



HAL
open science

The contribution of game theory to the territorial intelligence Illustration from a case

Michel Carrard

► **To cite this version:**

Michel Carrard. The contribution of game theory to the territorial intelligence Illustration from a case. 2022. hal-03772665

HAL Id: hal-03772665

<https://hal.science/hal-03772665v1>

Preprint submitted on 8 Sep 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

The contribution of game theory to the territorial intelligence

Illustration from a case

Michel CARRARD

Research Associate

National School of Engineering, Bourges

RESO-UMR 6590 National Centre for Scientific Research, Rennes 2 University

Passed the aggregation in Economics and Management

PhD in town and country planning

Michel.carrard@ensi-bourges.fr, 02 48 48 40 67

Professional address:

ENSI de Bourges – 88, Boulevard Lahitolle, 18020 Bourges cedex

Summary: Defining precisely one's choices and methodological objectives is required when using game theory. Moreover, the proximity between certain game theory concepts and those of a future-oriented approach, has allowed a futurist reading of the results of this study.

Résumé : L'utilisation de la théorie des jeux sur des problématiques territoriales nécessite de définir précisément les choix et les objectifs méthodologiques. En outre, la proximité entre certains concepts de la théorie des jeux et ceux de la prospective permet une lecture prospective des résultats obtenus.

Keywords: Notre-Dame-des-Landes airport, Nantes, Rennes, town and country planning, reflexive modelling, future oriented approach, game theory.

Mots clés : aéroport Notre-Dame-des-Landes, Nantes, Rennes, aménagement, modélisation réflexive, prospective, théorie des jeux.

The transfer of Nantes Atlantique airport on the Notre Dame-des-Landes site (NDDL)¹, in 2015, will change the equilibrium in air airport in the Great West. Communities, in particular, will have to reflect on the status of the future airport. Two options were discussed during the Public Debate. The first, submitted by the state, (the project developer), is that NDDL will become the airport of the Great West². The difficulty, as the chairman of the Public Debate pointed out, is that the notion is vague and raises the question of the fate of the other existing airports. In the face of these difficulties, a second option was submitted that will make of NDDL the largest airport in the west³.

These two projects relate to conflicting territorial dynamics. The project of making of NDDL the largest airport in the West sticks to the existing pattern in which airport competition is a consequence of territorial competition. The predominance of NDDL airport would result from a trade war between the different platforms and would therefore be imposed on other communities. Conversely, the project of making of NDDL airport the largest airport in the west shows a break by introducing the prospect of coordinated airport strategies. The airport would become a public good that would enhance the attractiveness of the two regional areas (Brittany and Pays de la Loire). Thus, depending on the choice for either option, NDDL airport may fuel metropolitan rivalries or become "a unifying project on the Great West scale" (Committee of inquiry, 2007). Whatever conjectures can be made, the status of the future airport will be the result of interactional processes and complex decision making between communities. Game theory that describes how rational individuals behave in situations of interdependence was used to analyse the impact of NDDL airport on the future relationships between Nantes and Rennes⁴. This choice, however, raises several methodological questions. The objective of this contribution is to present the principles of a methodological work that has mobilized the resources of this discipline to illuminate a town and country planning issue (Carrard 2009).

First, we will introduce the concept of reflexive modelling from which we carried out this study. Then we will recall the proximity between the concepts of game theory and those of a future oriented approach. Futurist reading has thus been attached to the results of this work. Finally, we will illustrate our point from the "community game" developed in this work.

I) Game theory and town and country planning

Game theory allows to describe and analyze the interactions between players in the form of strategic games (Pénard, 2004). It has grown considerably since the publication in 1944 of "Theory of Games and Economic Behaviour" co-written by John Von Newman and Oskar Morgensstern. Economists were the first to appropriate this tool then researchers from many disciplines followed suit. Paradoxically, game theory is still used very little on issues of town and country planning. This is all the more curious since these issues are often closely related to those of the interdependence of actors and the strategic problems it poses. In what follows, we will show that the use of game theory on territorial issues is possible provided the criticisms it is generally subject to are taken into account. (Fischer, 1989, Thépot, 1998, Guerrien, 2002).

