of the cooperation which are successful for the actors but at the same time damaging for the economy (e.g. reducing the competition, agreement to the fix prices, marketing or production etc.). Cartels are illegal, but even so from time to time the companies try to enter into such agreements. Cooperation and competition are characteristic for the relations of the cluster actors, too, but a successful cluster is not about the restriction of competition. We cannot, of course completely exclude the possibility of parasites, undesirable groups of companies that abuse cooperation and especially the support for forming cooperation to reach their sinister goals.

2/ no panacea

The well documented success-stories about the profitable and favourable effects of the cooperation in the frames of a cluster might give the impression that joining a cluster will solve all business problems. Participation in a cluster might be a more effective way to reach one's goals, but it should not be the goal itself. Managers, who wait for such a miracle, completely miss the point and will fail miserably. Companies focussing on participation only will not be able to benefit beyond the obtained participation.

3/ herd attitude

To found a cluster – it is trendy nowadays. Business actors often feel that it is more profitable to join a cluster than to let the opportunity slip away. They do not really think of what this seriously means in practice, they are just toying with the vision of the word 'cluster'. The idea of cluster is slowly becoming a myth.

4/ lack of business and ambitions of the actors

The cluster itself is an answer for the challenges of the economic competition. Increasing the competitiveness of the companies the cluster gives them confidence that they will have success in the fields of market struggle. The cluster is not a charity organisation, this is actually a secondary result of the companies' activity. Misjudging where the cluster can help its actors can lead to bad experiences with any cooperation.

5/ isolation effect

If the cluster actors do not have enough information to make the right decision on their own market position or market share, then their cooperation is suffering from an isolation effect and their results must be non-competitive in the global

market. It means if there is a product in the global market, which is more easily and more cheaply available and moreover it has a better quality than the product of the cooperation, then the cooperation itself is not successful. Why? Because with right assessment of the economic situation and also with having marketable information and even with involving outsiders in the business, successful economic cooperation – including the competitive products – would be easily guaranteed.

6/ growing apace with the subsidies and grant dependency/rent seeking

Getting subsidies for cluster development – this is the main business of the cluster, therefore the profit increase comes only from the subsidies.

7/ free-riders

The spread of this behaviour, getting the benefits of the operation of a cluster without any willingness for real cooperation could jeopardize the success.

8/ extremes

The overconditioning and overregulation of the cluster's operation, the elaboration of complicated rules of procedure, the forced and unnatural increase of the cluster actors' number put high risk even on the operation of a successful cluster.

In the cases the cooperation between companies is not the result of an organic development. In a market economy a company and its partners naturally have economic cooperation and if these relationships become serious and intensive then, the partners are ready to pave the way for a cluster initiative. But… the natural relationships and cooperation between the companies, the industrial condensation points which helps the development of clusters and the favourable business environment could not guarantee the development of a successful and a self-supporting working cluster in an examined area. On the one hand there are clusters recognised, which operate at industry concentration points, have a suitable company size, supporting environment, a successful cluster manager etc. and are not successful despite these facts. On the other hand other clusters which do not operate under above mentioned circumstances and thus should in theory die, in practice flourish. These facts suggest us to look deeper into the incentives in the operation of a cluster. After all, what drives the cluster and its actors?

II Game theory

Game theory studies strategic conflict situations. What are the characteristics of these situations? Firstly, the parties are *selfish*: for a conflict of companies this simply means that they want to maximise profits although in general the utility of the conflict's outcome can manifest in various non-monetary forms, too. Secondly, the conflict's outcome depends on the parties' actions. We call the conflict situation a game and the involved parties the players. The name probably comes from the fact that the father of game theory, the Hungarian genius John von Neumann was originally interested in developing a mathematical theory of bluffing in poker and his mathematical results found applications in economics and beyond only years, decades later (von Neumann & Morgenstern, 1944).

The *strategy* of a player determines his actions for every possible game scenario. As a result, given the strategies of the players, a game can be played and the outcome can be determined by a mediator or a computer. Therefore the payoffs, such as profits of the players can also be determined once the strategies are known.

We can describe a game in various forms, but there is one difference that divides games into two groups: cooperative and non-cooperative games. The difference is in the legal environment: noncooperative games are played in anarchy, in an environment where agreements are only kept if the parties are interested in keeping them. In cooperative games, on the other hand we assume that it is possible to make binding agreements. This distinction is largely due to Nash, who made key contributions to both types of games (Nash, 1950, 1953). While the language of the two types of games is remarkably different researchers have shown that the conclusions drawn from the two types of models are essentially the same. The different formulation, however means that the two types of games are used for different situations: noncooperative games are best suited to study the detailed interaction of a few players, while cooperative game theory can handle the interaction of large groups of players. Since a cluster is a selfish cooperation of economic agents, cooperative game theory is the better suited of the two to study the interaction. Nevertheless we start with a few simple concepts from noncooperative game theory that, on the one hand illustrate the modelling power of game theory better, and motivate our use of cooperative game theory later. But before we move on to the theory let us consider a simple story.

Company A has a brilliant idea that could be developed into a very successful and profitable idea – with the right partners. The CEO of A meets the CEO of B at a reception and over a crab sandwich they realise that they have some common interests: B could help company A to materialise this brilliant idea. For reasons that we do not need to go into here B's help is not enough, at least two companies of this type are needed. Fortunately B has contacts with C and D, either of which can serve as a second company, in fact A, C and D could also realise the project. The CEO of A finds the plan good and suggests to share the expected extra profit of 12 million to be shared equally among the four actors of this cluster. Will this work?

The shortest answer is: No. If the companies A, B and C can also do the project and obtain the same profit it would be foolish to include D in the project and pay it 3 million, wouldn't it? OK, D can stay on board, but with a much more modest share of the proceeds. Oh, but the same argument applies to B, or C that are of the same "type" of company as D. So, as a matter of fact A takes all and the substitutable members of the group get almost nothing. Moreover, even over the little payment they would get, the would start an eternal battle any two of these trying to skim the third company by kicking it out if the business.

We have only leaped over a tiny detail. A has no contact with C or D. A can only cooperate with these companies if B helps it, if B is on board, if you like: with B's permission. While companies A, C and D could realise the project, such a cooperation is simply not possible. But then B has a new, special role: B can connect A with the right people. If we look at it again, there are only two ways the project could be realised: A, B and C or A, B and D. As C and D can substitute each other, they will not get much of the (extra) profit, the profit is shared between A and B. They can share the profit equally as 6–6 millions, but if any other distribution emerges neither of them will have the possibility to increase its share. After the offer of company A, B getting 9 millions is a likely outcome, for instance.

We have noted that C and D are perfect substitutes, in other words one of them is superfluous. So why did B suggest two partners at the first place? Consider the same setting when D is not there: Then only full cooperation of all the parties can realise the project. In such a setting B's role as intermediary is secondary, company C can rightly demand a share of the profit and this share is a loss to A and B. In other words A and B profit from having both C and D in the cluster.

Finally note that the assumption that a company will cooperate for zero profit might sound unrealistic. Of course this is zero economic, rather than accounting profit where the company has been compensated for all production costs as well as its

opportunity cost (the cost of doing this project rather than investing its resources elsewhere) and a compensation for risk. Getting a zero profit is therefore not the same as not getting paid, but a higher profit is naturally preferred. In practice a zero profit case will not arise due to imperfect substitutes, capacity constraints or switching costs, but these only mildly affect our conclusions.

As we have said this story is simple, but real clusters have similar, though naturally more complex interactions, where the same arguments could be used. In the more complex cases, however the calculations may be a little more involved requiring a more general and more formal treatment.

II.1 Non-cooperative games

A non-cooperative game consists of three elements. Firstly, N is the set of players {1,…,*n*}, with a generic element denoted by *i*.The set of strategies available to player *I* is denoted by $\sum_i$. and we denote a particular strategy by σ_i.[1] A strategy profile σ is the collection of all the individual strategies. ∑ collects all possible strategy profiles. The utility of a player determines the payoff of the player given the entire strategy profile. So, for instance, if the players have chosen the strategies σ, the payoff of player *i* is given as $u_i(\sigma)$.

First we explain the so-called Prisoners' dilemma. The story goes as follows: after a bank robbery two suspicious persons are captured with illegal weapons. The police has no evidence that they committed the crime, so the two suspects are interrogated at the same time in separate rooms. Four scenarios are possible depending on whether the suspects cooperate with the police or deny the crime. If they both deny, the police does not have evidence, so they must be released with minimal charges for the illegal weapons. If they both cooperate, they can be charged with the robbery, but get some reduction of the prison sentence for their cooperation. If on the other hand one of them cooperates and the other denies, the first is set free for the cooperation while the other is put to jail for a long sentence that is made even longer by the refusal to cooperate with the police. In the following table we present the game in normal form, in each case the first value is the utility of the first suspect, the second is that of the second suspect in this outcome. A longer prison sentence is represented by a smaller utility (a negative number with a larger absolute value).

Suspect 1 \ Suspect 2	Cooperate	Deny
Cooperate	(-5, -5)	(0, -10)
Deny	(-10, 0)	(-2,-2)

1 Prisoners' dilemma

By the *solution* of such a game we mean finding the strategies the suspects (or players, in general) will choose. The difficulty in finding the solution lies in the fact that the outcome and the payoffs depend on the strategy of both players. In other words a player must choose his strategy making some assumption about the other player.

The inspection of the game in Table 1. suggests that the players should choose (Deny, Deny) to get the highest utility. Unfortunately these are criminals, so they might ignore a possible agreement before the questioning they might act differently. Indeed, if any of the suspects chooses the strategy Deny, the other profits from Cooperate. Since the argument applies to both criminals, it is not very realistic to assume that any of them will think (Deny, Deny) is realistic. If one criminal chooses Cooperate, the other's best response is Cooperate, too. This also means that if they agreed to (Cooperate, Cooperate) neither of them would have a reason to act differently. This is precisely the equilibrium we are looking for.

We call a strategy profile $\boldsymbol{\sigma}^*$ a *Nash-equilibrium* of a game, if the strategy chosen by any of the players is a best response to the strategy of the others. Mathematically:

$$ui(\sigma^*) \geq ui(\sigma i, \sigma i^*) \text{ for all } \sigma i.$$

Situations involving public goods often resemble the prisoners' dilemma. In a cluster the public good is a joint project, where the actors of the cluster can choose an effort level to contribute to this project. While choosing a high effort would be better overall, the individual actors prefer to free-ride on others' efforts and spend own resources on own projects ultimately leading to the breakdown of the project and a dysfunctional cluster.

In real life we do see public goods realised, and cooperation is often possible in similar prisoners' dilemmas. How can be rescue cooperation? A suitable legal framework using hefty fines can change the payoffs so that shirking is not a best response. We return to this topic in the following section. As the legal framework is never perfect, the enforcement may come too late, we may wish to look for self-enforcing mechanisms to maintain cooperation.

[1] To be precise these are the mixed strategies that include a randomisation over the so-called pure strategies *S*.

If the interaction lasts for more the one encounter the utility from a decision must also include the utility from future encounters. Mutual trust and mutual cooperation can be rewarded by future trust and cooperation. If the probability of future encounters is high and value of future money is high (the inflation is not too high), it is less likely that a one-time defection and the corresponding high payoff is greater than the value of future cooperation.

Note that this value of future cooperation is only there if the game is played repeatedly forever or at least is repeated with high probability. A cooperation with a definite or likely end does not help: in the last period the cooperation breaks down removing the incentives in the previous period to cooperate, and so on.