1) Objections made to game theory

Two types of objections are made to the use of game theory to analyze real situations. The first is about the ability of game theory to describe reality as its formalism is too restrictive to take the complexity of reality into account. The second is that game theory does not "claim to say what is", because the assumptions of its models are too simplistic. Thus, for example, the assumption of unlimited and one-dimensional rationality that considers that individuals whose only goal is to maximize their gains, are capable of assessing all possible present and future outcomes of a situation. Besides, many cases have no equilibrium or, on the opposite, show a multitude of equilibriums. Each

¹ Article 1 of decree, JO issue 35, February 10, 2018, corrected in JO issue 40, February 16, 2008.

² The website dedicated to the project is entitled "Project of Airport in the Great West - Notre Dame des-Landes ". In addition, the declaration of public utility of February 9, 2008, retains the same name in its articles 1 and 2

³ In his concluding report, chairman Bergougnot noted: Failing to be the airport of the Great West, a concept all the more fuzzy as no closure of any existing airport was planned, NDDL, could be the largest airport in the West" (CPDP-NDDL, 2003, p. 82)

⁴ This study was backed by the Agency for the Planning and joint Development of Greater Rennes (AUDIAR).

time there is the problem of indeterminacy of the game outcome. In the end, the distance between the boundaries of game theory and the complexity of actual situations significantly reduces its ability to help in decision making.

2) *Choosing a method: reflexive modelling*

Faced with these criticisms, some theorists point out that game theory does not have to be prescriptive and that it does not endorse any behaviour or favour any strategy (Aumann, 1987). It essentially limits itself to identifying the logical consequences of the players' decisions. In this context, Jacques Thépot believes that game theory offers a different perspective of work he calls reflexive modelling (Thépot, 1998, p. 8 and following). The latter "claims it acts further upstream on the mental representation from which the decision maker structures his schematic vision of reality". This mental representation refers to the decision maker's ideas, his beliefs, his a priori, and his experiences. This concept is totally subjective. Moreover, unlike normative modelling that produces a decision by attempting to represent reality, reflexive modelling is oriented towards the decision maker and sets itself the objective of extracting from the real "a few stylized facts from which other stylized facts are inferred, by using simple models of game theory which will be submitted to the discretion of the decision maker".

Reflexive modelling allows game theory to describe and analyze real situations. This concept provides an objective as well as a methodology of work. It provides an objective since this type of modelling does not claim to replace the decision maker or to provide him with a ready for use solution (Thépot, 1995) but to help him to clarify his strategic choices. The aim is then less to determine the existence of solutions than to clarify the nature of the difficulties to reach them (coordination problems, conflicts of interest, impasses in cooperation, reputation effects, etc...). Reflexive modelling provides a methodology as this approach claims to describe only the nature of the strategic interactions of players so as to draw logical implications and consequences.

Reflexive modelling thus allows to address real situations that are significantly more complex than the games presented in textbooks. It is more a practice of game theory than an application of game models in the strict sense. In this context, it is necessary to clearly define the results of the models in comparison to the selected stylized facts. Besides, the results can, in line with the above, be used to question some ways of thinking so that the decision maker, through a dialogue with the modeller, is in a position to ask and/or criticize the model and sharpen his mental representation (see the "community game" below).

If reflexive modelling allows to use game theory on town and country planning issues, the modelling of real situations raises another question. Designing a game, to understand the logical implications of the interactions of local actors, is implicitly asking about their future. But in France since the 1950s, issues concerning the future of the territories falls more on a future oriented approach than on a reflection using game theory. If the two disciplines have their own history and their body, some game theory concepts can, however, be interpreted in a futurist way.

II) **Game theory and territorial future oriented approach**

On several occasions, Christian Schmidt has proposed to renew the tools developed by futurists by introducing game theory concepts. (Schmidt, 1991, 1999, 2000). Recognizing that game theory has become a sort of "universal supplier" that successfully irrigates a lot of disciplines, Christian Schmidt is surprised that prospective theory has not opened itself to that contribution. Still, futurists use some concepts that are close to those of game theory. We will illustrate this point from the approach of prospective scenario, the solution concept of game theory along with that of metagame.

1) *Proximity between the concepts of scenario and solution to a game*

In its exploratory approach, for instance, a scenario stretches from a present situation in order to describe a succession of events leading to a possible future (Julien Alii, 1975). Highlighting the possible misuse of the term, Michel Godet clearly said that a scenario is not the prospective reality but a means to represent it with a view to illuminating the present action in the light of possible and

desirable futures. (Godet, 2004, p. 10). Proximity can be found between this concept and the outcome in game theory⁵. As Christian Schmidt noted "game theory now uses a wide range of solution concepts. Each solution coincides with specific standards of behaviour [cooperative or non cooperative, with complete or incomplete information] which, if adopted by each decision maker, lead the considered world to a social order that matches this solution (Schmidt, 1999, p. 53). The solution to a game, when it is reached, suggests the existence of "a viable social order", that is to say, such a state of the world that the mutual interest of players ensures its stability. The social order resulting from a Nash equilibrium⁶ or one from the heart of the game⁷, are stable because these solutions describe states in which players have no interest in changing their behaviour any more for fear of ending up being in more unfavourable situations. Other game solutions that set the distribution of wealth and/or power between several players like the Shapley value⁸, if they do not have the same stability criteria as the previous solutions, are based on the fair sharing of gains between players and may, therefore, be considered stable. So, the solution concept allows to turn the discussion towards the futurist. "Game theory can, on intuitive bases, ultimately identify some socially possible futures among the many conceivable scenarios" (Schmidt, 1999, p. 56).

The solution concept also allows an internal control of scenario consistency (Schmidt, 2000). Three situations may arise which can help the futurist to identify scenarios. The first case when the solution to a game is an empty set, then the related scenario must be abandoned because of the instability inherent in its construction. The second, when the solution is unique, then the scenario identified is the only stable state, and should be analyzed carefully. Finally, as mentioned above, a game may sometimes have several solutions. Such a situation poses a lot of problems to game theory to the point that some see it as its main weakness. But "it is no longer the same with a future oriented approach in which [such a situation] rather presents an advantage, in so far as [it] extends the list of possible futures and helps to refine their classification"(Schmidt, 1999, page 58). Indeed, among these equilibriums, some may be more advantageous or may reflect different social organizations. This situation leads to compare the stability of worlds each equilibrium refers to. This can lead the futurist to make recommendations based on criteria that are external to the game itself.

2) Metagame and territorial future oriented approach

Another future oriented interpretation can be attached to our work. Christian Schmidt noted that "The intelligence of a social situation is scarcely reduced to the understanding of a single game" (Schmidt, 2000, p. 258). So, it is often necessary to use several games to describe the interactions that link the different actors in a given situation. This multiplication of games is the opportunity to refine the analysis of certain types of interactions. That's why we developed three games, which each in their own way, have approached an aspect of the interactions between the players concerned by the future airport. The focus is on the institutional dimension of the players in the "community game". In the other two games, the «Airport / Airlines Game" and the "Airport in the Metropolitan Loire-Bretagne Area game (EMLB)" attention is focused on airports and their interactions with airlines. If each game is an independent model, none is completely cut off from the other two because the players are the same from one game to the other. In addition, the solution to a game can affect the next game, etc... All three games can be seen from a future oriented approach, as a metagame (Howard, 1971, Schmidt, 1991, 2000) which includes such games as many sub-games⁹.

⁵ The solution concept refers to the conditions imposed on the strategies of players, which if they are verified, become the solutions of the game.

⁶ Nash equilibrium is a solution concept for non cooperative games that corresponds to a situation in which no player has an incentive to unilaterally change his choice, for fear of winding up being in a position lower than the previous one.

⁷ The heart is a solution concept for coalitional games (more than two players) which imposes that no coalition moves to another by improving the payoff of its members.

⁸ Shapley value is a solution concept that allows to define the share of surplus to be given to a player. It corresponds to the weighted average of the contributions of this player to the coalition he belongs to.

⁹ If we have not gone as far as formalizing this métajeu (partly due to the fact that the three games overlap imperfectly), the comments made on each game have occasionally mentioned this point.