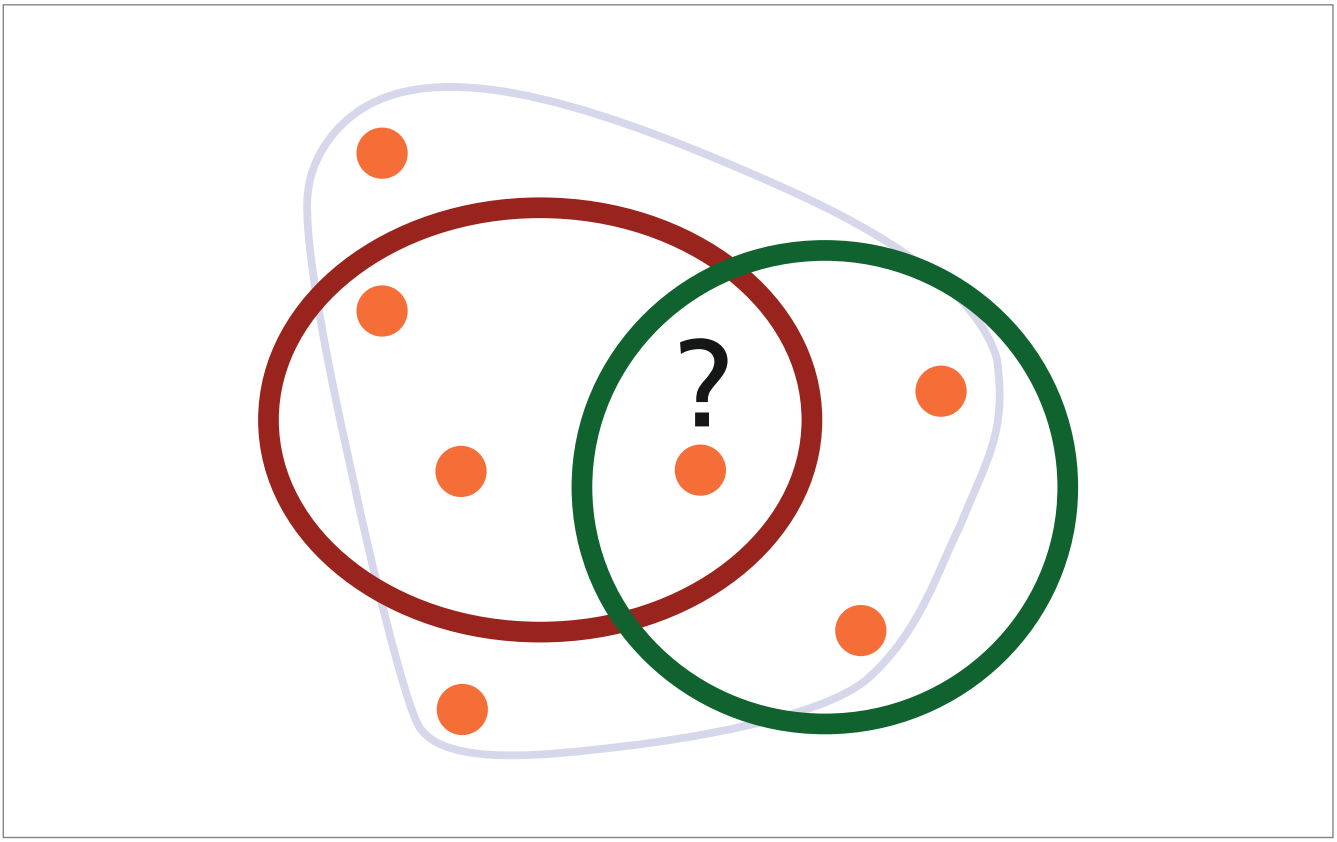
II.2 Cooperative games

The main difference between cooperative and non-cooperative games is that in cooperative games players can make binding agreements, i.e. agreements they must keep. In cooperative games the interest is on the formation of coalitions (see Figure 2) and on the sharing of the benefits of cooperation rather than the means to achieve these. At the same time the so-called Nash program works on showing that the very same results could be obtained as equilibria of non-cooperative games. Put it simply: we can say that cooperative games are result, non-cooperative games are method oriented.

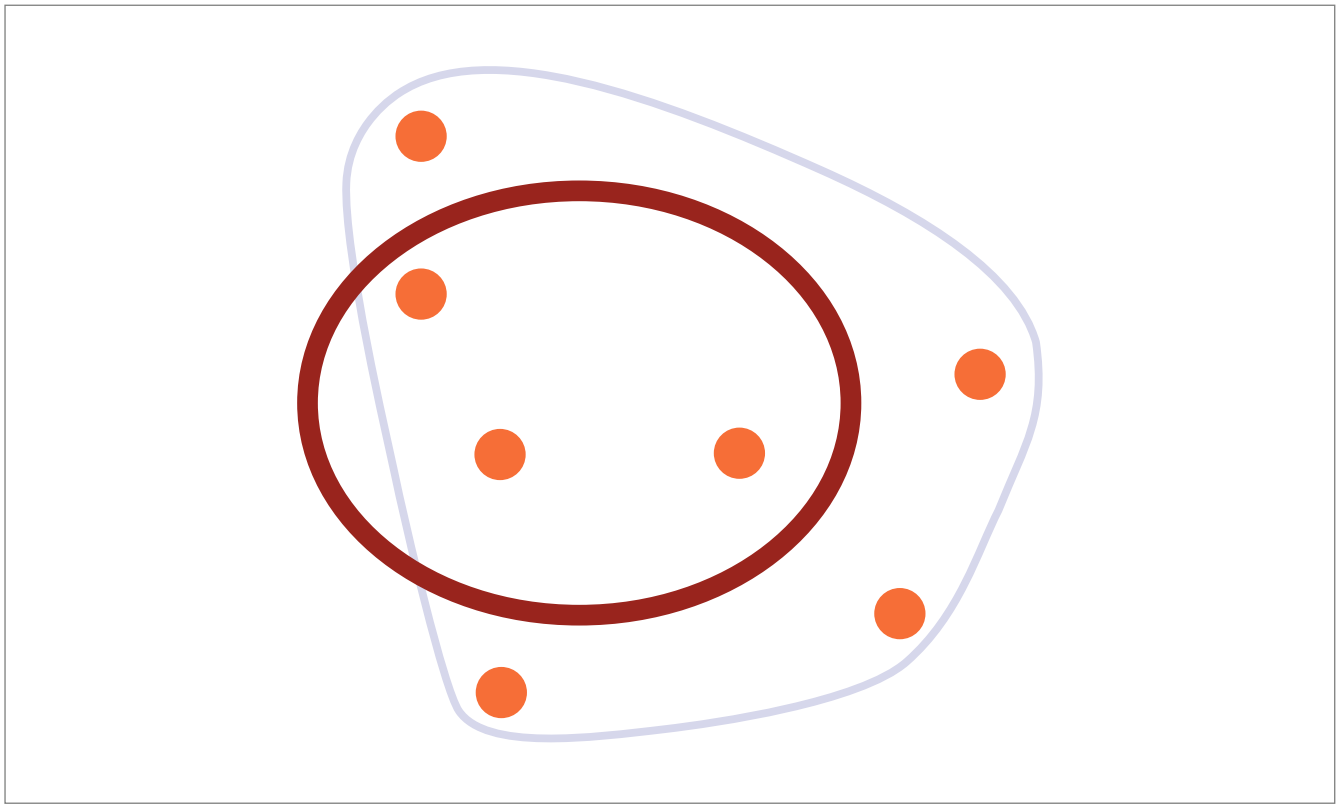
In the following we introduce the basic ideas and terminology of cooperative games.

We still have a set of players and this set is denoted by *N*. Subsets of this set, that is, groups of players are the *coalitions*. Actions, strategies are implicit and are limited to choosing players for cooperation. Instead of a utility function for individual players, we have a value *V* for each coalition (Figure 3).

The idea of this value function originates from von Neumann & Morgenstern (1944) who determined this value assuming that if a coalition *C* forms the remaining players play *against* this coalition. Whatever *C* is *guaranteed* to make from this situation is its value. Now we simply give the value of each coalition. If we also make the assumption that members of a coalition can arbitrarily share this coalitional value then we talk about a game given in characteristic function form or simply a transferable utility (TU)-game.



2 In cooperative games strategies are limited to the choice of cooperation. In this example the player makes a choice between the "red" and the "green" coalitions – or staying with the ("blue") grand coalition.



3 The characteristic value of the "red" coalition is classically defined as the minimal value obtained when playing against the complementer coalition, that is, the coalition of the remaining players

What is the solution of such a cooperative game? In purely cooperative games we assume that the grand coalition forms where all players cooperate and the solution only specifies how the players will distribute the value of the grand coalition. In some situations this assumption may be too restrictive. If, for instance we want to know if a group of regional companies should form a cluster, we may also want to know if all these companies have incentives to belong to the cluster. In such a case the problem is two-fold: which coalitions form, and how do these coalitions share their values among their members. For the moment we will focus on *games of pure cooperation*. An imputation is a distribution of the payoff of the grand coalition among its members, such that each player gets at least as much as it can get without cooperation, that is, as a single-player coalition.

As there are no strategies in these games, the equilibria defined for non-cooperative games are of no use. There are at least two types of solutions and two very popular solutions: the core and the Shapley-value. Before we move on to a more formal definition we provide the intuition of these concepts by means of two simple stories.

For the sake of this example consider a cluster producing and selling furniture. Some of the actors specialise in office, kitchen or children's furniture, others in marketing, logistics or producing brass parts. It is natural to assume that the brass part manufacturers could form a (smaller) cluster themselves and share technology, buy and sell in large quantities etc. etc. such a cluster clearly has some potential benefits. Now suppose that the furniture cluster generates some extra profit thanks to costs savings and extra trade generated. How to share this extra profit?

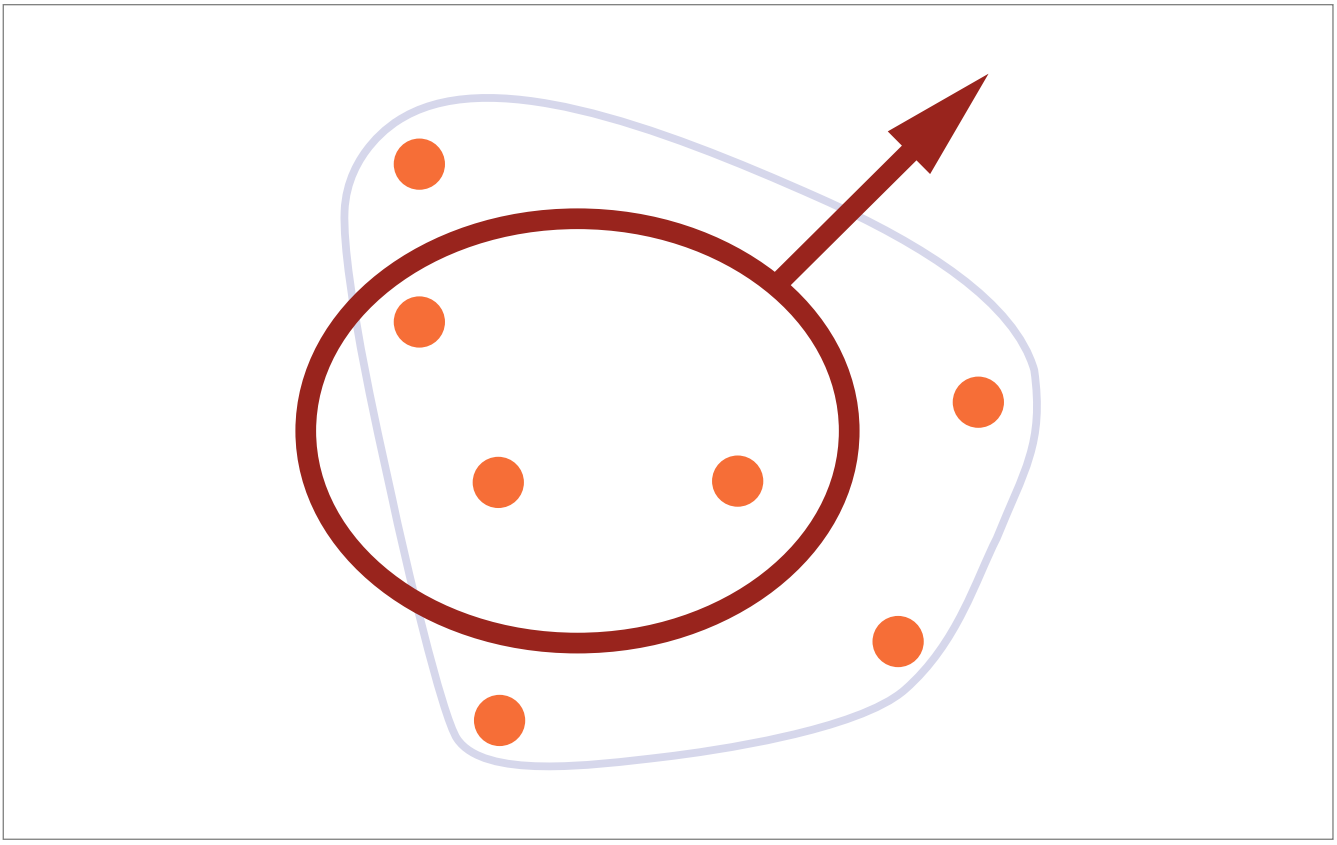
Of course one should not imagine a pile of banknotes or a sum sitting on a bank account: the money is often of the forms of cost savings that may be realised unevenly. If therefore the brass manufacturers feel that they get less than what they could make with the same facilities outside the present cluster, they might demand a higher share or threaten to leave the cluster. The higher share of the extra profit is probably in the form of higher prices in the contract for brass parts. Is this attractive for the rest of the cluster? Well, the rest of the companies could also buy the parts from other sources. If the cluster is worth more than its parts – it is superadditive – then an agreement is always possible. Quite similarly, each group of actors: merchants, kitchen makers, small companies, large companies, etc. could – and should – consider its outside options. We say that

the allocation of the extra profits is in the core if all these companies find the allocation reasonable and they cannot – justifiably demand an increase of its actors collective share.