III) Illustration from the "community game"

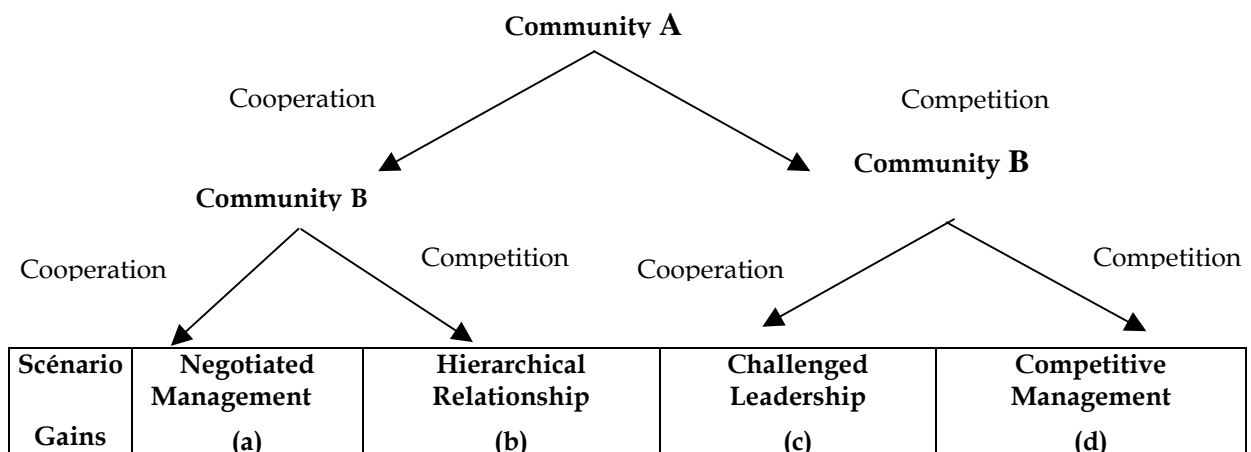
We can illustrate what comes before from the "community game" developed in our study to analyze the interactions generated by NDDL airport between Nantes and Rennes¹⁰.

1) *The community game*

Let A and B be two geographically close cities similar in demographic and economic terms. A has an inter-regional airport meant to be the leader while B's airport is only meant to be local. The catchment area of the leader is bound to spread and overlap that of B. The objective of both playing cities is to use their infrastructure to maximize their attractiveness (in terms of GDP, job creation, etc...). Each community can choose between two strategies: cooperation or competition. Their combination leads to four scenarios:

- The "negotiated Management" scenario results from cooperation between players. It corresponds, in the case of Nantes and Rennes, to the NDDL option, *the airport of the Great West*.
- The "hierarchical Relationship" scenario in which the community A chooses competition while B chooses cooperation. It reflects the authority of A airport over B.
- The "challenged Leadership" scenario in which B is the competition and A the cooperation. Here, the leadership of A is not allowed (first scenario) or imposed (second scenario) but challenged.
- The "competitive Management" scenario when both players adopt competitive strategies. It corresponds to the NDDL option, the largest airport in the West.

Figure 1: Community Game Tree (Carrard, 2009)



With a, b, c, d, scenario utilities for communities A and B

2) *The position of players at the end of non-cooperative strategies*

Analysing the preferences of communities has allowed to determine their utility function for the different scenarios. Playing town A will use its infrastructure to assert its airport leadership because it is the attitude that maximizes its attractiveness. The following order: $c > d > a > b$ can then be inferred. Unlike A, Playing town B will have to resist and / or look for a status quo so as to preserve its traffic potential intact. The following order is then inferred: $a > b > d > c$ ¹¹. To quantitatively illustrate the consequences of these assumptions on the two communities, a relative value (from three for the first

¹⁰ The game is non-cooperative. It is played with complete information because each player knows the game configurations and the associated gains. On the other hand, the game is played with imperfect information because the players playing simultaneously do not know their partners' choice. The game will be played with perfect information when tested with a group of volunteers (see below)

¹¹ Playing town B may rationally prefer "negotiated Management" to "challenged Leadership, because by choosing the latter scenario, it exposes itself to the leader's reaction. That would lead them to "competitive Management".

choice to zero for the last) can be assigned to each preference order. This assessment determines the game payoff matrix.