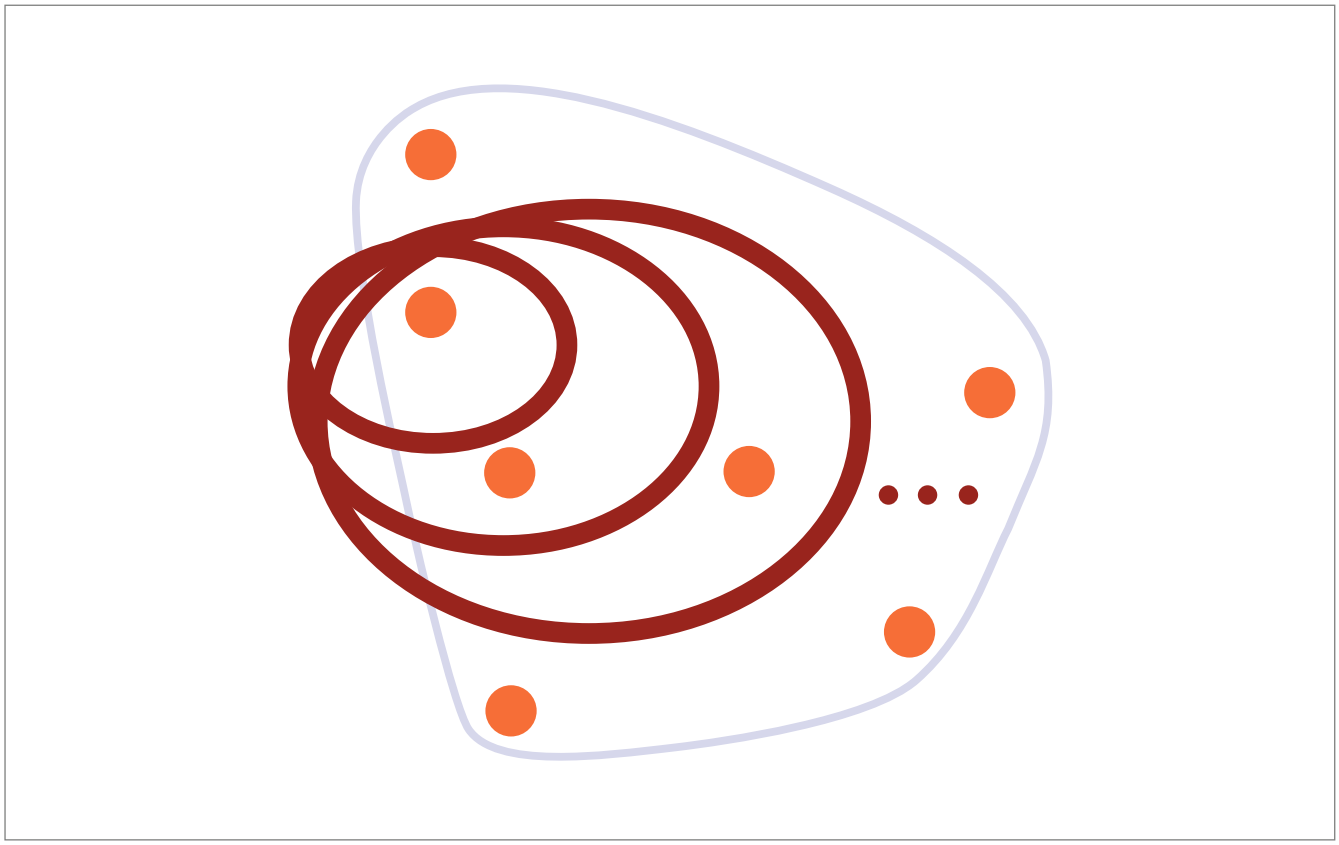
For the second example consider a cluster of companies building and using a shopping mall. Different shops or groups of shops might have different preferences. The luxury shops insist on the marble pavement, the banks want to have high security measures, the hypermarket an easily accessible shopping mall, the cinema the late opening hours. Each of these demands increase the total cost of the project. The question is: how to share the profits when we know that the costs depend on the actors' wishes. One possible method is to use the core again, but in this setting the Shapley value is more natural. For this number the actors as A1, A2, etc. First assume that only A1 builds and operates the mall. The costs will obviously be lower, but so will be the profits. The difference (possibly negative: a loss) is what A1 could obtain on its own Now take A2 and see what does it add. The two companies need a somewhat bigger mall, may attract more customers, so we can again calculate the value for the two-company mall. The contribution of A2 is the increase of the profit with respect to the single-company mall. Note this amount next to A2's name. And so on for A3, A4, etc. This row of numbers tells us how much each of these companies added to the value of the project. Clearly, this order is not very favourable for A1: it practically must build the whole mall with high costs, while A89 may incur no extra costs at all despite a long list of special requirements – already satisfied thanks to actors coming earlier. To make this fair we consider all possible numbering of companies – there may be very many such numberings – and take the average contribution.

Academics widely consider these methods as acceptable ways to share the profits and in fact such metods have been used for building airport runways (sharing the costs among landing aircraft, (Littlechild & Thompson, 1977)) or managing the Tennessee river (sharing the costs among nearby farms, shipping companies, and cities in the Tennessee Valley (Straffin & Heaney, 1981)) among others. In the rest of the section we present a short technical summary of these two concepts. This section may safely be skipped, this will not hamper the understanding of our paper.

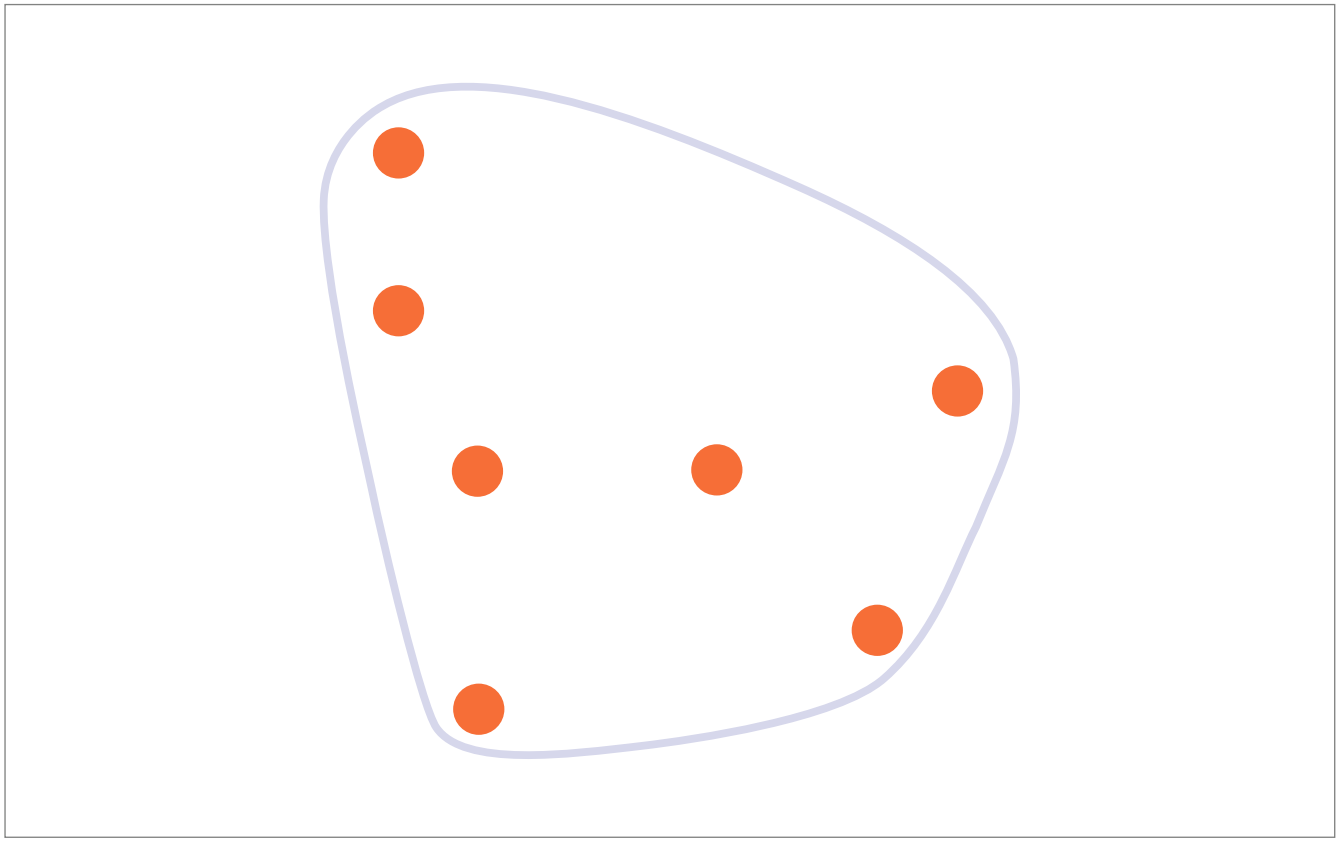
The *core* (Gillies, 1959) is the cooperative equivalent of the Nash equilibrium, but it allows also for coalitional deviations (Figure 4). The core collects imputations such that for all coalitions it holds that the total payoff paid to members of this coalition are equal to or higher than the value of the coalition. Were this not true, the coalition would not sign the agreement, but rather operate on its own. While it may seem rather dif-



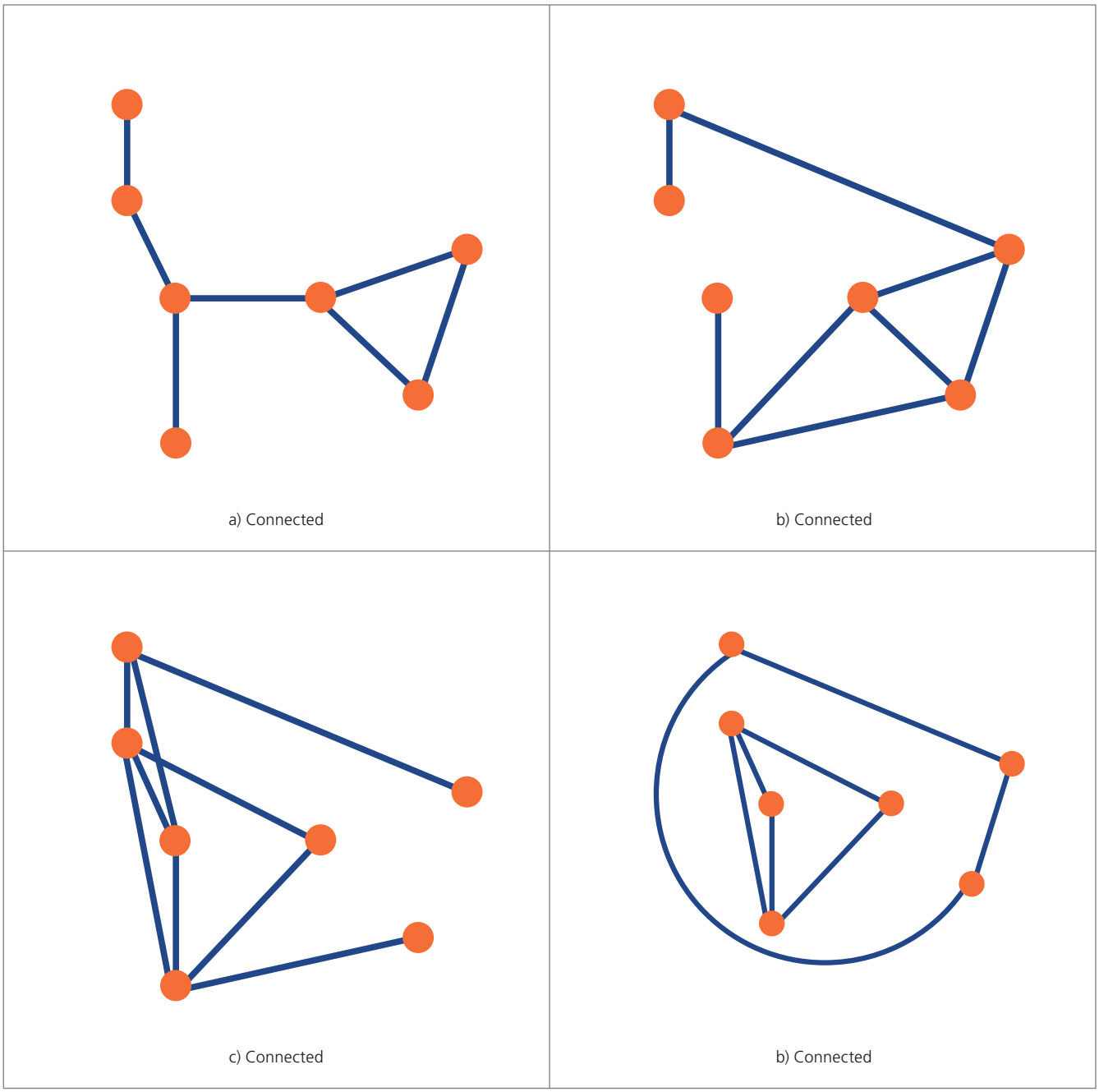
4 In the core no coalition of players benefits from forming and leaving the cooperation.



5 The Shapley-value takes the average marginal contribution of a player. For this all possible orders in which a coalition may have grown are considered.



6 A coalition has no structure



7 There may be many different network structures supporting the same coalition. Networks a), b) and c) all support the coalition in Figure 1, while network d) is disconnected and therefore cannot support the same coalition.

ficult to satisfy the demands of all coalitions most games have many imputations that satisfy them. Unfortunately there are also many that do not have any. We say that the core of such games is *empty*. So-called *balanced* games have non-empty cores (Bondareva, 1963; Shapley, 1967). To have an empty core means that the total resources available to the grand coalition are not sufficient to simultaneously satisfy the coalitional demands.

A whole stream of literature has been motivated by the potential emptiness of the core either to see what happens in the game if the core is empty or to somehow save cooperation. For instance the minimal dominant set (Kóczy & Lauwers, 2007) contains imputations that emerge dynamically after playing the game for long. Approximate cores (Shubik & Wooders, 1983) take the costs of forming/breaking agreements into account: when these costs are high, higher than the gains from leaving the grand coalition, cooperation survives.

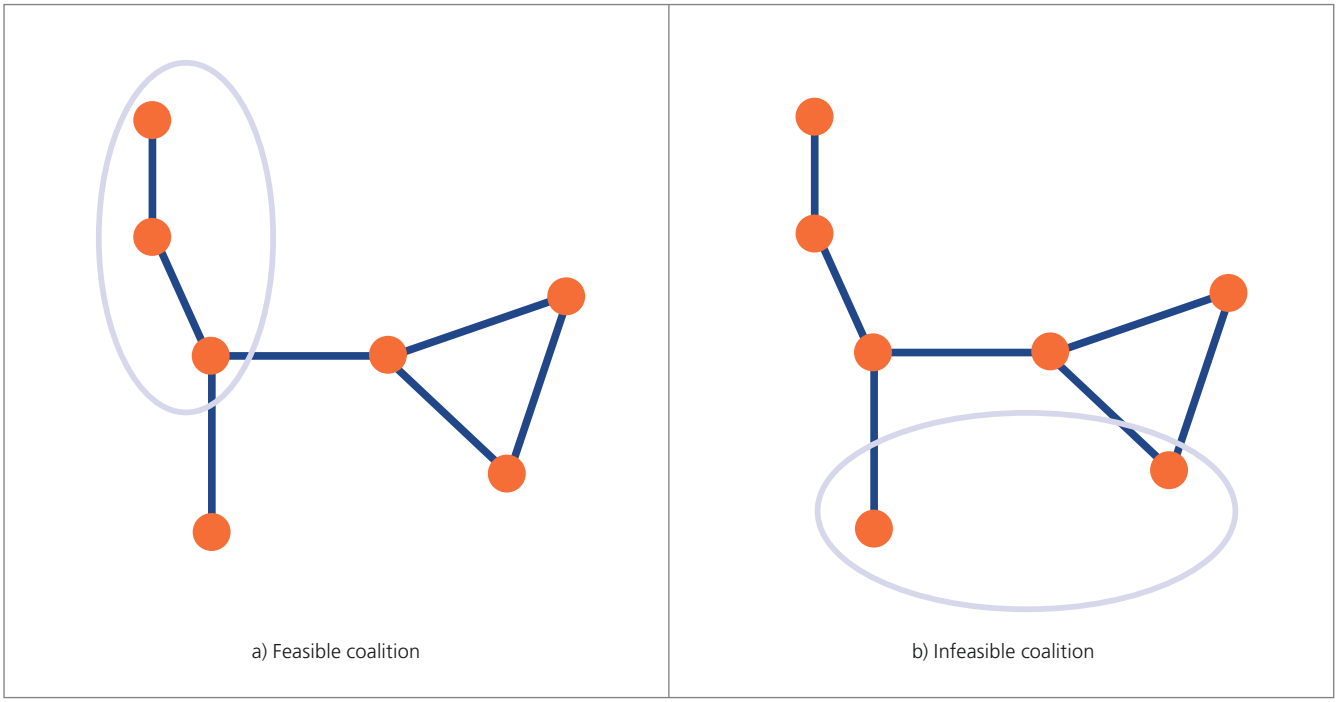
The sharing aspect of imputations is better expressed by the *Shapley-value* (Shapley, 1953), that pays the marginal contribution to each player. It can be best understood by a story: Initially the first player has its own value as a single player coalition .The the second player arrives and it contributes the difference between the value of this duo and the first player's single player coalition, and so on (Figure 5). We then take all the $n!$ possible orderings of the players and take the average of a player's marginal contributions.

The Shapley value is never empty, it is always defined. (Dubey, 1975; Neyman, 1989; Shapley, 1953) and others have shown that the Shapley value determines the only way to divide the total coalitional value if we require some simple, often elementary properties, such as symmetry, to hold. The Shapley value gives a fair way to share the coalitional payoff, but it is not always a stable way. The Shapley-value belongs to the core in so-called convex games (Shapley, 1971), but it may well be that the core is not empty, but the Shapley value is outside the core. In such games the allocation that is considered fair is simply not accepted by all coalitions.

II.3 Networks

Coalitions are a greatly simplified version of reality as they lack internal structure (Figure 6). In some situations the structure of cooperation has a role, too. Where personal connections or trust play a role only cooperation between parties that are connected to each other personally or who trust each other are possible. In such situations a player can have a high value simply for connecting other, productive players (Borm, Owen, & Tijs, 1992; Herings, van der Laan, & Talman, 2005). The core can also be generalised to games where the connections among the players are important. For such TU games over a network we must have a value function and know the underlying network of players.

In network games only coalitions that are connected make sense (Figures 7a-c and 8a). A disconnected coalition (Figures 7d and 8b) means that some of its members cannot communicate and therefore coordinate. Such a coalition then clearly cannot form.



a) Feasible coalition

b) Infeasible coalition

8 Coalitions under network 2a. The coalition in Figure 3a is connected, while Figure 3b is not. Members of the coalition on 3b cannot communicate and are therefore not a threat.

III Cluster games

By now it may be clear that game theory, especially cooperative game theory, models conflict situations very similar to those that can arise in a cluster. Over the decades researchers have written hundreds, possibly thousands of papers researching these games, providing ways to "solve" these games, that is, acceptable ways to solve the conflict among the players as well as describing properties of these games that guarantee, for instance, that a conflict can be a win-win situation.

In the following we formalise the connection between cooperative, so-called TU games and clusters making it possible to use the enormous literature written for games to be used in the study of clusters. The ultimate purpose of this exercise is to translate the game theoretic properties into golden rules for cluster evaluation.

Our aim is to evaluate clusters by game theoretic means. This requires first the translation of the problem into a mathematical format, solve the problem using game theoretic methods and translate back the results into practical recommendations.

We are interested in the possibility and nature of cooperation in clusters, so modelling clusters by cooperative games is the natural choice. Since the participating companies and institutions are naturally interpreted as players the question that remains is how to find the coalitional values, that is, the characteristic function. In other words: what is the value of a coalition?

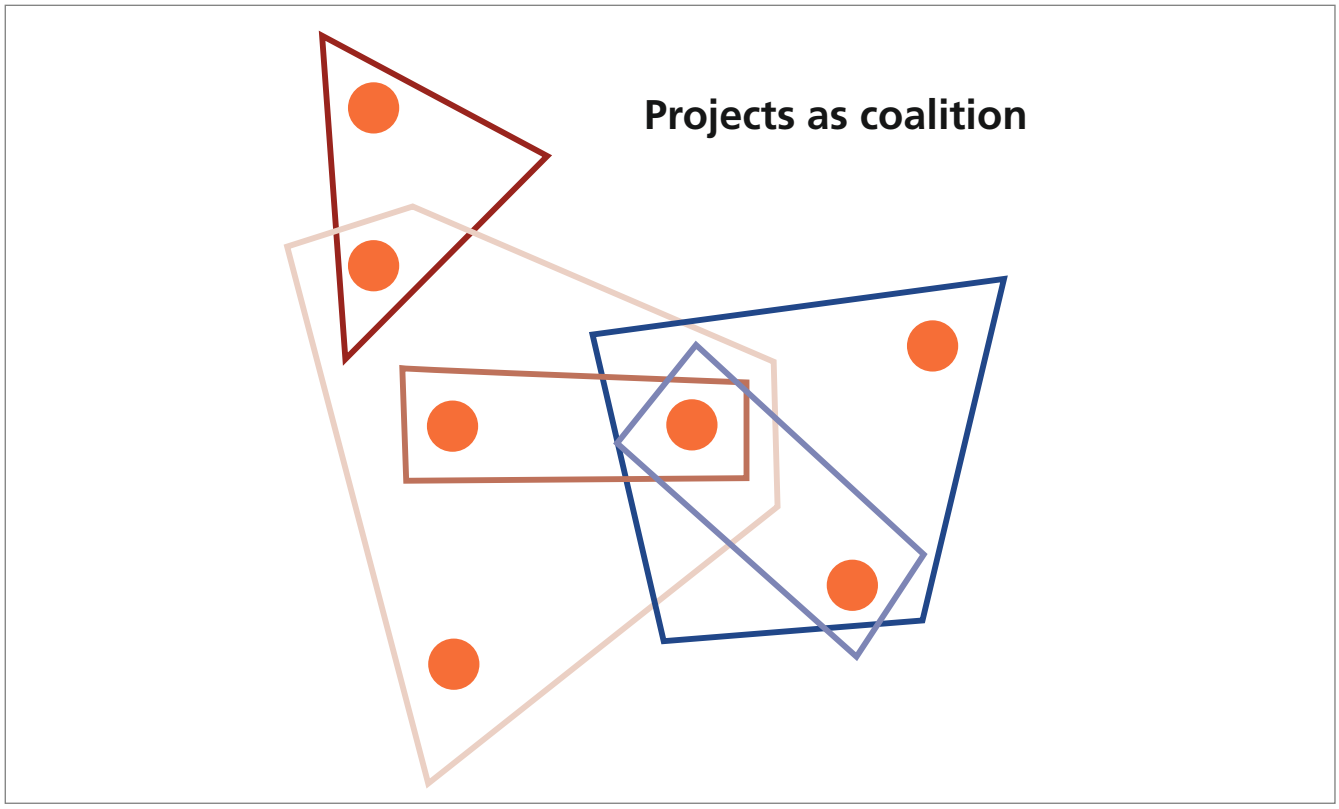
We see two possible interpretations: (1) Projects as coalitions (Figure 9) or (2) Clusters as coalitions (Figure 11).

III.1 Where are the coalitions in clusters?

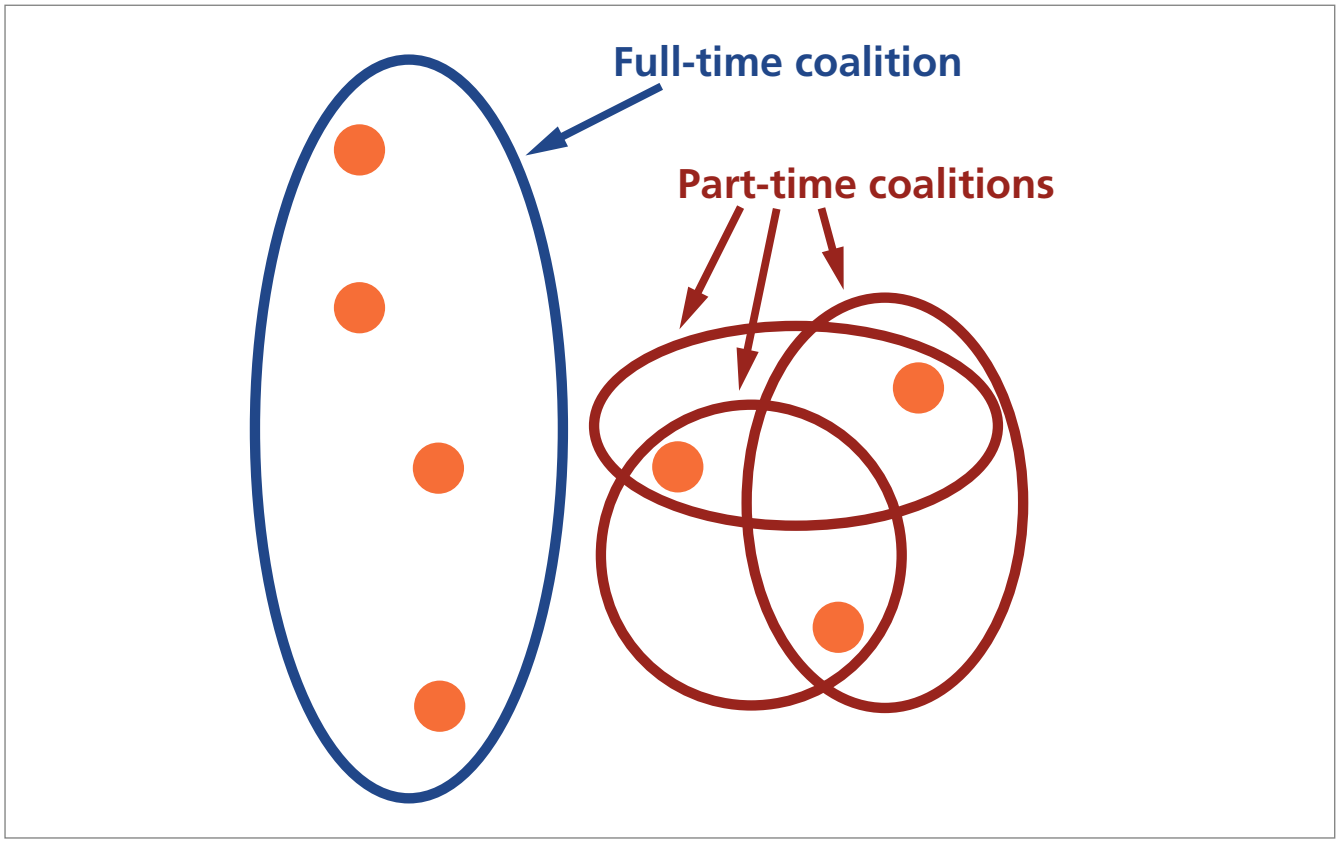
Projects as coalitions/coalitions as projects

A project is a form of cooperation among actors of a cluster that has a clear project plan, project objectives and an estimated project profit. This project profit is the value of the coalition. What are the advantages or disadvantages of this approach?

The single most important aspect of a project is that it is something specific, material and therefore the profitability of a project is a natural question, something that is also raised by the participants already before joining the project. On the



9 Projects as coalitions



10 Balanced collection: The members of the blue coalition are committed to it, while the members of the purple coalitions share their time between two such coalitions each.

other hand we do not only look at the behaviour of a cluster in the present, but would also like to understand future contingencies. For that we would need information about future or even potential projects. For such projects the same information is not available or is not accurate. In a cluster it is perfectly natural that a cluster actor will participate in multiple projects and share its time among these activities. This behaviour is not natural in cooperative games, coalitions do not generally overlap.