Figure 2 : the payoff matrix

Community B	Cooperation	Competition
Community A		
Cooperation	<i>Negotiated Management</i> (1 , 3)	<i>Challenged Leadership</i> (0 , 2)
Competition	<i>Hierarchical Relationship</i> (3 , 0)	<i>Competitive Management</i> (2 , 1)

It is observed that for A, cooperation is a dominated strategy since, whatever the choice of B, playing town A always gets a higher relative gain in playing competition. If B is "cooperation" playing "competition" for A yields 3 instead of 1 with "cooperation" and if B is "competition" that yields it 2 with "competition" and 0 with "cooperation". Competition is then a dominant strategy for that playing town. In this case, the only strategy that maximizes the relative gain of B is competition. The Nash equilibrium of the game matches the "competitive Management" scenario¹². This raises the question of the optimality of that equilibrium, however, in the Pareto sense, for the "negotiated Management" scenario ensures a higher relative gain (with $4 = 1 + 3$).

3) *Playing the community game*

In the context of reflexive modelling of the situation, Rennes and Nantes players were offered to participate in the "community game". This was, initially, to assess their preferences for the scenarios from political, economic and social criteria. Then, they were asked to play the game. As the proposal failed to reach its end¹³, we will present some results obtained with the test group¹⁴.

3.1) *The methodological framework*

In the absence of real financial incentives (the participants were not getting gains from their choice in the game situation), the exercise does not fall within the framework of experimental economics. Its objective though was not refuting theoretical models, but assessing the preferences of the individuals subject to the exercise. Thus this exploratory approach is akin to the method of stated preferences (Kroes EP, Sheldon RJ, 1988), often used in transport, which uses what individuals assert their preferences are in order to estimate their utility function in different scenarios of service offering.

3.2) *The experimental protocol of the first part of the community game*

- Conditions of execution: the eight participants were grouped in pairs. Within a couple, each player embodied one of the two communities. The allocation was made randomly. The players were not allowed to communicate.
- The ranking of preferences: the players were given a grid on which they had to set a preference order for the scenarios, for each decision criterion (political, economic and social). The ranking

¹² In game theory, the method that consists in determining Nash equilibrium from the successive elimination of dominated strategies is called the method of iterated dominance

¹³ If Nantes and Rennes players had shown favourable to the initiative at first, one of two parties declined the invitation at the last moment. The group should have been composed of twelve people, namely, six Nantes players and six Rennes players.

¹⁴ The test group was composed of three researcher teachers and two students from Bourges ENSI to whom three outsiders were added: the Director of the National Centre of Industrial Risks (NCRI), the Development Manager at MBDA and an engineer of the Industrial Risks National Centre.

was done four times integrating specific information each time. Then, a value associated with each scenario was set.

3.3) Some results to illustrate this experiment

In the first ranking, the participants were asked to rank the scenarios according to their preferences while in the fourth, the participants who played for A were asked to rank the scenarios according to their assessments of B's preferences and vice versa¹⁵.

Figure 3: the matrix of payoffs of the first and fourth ranking

Community B	Cooperation	Competition
Community A		
Cooperation	<i>Negotiated Management</i> (2,75, 4,5)	<i>Challenged Leadership</i> (-3, 4,5)
Competition	<i>Hierarchical Relationship</i> (5,25, -1)	<i>Competitive Management</i> (1, -2)

Community B (played by A)	Cooperation	Competition
Community A (played by B)		
Cooperation	<i>Negotiated Management</i> (0,25, 4,75)	<i>Challenged Leadership</i> (-3, 3,25)
Competition	<i>Hierarchical Relationship</i> (4,25, -3)	<i>Competitive Management</i> (4,5, 1)

In comparing the responses, we can see that the gap between the scenarios is marked more when a player's assessment is made on the preferences of the other player (fourth assessment) than on his own preferences (first evaluation). The scenarios "Negotiated Management" and "Competitive Management" are mainly concerned. The first evaluation shows that A assigns a value of 2.75 (out of 6) to "Negotiated Management" while B thinks that for A this scenario is only worth 0.25 (fourth assessment). Conversely, B assigns a value of 4.5 to "Competitive Management" for player A (fourth assessment), while the latter gives it only a value of 1 (first evaluation). This gap between what is perceived by one and felt by the other may ultimately constitute margins from which players can mutually adjust. Indeed, it appears that A gives more value to cooperation (2.75) than B thinks (0.25) while B gives less value to competition (-2) than A assumes (1).