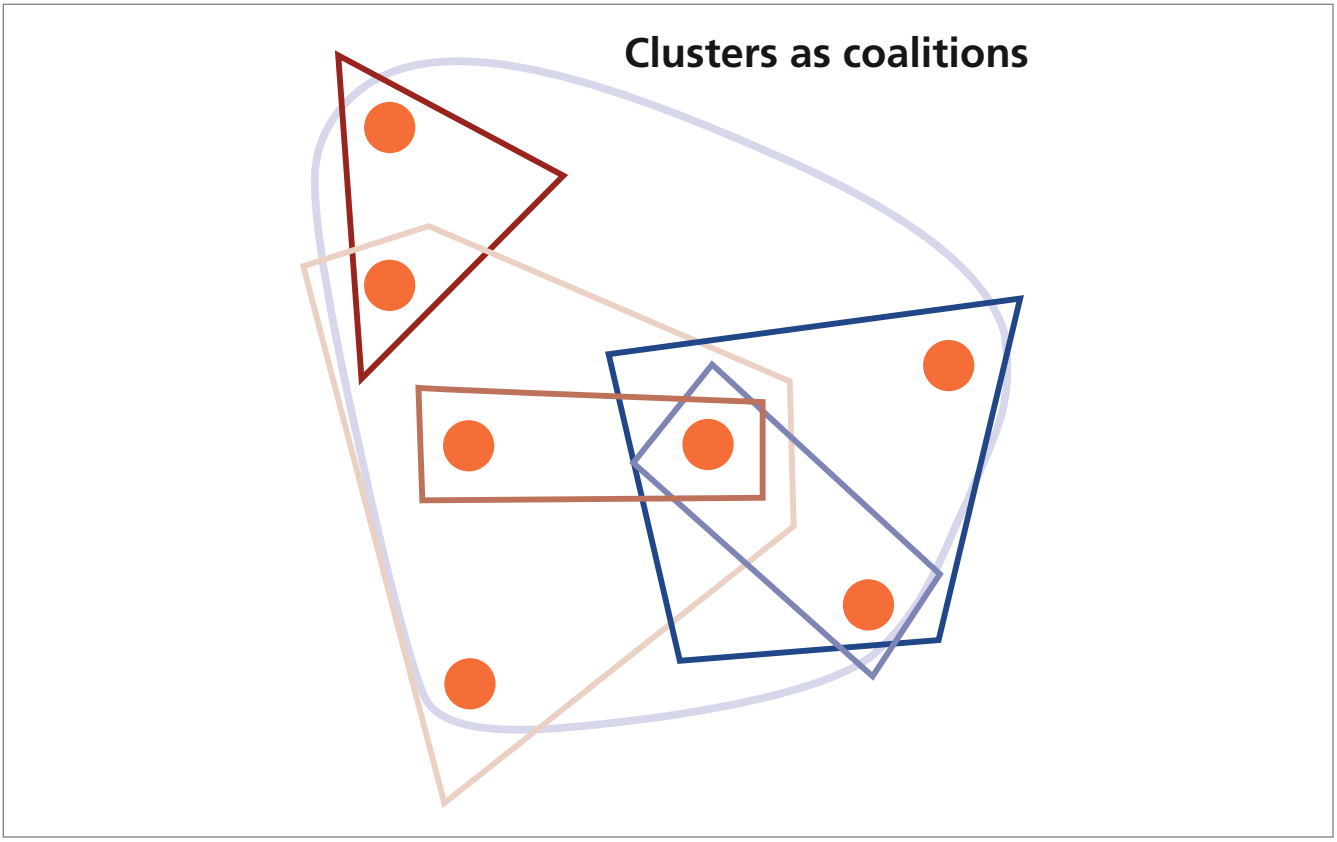
Overlapping projects can be modelled by so-called (balanced) collections (Figure 10). In a balanced collection each player spends the same amount of time on the projects including possibly a project that does not involve other players. The limitation of this setting is in the assumption that a project requires the simultaneous cooperation of the players, in other words, actors of a particular project/coalition must spend the same amount of time on that project/in that coalition. This is clearly a restrictive assumption that will not typically hold in a natural setting.

Clusters as coalitions/coalitions as clusters

In general a cluster is not created for a single project nor for a small set of projects but rather to be an incubator for new ideas and projects.

Basing our calculations on current projects only can be very limited and may only be indicative of the minimal potential of the cluster. So instead, we see a coalition as a cluster, possibly with some ongoing projects, but also with the potential for new projects. The value of a coalition is then the present value of all future profits coming from the projects from within the group. This value is comparable to the value of a stock that is also seen as the present value of the future stream of dividends.

This second concept is much more general. While it clearly includes the value of a project if the set of participants coincides with the coalition, it also allows for other projects by subsets of the coalition members. As a special case it includes the profit from singleton projects, that is, from projects that do not need cooperation with other players. On the other hand it does not include the profit of projects that require cooperation with outsiders. The complexity of this approach is also its disadvan-



11 Clusters as coalitions

tage. Just as there may be disagreements about the value of a stock, the value of such a cluster-coalition is also difficult to determine. Especially that the definition of the game requires an exponential number of such valuations.

III.2 About translating clusters into games

Game theory is a branch of mathematics with widespread applications in business and economics as well as many other disciplines from biology to politics. Being a theoretical science its models live not even in sterile laboratories, but in the idealised realm of sets and factorials and Greek letters. Real Life must surely be more complicated! Has such a model anything to do with reality?

We believe, it does. In fact, it is not only us, but the ocean of working applications prove that on the one hand people, but especially companies can very well be modelled by the homo oeconomicus, the selfish man and on the other, that game theory is flexible enough to accommodate small deviations from the standard setups. Is this also the case for clusters? While we are quite optimistic, one has to carefully check and investigate whether the fundamental assumptions of game theory also hold in the setting of industrial clusters.

In the following we outline a set of questions and hypotheses corresponding to these basic assumptions. If these hypotheses are tested to be valid, a rather standard game theoretic approach can be used. If some are found false we may still use the model, but with certain modifications. If many of these assumptions are false, new richer models need to be developed. We must note that this is a very unlikely case and once again point at the numerous applications where the game theoretic approach has already proved itself useful.

In the first group of hypotheses we focus on the fundamentals.

As a first prerequisite we would like to understand what drives clusters, what drives the formation of clusters. We depart from the usual principal-agent approach where the conflict is between the owners and the managers of a company as cluster actors are often too small, owners are often the managers as well. We expect the dichotomy to lie between the profit or value maximising totally rational faceless investor and the entrepreneur who is driven by creativity, by the joy of creating something new and the joy of collaborating with others. We

do not say that the two aspects cannot live along each other, but before going any further we must understand if the cluster is a means to reach a higher profit level, to collect previously unrealised profit or it is perhaps the goal itself.

The motivation for this question is clear. While some clusters kick off with intense cooperation, with very clear goals and objectives, there are clusters founded by friends and schoolmates with the aim of co-operation with old acquaintances hoping that something useful comes out of it – and in the meantime the collaboration is fun, all will enjoy business lunches.

The formation of clusters is supported by national and EU institutions. In extreme cases obtaining this support can be the goal itself. Naturally all clusters must have a project, such clusters have such projects, too, but the realisation would be possible without the formation of the cluster. Such a cluster is clearly about money, so it clearly belongs to the first group, where the aim is maximising profits, and the national or EU support is just one way to realise this.

A company is approached by another company to do a joint project. The offer covers all project-related costs (including standard profit rates to satisfy investors) plus 1% of the remaining profit. Rationally the company should accept the offer since every bit of extra profit is great. In practice, however, the company may be offended by the small share and ask for more or reject it. This example of an ultimatum game illustrates that economic rationality cannot be taken for granted.

Hypothesis 1. Companies join clusters as a homo oeconomicus, with the intention to harvest profits that could not be harvested otherwise. Other factors, such as the joy of creativity and collaboration facilitates this co-operation but only play an auxiliary role and can be expressed in financial terms.

III.3 The bases of decision making: Do actors like profit?

Irrespective of the answer to the first hypothesis we would like to understand the mechanisms that result in a company or other legal entity joining a cluster. We would like to know to what extent can these mechanisms be considered as formal. Do companies use formal protocols before such a decision is made?

The next generation solar panel will be a massive hit: governments provide better and better incentives to reduce energy usage, and on the other hand their high efficiency might mean that installing them will be a profitable decision for many homes and organisations. Several companies and research groups are in the race to come up with the first working model. While there is a lot of uncertainty in the patent race, three things are clear: the company that can file the patents first takes most of the market, the rest may have spent large amounts of money on the research, but most of this has just been wasted, and money can accelerate the research process. So if you put in more money, you are more likely to win, but if you lose nevertheless, you lose more.

This is a lot like the dollar-auction, where a 100-dollar bill is auctioned away, but with the catch that all bids, including losing bids, must be paid. Here the prize is the profit made with the product, while the bids are the research costs. Once one enters the dollar auction, it is difficult to stop. The difference between a winning and a losing bid is just a few dollars so if we compare this with the prize, it is surely worth putting it in. If all actors think this way, however, the bids can go way beyond the 100 dollar figure – we may see this in the research game, too: Once in the patent race companies try to avoid being a close second either by quitting the game early or by outbidding the others.

Our interest in these issues is twofold. On the one hand – related to hypothesis 1 – we would like to understand what drives cluster actors, what are their objectives. On the other hand, in order to use mainstream economic and game theoretic models we must have companies that are rational (in an economic, that is: homo oeconomicus sense), companies that work on maximising their profits and make well-informed decisions with this objective.

If our hypothesis is false, not all is lost, but a formal analysis of strategic decision making would require more complex mathematical apparatus.

Hypothesis 2. Companies take conscious decisions when joining clusters and this decision is just as formal as the decisions when joining any other co-operation.

So what are the pros and cons of joining a cluster. On the one hand actors of a cluster expect profits from projects that would not realise otherwise or from economies of scale or scope realised through the cluster. What are the costs on the other hand? The costs of running a cluster initiative or cluster organisation are not substantial when compared to the possible benefits. Even if all these costs are for nothing, the losses are not severe so however small the probability of realising the foreseeable profits is the benefits outweigh the direct costs. There are however other costs, too. A cluster can only become an incubator for new projects if the actors share confidential business information. The cost here is sharing this information.

One thing that is not clear is how deep the economic analysis of these companies is. Consider a company making funny T-shirts. Creativity is costless so the price of such a T-shirt is really just the cost of the T-shirt (for simplicity we say this is 0) plus an arbitrary markup for the creative design. Suppose this markup is somewhere in the range 1… 00. The company knows that there are many similar shirt-makers around, and they will lose customers unless they sell significantly below the average price, but make as much money as possible. Say, around half of the average price of similar funny T-shirts. How much should it value its creativity? What should we say?

This is a well-known game that has been asked at various audiences, but the patterns are always the same. There are some fifties, twenty-fives,… ones. What is the good answer? Let us say right now that the correct answer is very difficult, as we will see it from the following argument. The naive company will just say: we have no info about other prices yet, so we might as well choose any number. This is the level-0 argument. The level-1 argument is a little more sophisticated: Since no T-shirt can be more expensive than $100, if we want to be among the cheaper half, we should never say more than fifty. Those saying fifty probably think level-1. The level-2 argument goes further. Since nobody will sell for more than $50, we can only be much cheaper than the average if we do not sell for more than $25. But then the argument can be repeated and the level 3–4–5–… arguments claim that one should never sell for more than (rounding the numbers) 13, 7, 4, 2,… 1. If all the companies are fully rational one can only remain competitive if the price is 1. Is this the best way to make profit? Is this how the company makes the most profit? Most likely not. The company choosing this price is clever enough to make such a high-level argument, but fails to realise that not all companies are equally sophisticated. A sophisticated company will realise not only that the argument does not stop at 50, but also that some other companies do not go further. For an accurate answer we must think how sophisticated our competitors may be. This depends on the composition of the decision makers, but for a general crowd 12 may approximately be a good answer (so long as not too many people read this text).

This example illustrates the importance of understanding how sophisticated the actors are. While such a detailed analysis is not necessary a number of simple hypotheses clarify the basic issues.

Hypothesis 3. Companies do a cost-benefit analysis comparing the cost of sharing confidential information with other cluster actors and the foreseeable benefits from the projects.

As a technical detail we would like to understand how companies handle future profit streams. Two aspects are considered. First: the possible sources of income. Clusters are there not only to create a formal environment for current projects and co-operations, but as an incubator for future ideas, for future projects. In fact, clusters are not needed to complete ongoing projects. Do companies understand this difference and include future projects in their cost-benefit analysis?

Hypothesis 4. Cluster actors attach value to projects in the cluster that are not yet realised.

How is this value estimated? On the one hand companies have difficulties even to estimate the value of current projects, how could they have estimates the value of projects they do not even know who are they with or what will the contents be. Such detailed information is difficult to obtain and are superficial. We would, on the other hand understand the long-term expectations of cluster actors: do they expect similar profits from their cluster participation even after the current projects have expired or beyond the current projects? Do they expect less or more? How much less or more? It is important to stress that we do not need to check the validity of these estimates, we only need to understand the information that the companies base their cost-benefit analysis on.

The profit from (present or) future projects does not come at the time of the investment. How is this profit stream aggregated so that it becomes comparable to the costs that occur at the time of the decision? (We realise the future projects will require project-specific investments that are subtracted from the incomes realised at the same time; the profit is the difference of the two that can at times be negative.).

We consider two possible scenarios. Companies base their decisions on predictions for a finite horizon, such as for the coming 3–5 years. For this limited horizon it is still possible to make relatively accurate predictions based on data and models used for "standard" business plans. Longer estimations require additional data and perhaps more refined models, the cost of which outweighs the increased accuracy of predictions.

Ideally, however, and this is the second option, the present value of an infinite income stream should be considered with appropriate discounting. This approach is not only useful mathematically, but is –theoretically- the common practice to calculate the value of a company with publicly held shares or of a real estate. The difficulty lies not only in the estimation of future profits, but also in determining the discount factors. The discount factor can incorporate, besides the devaluation of currency also the decreasing probability that the cluster will exist or that the company is still part of the cluster.

In practice we expect a compromise between the two approaches limiting a horizon, but discounting future profits. How do companies treat future profit streams?

Hypothesis 5. The value of a cluster for a particular company is discounted money-stream within a given time horizon with a discounting reflecting the depreciation of the currency as well as the probability that the project or stream of projects will be discontinued.

Given our hypotheses about the way companies make decisions about clusters we can move on to the decisions about forming a cluster. Some of our hypotheses will likely be false: this will influence our models to some extent, but, as we have indicated earlier already, this does not normally turn our approach invalid.

III.4 Cluster code – structure: Do actors think about present and future alternatives?

In the following we state a number of hypotheses about the *cluster code*. Some clusters do not have a formal *contract*, but operate more on a club-like basis. In such a case by contract we mean a collection of formal and informal agreements that are nevertheless commonly known to the actors of the cluster. In the code we also include the general framework supporting the writing of contracts for projects that do not include all actors of the cluster. Such a framework does not only provide a possible legal aid, but outlines the general principles of the cluster. These principles determine not only the current contracts related to current projects, but form the basis for future contracts related to future projects. In sum, by cluster code we do not necessarily mean a written, legal code, but the de facto standards of behaviour regarding present and future agreements. We must underline the crucial role of the cluster manager in creating and – in the absence of a legal document addressing all issues below – maintaining and enforcing this code.

The first thing we note is that such a code is essentially about the distribution of the profits of the cluster. While the code can specify property rights or hierarchies these all have monetary values and can be expressed as payoffs. This is especially true for the allocation of such rights or duties when applied to future contingencies.

In our first hypotheses in this section we look at the nature of cluster codes. We believe that a project does not start until payoffs are specified for all contingencies. This really means two things: firstly, that companies, when starting a project, realise the possible alternative project outcomes. Put it simply: they realise that the project can be failure producing a loss, a success producing a profit, it can be a huge success producing a profit beyond expectations and at last it may create a benefit even success, but different from the expectations. Does the code specifiy contingencies for all possible outcomes?

Hypothesis 6. The cluster code addresses alternative outcomes.

Note that the alternative outcomes may be due to external, but also internal circumstances or events.

It is also important that the code does not only recognise the alternative outcomes, but that it provides rules for allocating profits (or losses) for all possible states of the world (up to relevance to the cluster). Do actors consider "unlikely" events when making decisions?

Hypothesis 7. The cluster code specifies contingencies for off-equilibrium or non-ideal outcomes too.

Let us stress the importance of Hypothesis 7: If this Hypothesis is not true profit-seeking companies might join a seemingly – for them – disadvantageous cluster expecting a different outcome that, on the other hand, is favourable to them. Instead, companies must see clusters as a full package, making a decision that is rational regarding the entirety of the code.

IV Setting the golden rules

Having clarified the basic framework for decision making and having thereby made the connection to game theory we can now move on to discuss the cooperation-related decisions a cluster actor company must make. Understanding the incentives of the individual companies we can discuss properties of the cluster they constitute. In particular we may be able to translate game theoretic concepts into golden rules of cluster evaluation. As an ultimate goal our model could produce quantitative predictions about a cluster's expected performance or stability.

IV.1 Joining a cluster: Do actors look for profit?

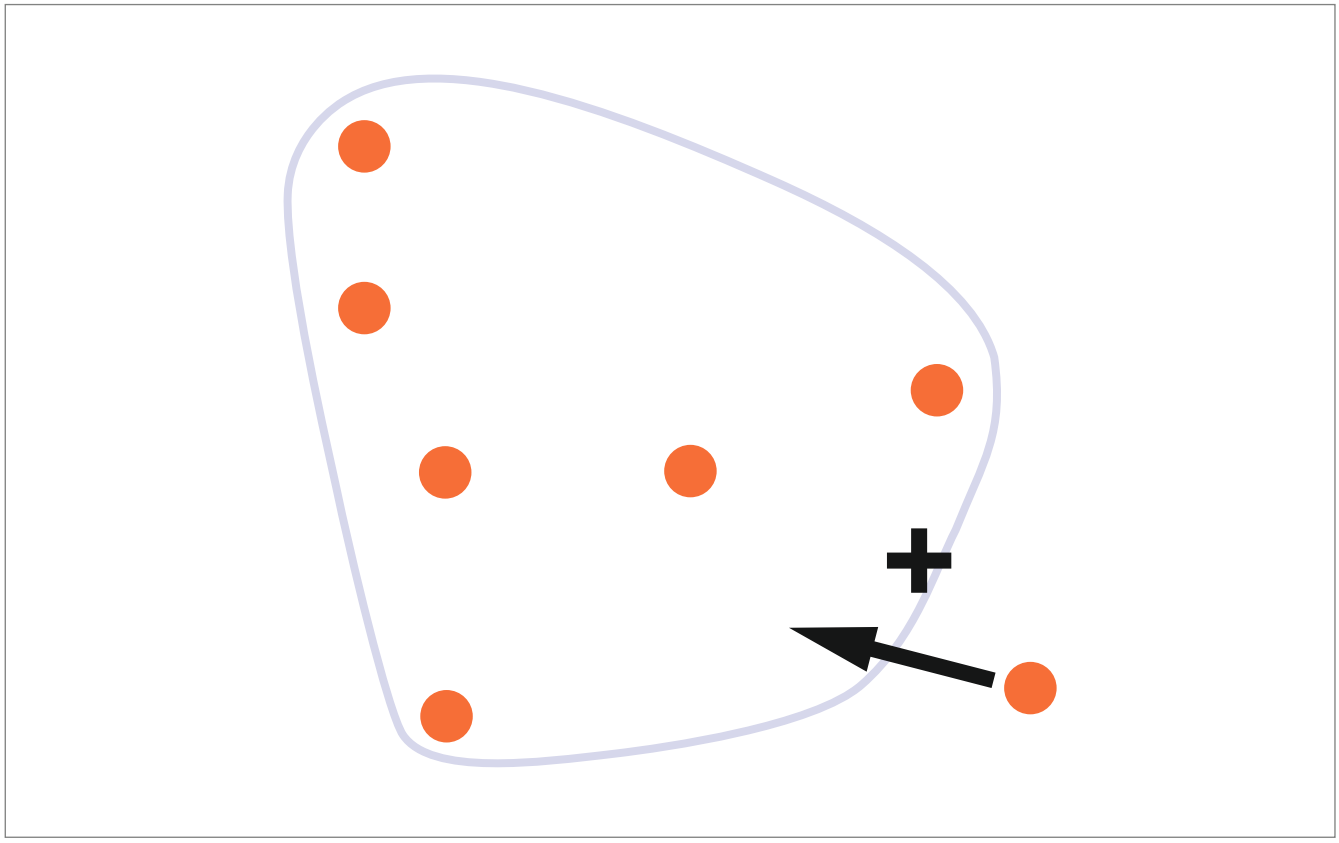
Now that the structure of the cluster code, directly or indirectly specifying payoffs in all world states is given we can move on to the strategic decisions of the companies.

The first property, Hypothesis 8 is very natural. This corresponds to individual rationality in game theory and is a usual precondition for solution concepts.

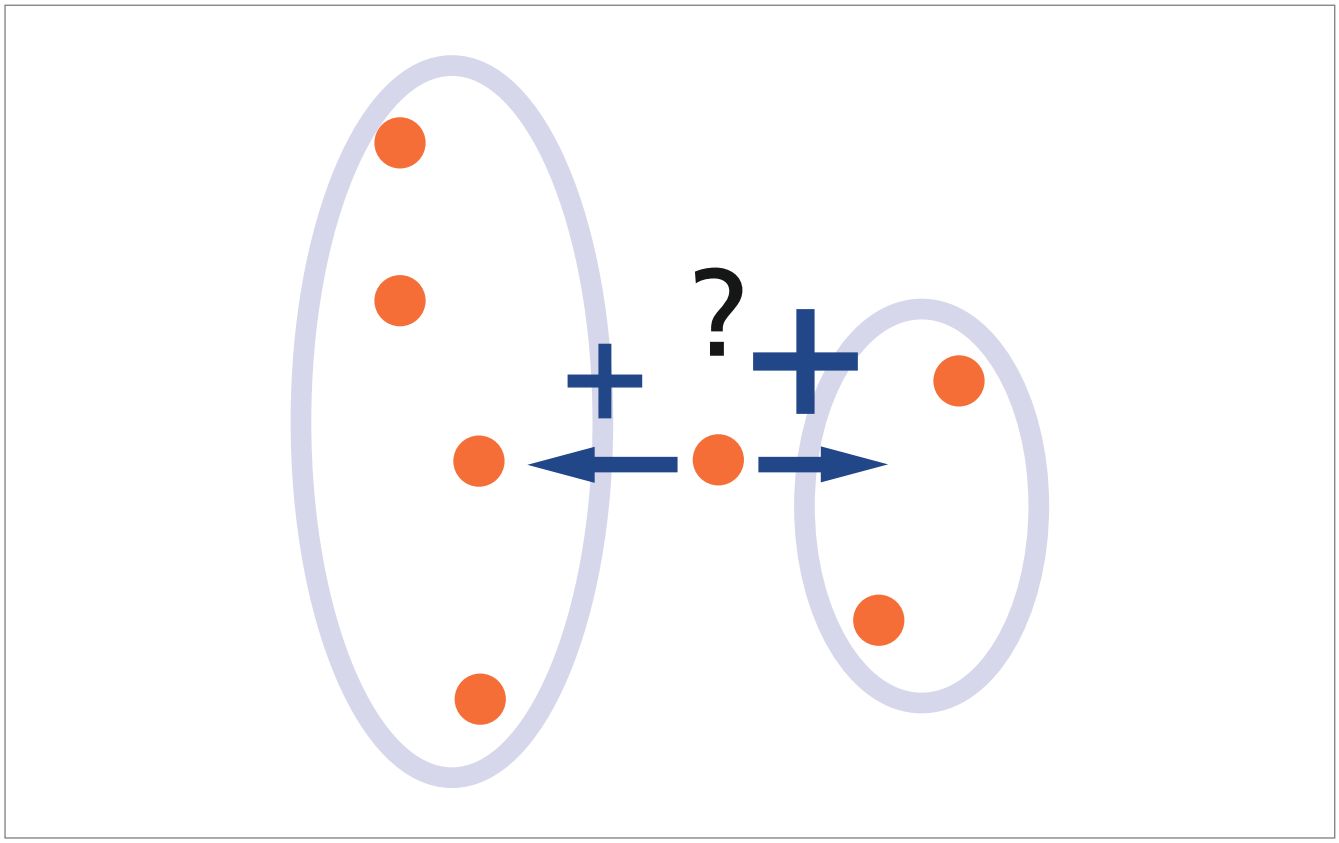
Hypothesis 8. A company only joins a cluster if this brings additional benefits.

While some of the well-known clusters overseas have emerged in an organic way, in Europe it is common to expedite the process with a top-down approach, "creating" a cluster. While we do not want to speculate on the particulars of this process there will be a point when a company makes a decision whether to join a particular cluster and at this point the cluster is either already existing, or is already forming, but already in this latter case the scope of cooperation, the possibilities for joint projects as well as some of the cluster code is known. In sum, the company has some information – however vague – on the prospects with this cluster.

Given that joining a cluster involves some costs, too, one should normally investigate other alternatives. For the moment suppose that a company has the possibility of joining one of two clusters. Of course it should join the one that brings higher profits.



12 Only join a coalition for extra profit



13 Choose the more profitable cluster

Hypothesis 9. If a company has the possibility to join one of two clusters the company will join the one that results in higher payoffs.

Note that in general companies may join more than one cluster and sometimes they do, but this is rare for companies with a profile corresponding to the main profile of the company.

So far our hypotheses are hardly more than concompanyations of standard assumptions or perhaps some elements of a decision making process formalised into a statement. Hypotheses in the following are far less obvious and while the statements are stated as hypotheses, we do not expect that all will be accepted. In any case, we must note that if some of these hypotheses are rejected that can, in itself, have severe consequences for the behaviour of the cluster.

In the aforementioned scenario, where clusters are created in a top-down approach companies rarely have possibility to consider joining more than one cluster. A typical company will be invited to some meeting with the prospect of joining a cluster whose code is either already clear or is shaping up. Yet, a rational company should, before joining a cluster, do a full analysis of its options. By Hypothesis 8 it should only join a cluster that brings additional benefits. The following statement adds a more general condition regarding the choice among multiple clusters.