Conclusion and prospects

The aim of this contribution was to methodologically place our study that has used game theory in order to reflect on issues of town and country planning. We recalled that if game theory concepts are not easily transferable to real cases, reflexive modelling offers interesting prospects to address

¹⁵ Here we have strayed from the traditional approach of game theory that assumes that players define their preferences regardless of the preferences of other players. However, we can assume that a player can have "his own preferences on the preferences of others and that these preferences can have a strategic impact [...] it is unclear why in these circumstances, what each player knows about the preferences of other players would not be taken into account by a player in defining its own preferences "(C. Schmidt, 2001, p. 76).

situations in which the interactions between actors are strong. Reflexive modelling does not seek to determine an optimal strategy for a decision maker but rather to guide him in his decision making from a streamlining of his mental representation of the situation. A dialogue between the decision maker (s) and the modeller is required. We also recalled that game theory allows a futurist reading in so far as it allows to select the scenario that is the most likely and stable solution to a game, among a set of scenarios.

Finally, with respect to the subject of this conference, it appears that territorial intelligence can fully benefit from the contributions of game theory. To illustrate this last point, we will give two examples. The first, we have experienced in our study, relies on game assessment by the players themselves with a view to clarifying their preferences, beliefs, etc... (Reflexive modelling). These methods may help them to clarify their choices and understand, if not solve, the problems facing them. Commitment and strong involvement are then required from the players to participate in such experiments. The second example is related to the development of evolutionary games which, together with information technology tools, allow simulations of cooperation and competition between economic actors (Berro, Leroux, 2006). If it should not be regarded as a panacea, game theory can usefully complement the tools and methods already used to help territorial intelligence.

Bibliography

Aéroport du Grand Ouest, 2007, *Rapport et avis de la Commission d'enquête*.

Aumann R.J., 1987, « Game theory », In *Game Theory, the New Palgrave*. Londres : MacMillan.

Berro A., Leroux I., 2006, « Négociation public/privé et co-évolution stratégique au sein d'un cluster. Une simulation exploratoire en vie artificielle », XVème Conférence Internationale de Management Stratégique, Annecy/Genève.

Carrard M., 2009, *L'impact de l'aéroport Notre-Dame-des-Landes sur le devenir des relations entre Nantes et Rennes. Etude prospective à l'aide de la théorie des jeux*, Thèse de doctorat d'aménagement de l'espace - Urbanisme, Université Rennes II.

CPDP-NDDL, 2003, *Débat public sur le projet d'aéroport de Notre-Dame-des-Landes*.

Fisher F., 1989, "Game Economists Plays: a Noncooperative View", *Rand Journal of Economics*, Vol. 20, No. 1, pp. 113-124.

Godet M., 2004, *Manuel de Prospective stratégique. L'art et la méthode*, T2, 2ème édition, Dunod.

Guerrien B., 2002, *La théorie des jeux*, Economica, 3ème édition.

Julien P.A., Lamonde P., Latouche D., 1975, « La méthode des scénarios, une réflexion sur la démarche et la théorie de la prospective », *Travaux et Recherche de Prospective*, coll. Schéma général d'aménagement de la France n°59, La documentation française.

Kroes E.P., Sheldon R.J., 1988, "State Preference Methods: An Introduction", *Journal of Transport Economics and policy*, Vol. 22, No. 1, pp. 11-25.

Pénard T., 2004, *La théorie des jeux et les outils d'analyse des comportements stratégiques*, Université de Rennes 1, CREM.

Schmidt C., 1991, « Prospective industrielle et théorie des jeux : éléments de renouvellement méthodologique », *Economie Appliquée*, T. XLIV, 4, pp. 85-112.

Schmidt C., 1999, « Prospective et théorie des jeux », *Futuribles*, n°241, pp. 47-68.

Schmidt C., 2000, « Des décisions individuelles à la prospective sociale. Une médiation par la théorie des jeux », *Décision, Prospective, Auto-organisation*, Mélanges en l'honneur de Jacques Lesourne, Dunod, pp.245-263.

Schmidt C., 2001, *Théorie des jeux. Essai d'interprétation*, PUF.

Thépot J., 1995, « La modélisation dans les sciences de gestion ou l'irruption du tiers », *Revue française de gestion*, n°102, pp. 66-70.

Thépot J., (dir.), 1998, *Gestion et théorie des jeux. L'interaction stratégique dans la décision*, ed. Vuibert.