Hypothesis 10. A company should join the most profitable of all available clusters.

This property is known as coalitional rationality. It has two direct implications that are corollaries of this hypothesis, but, to be more explicit about these, we state them as separate hypotheses:

Hypothesis 10a. A company should leave the cluster if a more attractive participation offer becomes available in another cluster.

The word "leave" is to be used with care: being an actor of a cluster means that there are rights and obligations. The code of the cluster, by Hypothesis 7 specifies these for the event of departure, too. Once joined the cluster, a company must take the possible punishments into account when contemplating on the departure. The more common use of "leave" – and this is our understanding – is before joining the cluster, so it is more about leaving the negotiations. Here no commitment has yet been made, so a company will naturally be attracted by the more advantageous terms.

This is also true if the better offer comes from within the cluster. Indeed, most clusters have far more actors than a typical project requires and therefore a cluster consisting of only part of the actors of the original cluster (for a clear distinction we call the smaller cluster *subcluster*) would typically be a profitable cluster, too. While one often thinks that the whole is more than the two parts, crowding effects or the higher costs of managing a larger organisation creates real life situations where the part may be more successful.[2] In game theoretic terms we say that the game is not necessarily *superadditive*, that is, adding up parts does not necessarily create additional value.

Hypothesis 10b. A company only joins a cluster if none of the subclusters offer better prospects.

IV.2 Cluster code: How to keep all cluster actors happy at the same time?

In section IV.3 we have looked at the structure or "shape" of the cluster code. Now that the basis on which the companies joining decisions are made have been clarified we return to the cluster code, more precisely the distribution of the cluster benefits.

It is clear that there is no point in setting up a code that is not acceptable to the actors. If the cluster cannot provide better prospects than other clusters or its subclusters, some of its foreseen actors will not join.

We must handle two problems (corresponding to Hypotheses 10a and 10b) separately: *External threats* are somewhat more difficult to study as the threat is often not even on the map, but on the other hand the general industrial organisation (IO) literature already addresses the issues of competition between companies. The competition for a particular cluster actor is, to a great extent an issue of competition among substitutes, that is, companies that offer similar products or services. In our context the complementarity comes in the form of clusters being able to cooperate and produce profits with a given company.

In the following we look at the *internal threats*, that is, internal conflicts of interests that may destabilise the cluster. Ultimately we want to understand what makes a cluster stable against such destabilising forces.

As a minimal requirement the cluster must be more valuable than its parts put together (superadditivity at the top level is called *cohesiveness*), but, as we will see this is not sufficient, the game defined from the problem must also be *balanced* (Bondareva, 1963; Shapley, 1967). First we state a natural condition that corresponds to *coalitional rationality* in game theory and that defines the *core*.

Hypothesis 11. The code of a cluster ensures that the gain of any subcluster exceeds its profit as an independent cluster.

A few notes regarding this hypothesis. Firstly, it is important to emphasize that a subcluster does not need to secede or even organise itself to start a protest to get its share. Getting as much as it can obtain on its own is a right that must be respected by all parties to facilitate cooperation. This is a bit like a seat on an airplane: it is very rare that someone else takes our seat as such an action would usually lead to a conflict where he or she must give up the seat anyway. The same holds here. No fights are required as the rights are respected. A good cluster manager can ensure that the allocation of the profits is such that the conflict will never arise. To do this the cluster manager must be very familiar with the companies' potentials for cooperation.

Secondly this innocent condition is actually a family of a huge number of conditions for a typical sized cluster. The number of possible subclusters grows exponentially with the number of cluster actors: the addition of a single cluster actor doubles the number of conditions. Can so many, to a great extent conflicting conditions be simultaneously satisfied? Clearly, if the overall gains are less than the total gains of some non-overlapping subclusters (a partition of the cluster actors) this is not possible. Unfortunately there are cases when the gains of the cluster by far exceed the gains of such non-overlapping subclusters and still the ideal, stable allocation of the cluster profit is not possible, or in game theoretic terms: the core is empty.

Even if the core is non-empty not all allocations are ideal. Can such a cluster be saved from falling apart? The good news is that it can be. A series of carefully orchestrated changes in the code of the cluster will always lead to a stable allocation (a so-called imputation in the core), moreover the number of such changes is only proportional with the number of cluster actors and not the conditions in Hypothesis 11 (Béal, Durieu, & Solal, 2008; Béal, Rémila, & Solal, 2010; Kóczy, 2006; Kóczy & Lauwers, 2004; Yang, 2010).

[2] Let us already indicate distribuitional effects too: the whole may be more than the parts, but if the gains cannot be distributed in a mutually satisfactory way cooperation may break down.

IV.3 Social networks: How do projects form?

The expression "social network" is now widely associated with Web 2.0 sites and especially social networking sites. When we think of social networks and business we tend to associate to new websites – the development of the world wide web into this direction has very quickly dominated the original concept of social networks. While today we tend to see social networks as a way teenagers waste their youth although *networking* came way before the social networking sites or even the whole world wide web.

Networking is to build contacts for a possible future cooperation. Indeed, a cooperation is only possible if the parties know each other. Of course we do not talk about cooperation that is limited to putting together a product of the parts some cluster actors produce, but of projects where know-how, experience and business ideas are shared to achieve a better product. The underlying social or communication network also determines the cooperation possibilities for the cluster. Only connected projects are possible: projects where any two participants can be connected by a series of acquaintances. It is natural to extend this idea to clusters and subclusters: if a cluster consists of more than one component that are not connected to each other no joint projects will be possible, so having these components in a common cluster does not bring additional benefits.

Hypothesis 12. A (sub)cluster must be connected: Any other actor must be a friend's friend's… friend.

We realise that a cluster may also be successful as a club in helping actors to new acquaintances this being possibly the most direct way to obtain more than the parts put together. We do not want to underplay the importance of new friendships, but due to their uncertainty (we do not know who will be our next friend, even), the companies' decisions in joining one or another cluster cannot be made on the basis of these possible connections. Once these possible connections are realised the network of connections must be redrawn.

If Hypothesis 12 is found to be true we must slightly modify the evaluation of the cluster. Not all subclusters can form, rather: typically most cannot form as most are not connected. We can still consider our previous model, where the connections are ignored by simply setting the value of impossible subclusters to zero making them unattractive. In other words, actors of impossible clusters will never be unsatisfied as a group about the allocation of profits in a cluster. With this change the very same approach can be used as when the network of connections is ignored.

V Hypothesis testing

We have stated a dozen hypotheses about the way clusters operate (Hypotheses 1–12). In Section I we have given an extensive overview of the literature of cluster evaluation. One would rightly expect that such an amount of literature will answer some of our points. Our approach is, however rather novel focusing on the individual companies' incentives and decision making mechanisms that are quite different from the usual data that are more statistical in nature.

We have made every effort to answer these questions using our expertise in clusters and in game theory, but in the absence of an empirical investigation our conclusions remain just speculations. In the following, however we outline how the missing information could be obtained.

V.1 Fundamentals of decision making

We must, first of all understand if the cluster actors make decisions along the rationality principles we have outlined in the first set of hypotheses (Hypotheses 1–7). This requires a detailed insight into the decision mechanisms of cluster actors as well as the organisation and code of the cluster. We see two methods to collect such information.

Firstly we need to conduct *interviews* with the cluster actors' decision makers and the cluster manager. The interviews would follow a formal protocol, and with the help of economic psychologists the answers would be collected in an indirect way. Direct questions would not necessarily result in answers corresponding to the reality: when asked, whether they make sensible, economically well-founded decision mechanisms companies would be inclined to say yes even if this is not the case just to draw a better image of themselves.

Out second method would draw on the methods of experimental economists. We would like to conduct simple laboratory experiments to find out the motives of the decision makers. An economic experiment is conducted in a computer laboratory consisting of a server and a collection of workstations. Participants make decisions using this computer interface, and depending on the participants' decisions the rules of the game determine the individual payoffs. This setup has been introduced relatively recently and it is only the last few years that experimental economics grew into a fully recognised discipline. One of the reasons might be that the results are often surprising, demonstrating that culture and morals.

As a simple example consider the so-called *ultimatum game*. This game is about sharing a fixed sum, such as €100. The first player can propose a division, the second player can either accept or reject this. If the second player accepts, the division is final and the players get the corresponding sums as payoffs. If the second player rejects, the players get nothing. A rational second player focussing only on the payoffs should always accept the proposal, even if she is only offered €1 as this is still more than nothing. In a laboratory the parties are randomly matched out of the 12–20 participants so that the first player cannot be identified (and also the first player does not know the identity of the second player) and therefore personal ties, reputational issues should not play a role. In practice, however such an offer is rarely accepted, even offers close to the 50–50 distribution are sometimes turned down suggesting that second players are willing to incur costs in punishing in what they see as a deviant behaviour. Interestingly, a series of experiments have found that cultural aspects play a crucial role in determining what an acceptable proposal is: in cultures with a high degree of self reliance only little transfer is expected, while in societies where cooperation is essential for survival players may allow only a smaller share to be kept by the proposer.

The ultimatum game is, of course, just a simple example, but such simple games give us information about the way participants make their decisions. Of course hundreds of experiments have already been conducted, but these experiments typically involve undergraduate economics students with fresh memories of their game theory courses. The main reason for this is that research is typically conducted at universities where students are – thanks to the financial compensation – readily available. The second is that research budgets are always too tight so that the financial compensation offered in an experiment is less attractive to businessmen. This of course limits the applicability of those experimental results to our hypotheses requiring new experiments.

V.2 Profitability

While the questionnaires and experiments help us to gain general information about decision making in clusters, the second group of data is cluster-specific. Ideally we would like to have a figure for the cluster and all its subclusters that describe its profitability. This is an enormous amount of information that are not only sensitive data, but most likely this information is not at all available. In practice we do not need precise data, we need the profitability of the different subclusters, as perceived by the potential actors. In other words, we do not need to

conduct extensive economic analyses for all the (exponential number of) subclusters, but only approximate figures, as seen by the companies.

We are considering several possible methods to obtain relevant data realising that the cluster actors may or may not be too keen to spend time on such studies, but the details are still open for further research.

V.3 Networks

At last, for an analysis that takes the social or economic network within the cluster into account, we must have information about such links. We see 3 ways to gather such data. Firstly, when trying to obtain the value of subclusters, their actors might simply respond that they do not know these people and therefore cannot give an estimate of the value or profitability of that cluster. In practice, however, it is unlikely that such detailed information is available, the value of the clusters must be estimated in some other way, which takes us to the other two options.

A well-managed cluster is likely to have detailed and well documented information about past instances of cooperation as well as past business transactions. It may also have information on how the various cluster actors got involved, perhaps via other cluster actors. This is "hard" information on business relations and is informative not only about the existence of economic links, but also the intensity of these links.

At last, one may resort to questionnaires and interviews asking about business partners, although such "soft" information is more likely to be imprecise and incomplete and companies are likely to be reluctant to share such valuable information.

V.4 Conclusions on the data

Our aim is to study the micro-level incentives and therefore we need micro-level data. The incentives we uncover determine the internal stability of the cluster. The quantity and nature of the data needed for the game-theoretic analysis is therefore quite different from the usual benchmark-based evaluation of clusters. This does not necessarily mean that we must throw away single-number parameters. Once we get a deeper understanding of, for instance, the usual structure of the network of connections within a cluster, we can simulate similar networks and discover correspondences between the size of the cluster in terms of actors, the number of "friends" the average actor has. On the other hand there may be a (negative) correlation between the number of friends for the average actor and the geographical dispersion of the cluster. Unfortunately, to make use of such, readily available indicators one has to explore the relations with the more detailed data.

VI Conclusion

What does the game theoretic approach contribute to the understanding of clusters? In economics game theory has brought a complete renewal beginning in the 1950s. While earlier models focussed on profit maximisation and other – otherwise valid – arguments, ignored the obvious fact, namely that the interactions are, after all, driven by the individual actors, players, who will play according to the rules and incentives. By understanding the incentives of the individuals better we understand the nature of interactions: in this case the efforts put into the cluster better.

Our model is not omnipotent. Just as microeconomics must use demand and production functions we also need a lot of information and game theory cannot tell the prospects of a cooperation. Whether a product is good or bad, or how the economic climate might change in the near future are questions that are beyond our model.

But after testing of the hypotheses our model will present the possibility to identify such kind of regularity which will help all the cluster actors (policy makers, cluster managers, cluster actors…) to recognize better and sooner not only the risks regarding cluster operation but the methods how we can reduce these risks as well. We do hope that with the help of the game theory the cluster actors after weighing the opportunities up will be able to make rational decisions.

Our results will be also useful for training cluster managers so that the cluster manager him/herself shall help the operation of the cluster as a real "quizmaster" to reduce the recognizable risks, to initiate new projects, to support the implementation of the projects and last but not least to increase the "value" of the cluster in the actors' eyes.

They will also be useful for training cluster actors so that they will be ready to make a rational evaluation on one hand on their own value among the cluster actors cooperating in the cluster organisation and on the other hand on the cluster actors as well. They get to know the motives for the real co-operation and they can prepare themselves for the risks too. Being in possession of this information they will be able to make an established decision on what is the cluster worth and how they can use the co-operation within the cluster to increase their own profit.

For policy makers and organisations in some form or other interested in cluster support giving them more clear picture about the operation and risks of the cluster operation which helps to subsidize the clusters' development more effective and purposeful.

We do believe that the game theory can seriously influence the research regarding clusters, networks and other co-operations among companies. We must admit that in using our game theoretic approach for real-life clusters might have some practical difficulties might arise. We believe that these difficulties may be overcome and the benefit is a model that could show us the best way to maximize the outcome of our all investment as a cluster actor.

VII Bibliography

Boekholt, P. (1997). Innovative Networks in Regional Economies: Enhancing Infrastructures for Technology Creation and Transfer. In J. Mitra & P. Formica (Eds.), *Innovation and Economic Development, University-Enterprise Partnerships in Action* (pp. 119–137). Dublin: Oak Tree Press.

Bondareva, O. N. (1963). Some Applications of Linear Programming Methods to the Theory of Cooperative Games. *Problemy Kybernetiki*, *10*, 119–139.

Borm, P., Owen, G., & Tijs, S. (1992). On the Position Value for Communication Situations. *SIAM Journal on Discrete Mathematics*, *5*(3), 305. doi:10.1137/0405023

Braun, P., McRae-Williams, P., & Lowe, J. (2005). Small Business Clustering: Accessing Knowledge through Local Networks. *Journal of New Business Ideas & Trends*, *3*(2), 57–63.

Bryant, K., & Wells, A. (1998). A New School of Thought. In A. Wells (Ed.), *A New Economic Paradigm? Innovation-based Evolutionary Systems* (Vol. Discussion, pp. 1–4). Canberra: Dept. Industry Sciencer and Resources, Commonwealth of Australia.

Béal, S., Durieu, J., & Solal, P. (2008). Farsighted coalitional stability in TU-games. *Mathematical Social Sciences*, *56*(3), 303–313. doi:10.1016/j.mathsocsci.2008.06.003

Béal, S., Rémila, E., & Solal, P. (2010). On the number of blocks required to access the core.

Dubey, P. (1975). On the uniqueness of the Shapley value. *International Journal of Game Theory*, *4*(3), 131–139. doi:10.1007/BF01780630

Enright, M. J. (2000). The Globalization of Competition and the Localization of Competitive Advantage: Policies towards Regional Clustering. In S. Young (Ed.), *The Globalization of Multinational Enterprise Activity and Economic Development* (pp. 303–326). Houndsmill, Great Britain: Macmillan.

European Cluster Conference. (2012). Vienna Cluster Manifesto: Using excellent clusters to strengthen and restructure EU industry. Vienna.

Fukuyama, F. (1995). *Trust: Social Virtues and the Creation of Prosperity*. New York: The Free Press.

Fukuyama, F. (1999). *The Great disruption: Human Nature and the Reconstitution of Social Order*. London: Profile Books.

Gillies, D. B. (1959). Solutions to general non-zero-sum games. In A. W. Tucker & R. D. Luce (Eds.), *Contributions to the Theory of Games* (Vol. IV, pp. 47–85). Princeton: Princeton University Press.

Harrison, B. (1992). Industrial districts: old wine in new bottles. *Regional Studies*, *26*(5), 469–483.

Herings, P. J.-J., van der Laan, G., & Talman, D. (2005). The positional power of nodes in digraphs. *Social Choice and Welfare*, *24*(3), 439–454. Retrieved from http://www.springerlink.com/index/G18873X86K423L53.pdf

Jacobs, D., & De Man, A. P. (1996). Clusters, industrial policy and firm strategy: a menu approach. *Technology Analysis and Strategic Management*, *8*(4), 425–437.

Ketels, C. H. M. (2004). European Clusters. *Innovative City and Business Regions* (Vol. 3 Structur, pp. 1–5). Bollschweil, Germany: Hagbarth Publications. Retrieved from http://www.isc.hbs.edu/pdf/Ketels_European_Clusters_2004.pdf

Ketels, C. H. M., & Sölvell, Ö. (2004). *State of the Region Report 2004: Competitiveness in the Baltic Sea Region* (p. 38). Copenhagen & Stockholm. Retrieved from http://www.isc.hbs.edu/pdf/Baltic_Assessment_2004.pdf

Kóczy, L. Á. (2006). The Core can be Accessed with a Bounded Number of Blocks. *Journal of Mathematical Economics*, *43*(1), 56–64. doi:10.1016/j.jmateco.2006.09.002

Kóczy, L. Á., & Lauwers, L. (2004). The Coalition Structure Core is Accessible. *Games and Economic Behavior*, *48*, 86–93. doi:10.1016/j.geb.2003.06.006

Kóczy, L. Á., & Lauwers, L. (2007). The Minimal Dominant Set is a Non-Empty Core-Extension. *Games and Economic Behavior*, *61*(2), 277–298.

Leana, C., & Buren, H. (1999). Organizational social capital and employment practices. *The Academy of Management Review*, *24*(3), 538–556.

Littlechild, S. C., & Thompson, G. F. (1977). Aircraft landing fees: a game theory approach. *The Bell Journal of Economics*, *8*(1), 186–204. doi:10.2307/3003493

Lämmer-Gamp, T., Meier zu Köcker, G., & Christensen, T. A. (2011). *Clusters Are Individuals: Creating Economic Growth through Cluster Policies for Cluster Management Excellence* (p. 160). Berlin. Retrieved from http://files.conferencemanager.dk/medialibrary/f13db635-416d-4cbc-a465-78f2ff8796c6/images/Clusters_are_Individuals_NGP_Cluster_Excellence_project_final_report_DOK1952344_DOC.pdf

Marshall, A. (1890). *Principles of Economics* (Vol. 1). London: Macmillan.

McRae-Williams, P. (2004). Cluster strength and structure: How does this impact on the complementarity of a regions wine and tourism industries? *Creating Tourism Knowledge – CAUTHE 14th International Conference for the Council for Australian University Tourism and Hospitality Education* (p. 8). Ballarat. Retrieved from http://researchonline.ballarat.edu.au:8080/vital/access/services/Download/vital:1476/DS1?view=true

Meier zu Köcker, G., & Kind, S. (2012). Measuring effects and impacts of clusters and networks – But how? Evaluation and impact approaches clusters and networks. *Tactics Reflection Group meeting, Brussels, 15 March 2012*. Brussels.

Michael, E. J. (2003). Tourism micro-clusters. *Tourism Economics*, *9*(2), 13. doi:10.5367/000000003101298312

Nahapiet, J., & Ghoshal, S. (1998). Social Capital, Intellectual Capital, and the Organizational Advantage. *The Academy of Management Review*, *23*(2), 242–266. Retrieved from http://www.jstor.org/stable/259373

Nash, J. F. (1950). Equilibrium points in n-person games. *Proceedings of the National Academy of Sciences of the United States of America*, *36*, 48–49. Retrieved from http://www.jstor.org/stable/88031

Nash, J. F. (1953). Two-person cooperative games. *Econometrica*, *21*, 128–140. Retrieved from http://www.jstor.org/stable/1906951

Neyman, a. (1989). Uniqueness of the Shapley value. *Games and Economic Behavior*, *1*, 116–118. doi:10.1016/0899-8256(89)90008-0

Porter, M. E. (1990). *The competitive advantage of nations*. New York: The Free Press.

Porter, M. E. (1998). Clusters and the New Economics of Competition. *Harvard Business Review*, (November-December), 77–90.

Putnam, R. (2000). *Bowling Alone: The Collapse and Revival of American Community*. New York: Simon and Schuster.

Rosenfeld, S. A. (1997). Bringing Business Clusters into the Mainstream of Economic Development. *European Planning Studies*, *5*(1), 3–23.

Rosenfeld, S. A. (2001). Backing into Clusters: Retrofitting Public Policies. *Intergrating Pressures: Lessions from Around the World, John F. Kennedy School Symposium*. Harvard University.

Shapley, L. S. (1953). A Value for n-Person Games. In H. W. Kuhn & A. W. Tucker (Eds.), *Contributions to the Theory of Games* (Vol. II, pp. 307–317). Princeton University Press.

Shapley, L. S. (1967). On Balanced Sets and Cores. *Naval Research Logistics Quarterly*, *14*(4), 453–460. doi:10.1002/nav.3800140404

Shapley, L. S. (1971). Cores of convex games. *International Journal of Game Theory*, *1*(1), 11–26. Retrieved from http://www.springerlink.com/index/L6026427V776N535.pdf

Shubik, M., & Wooders, M. H. (1983). Approximate cores of replica games and economies. Part I: Replica games, externalities, and approximate cores. *Mathematical Social Sciences*, *6*, 27–48.

Straffin, P. D., & Heaney, J. P. (1981). Game theory and the tennessee valley authority. *International Journal of Game Theory*, *10*(1), 35–43. doi:10.1007/BF01770069

Strauss, J. R. (2010). Capitalising on the value in relationships: A social capital-based model for non-profit public relations. *PRism*, *7*(2). Retrieved from http://www.prism-journal.org/fileadmin/Praxis/Files/Journal_Files/Strauss.pdf

Verbeek, H. (1999). *Innovative Clusters: Identification of value-adding production chains and their networks of innovation, an international study*. Erasmus University, Rotterdam.

Watson, G. W., & Papamarcos, S. D. (2002). Social capital and organizational commitment. *Journal of Business and Psychology*, *16*(4), 537–552. doi:10.1023/A:1015498101372

Wikipedia contributors. (2012). Alfred Marshall. *Wikipedia*. Retrieved from http://en.wikipedia.org/wiki/Alfred_Marshall

Yang, Y.-Y. (2010). On the accessibility of the core. *Games and Economic Behavior*, *69*(1), 194 – 199. Retrieved from http://ideas.repec.org/a/eee/gamebe/v69y2010i1p194-199.html

Zaratiegui, J. M. (2002). *Alfred Marshall y la teoría económica del empresario*. Valladolid: Universidad de Valladolid, Secretariado de Publicaciones. Retrieved from http://dspace.unav.es/dspace/handle/10171/6115

von Neumann, J., & Morgenstern, O. (1944). *Theory of Games and Economic Behavior*. Princeton: Princeton University Press.

VIII Authors

Dr Zita Zombori

She is working now at the Chemical Works of Gedeon Richter Plc. She is responsible for the European Affairs, among others for the transnational cooperation aiming to strengthen Richter's position as innovation leader. Between 2008 and 2010 she headed the Hungarian Pole Program Office. The Program aimed to create a favourable business environment in the regional capitals in addition to the Hungarian Cluster Initiative. Before joining the Pole Program Office she held various positions in the Ministry of Local Government and Regional Development, the National Development Agency and at an intermediary body for Structural Funds resources. She has an established track-record of 15 years at the Hungarian Privatization and State Holding Company and at its predecessors. Her main projects included privatization and stock and bond issue processes of major Hungarian companies in the oil and gas, telecommunication, logistics and pharmaceutical sector among others.

She is a member of the TACTICS Reflection Group and she is involved in several European projects as well. She is also acting as a key expert to Polish Working Group on Cluster Policy. She is designated member of German Cluster Excellence Initiative's Advisory Board "go-cluster".

Endre Gedai

He is "Integrator", graduate engineer, expert of companies and of companies' cooperation.

His practical experience in corporate finance had been acquired between 1990 and 1994 in bank financing and from 1994 to 1998 as managing director of a venture capital company. From 1998 he had been acting as deputy managing director at the Hungarian Privatization and State Holding Company and as a member of more Boards and Supervisory Boards he had got practical experience in corporate management. From 2007 as colleague of the Hungarian Pole Program Office he has been dealing with the theoretical and practical research of clusters and he had taken part in the elaboration of the Hungarian cluster development model.

Dr László Á. Kóczy

Graduated from Cambridge he obtained his PhD at the Catholic University Leuven. Taught at Maastricht and Óbuda Universities, currently he is leading the Game Theory Research Group at the Research Centre for Economic and Regional Sciences, Hungarian Academy of Sciences, supported by the prestigeous Momentum Programme. He is a specialist in theoretical and applied game theory, especially cooperative games with externalities, industrial organization, social choice and scientometrics. He published over 15 academic papers attracting over 100 citations.

INSTITUTE FOR
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TECHNOLOGY

The Institute for Innovation and Technology (iit) covers the entire innovation spectrum on a national and transnational level. Its fundamental elements are the provision of assistance, analysis, evaluation, moderation and the accompaniment of innovative systems and clusters. Its departments provide the basis for these services and are as follows: Innovation Systems and Clusters, Innovation Support, Predicting Success of Collaborate R&D Projects, Safety and Security Systems, Innovation Life Sciences, Evaluation in the area of technology and innovation policy as well as Technical Education and Training.

More than 70 scientific employees are part of the team and contribute their technological and socio-economic expertise to project management. Their competencies range from diverse natural sciences, engineering and social sciences to economics.

Countries all over the world look for ways to increase their competitiveness. The contribution of cooperating companies in the form of clusters is rather substantial and therefore, for example, the European Union and its member states have long been supporting these cooperative efforts. This support may take the form of a more entrepreneur-friendly legal environment, initiate cooperation, but it may also mean non-returnable financial contribution.

This paper introduces an entirely novel way to study clusters by looking at the selfish, profit-seeking interests of the entrepreneurs, the actors of clusters. The approach, using game theory provides an exact, mathematical framework to study the conflict between the fruitful cooperation represented by the cluster and the selfish ways of the actors to follow their own – possibly short term – interests. The game theoretic approach makes it possible to identify not only good or bad clusters, provide recipes for solutions in some of the bad clusters, but also to define golden rules that do not only facilitate the evaluation of existing clusters, but help future cluster managers to create better, more stable clusters.