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FROM ARGUMENTATION TO NEGOTIATIONS: THE GAME OF DETERRENCE PATH

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Abstract. Negotiations are a process of social interaction between parties defending their own interests. To that end argumentation is an essential component for the success of the process, since it may help one party to convince the other parties that an agreement proposed by the former is appropriate.. A vast literature on the subject has developed in the last two decades [1]. The present paper uses a specific category of qualitative games, called games of deterrence to bridge argumentation and negotiations. Initially developed for analyzing nuclear doctrines [15], these games consider .two kinds of outcomes, acceptable and unacceptable ones. This binary feature enables games of deterrence to model argumentation through associating a strategy with each argument presented by a party. The playability of this strategy is assessed, which in turn determines the truthfulness of the argument [18, 19]. Likewise, when applied to bargaining, games of deterrence enable to find feasible agreements as the result of a sequential process taking into account the players' postures, i.e. the preferences of each player on the set of possible outcome pairs [16, 17]. The bridge between argumentation and negotiation is then built by associating with each set of arguments presented by the parties and recognized as true, a set of agreements consistent with these arguments, and in turn associating with each agreement an outcome for each party. It is assumed in particular that any agreement proposal associated with a set of inconsistent agreement is unacceptable for all parties. The model is tested on the case of a bilateral negotiation, in which the parties are two companies negotiating the conditions of a joint venture. Two versions of the case are developed. In the first one each pair of true arguments is associated in a bilateral relation with a single agreement, while in the second one the arguments pairs are replaced by pairs of arguments sets, such that different pairs of arguments' sets can be associated with the same agreement.

Keywords: argumentation, circuit, defeasibility, deterrence, dialog, equilibrium, graph, negotiation, path, playability, posture, preference, sequential game, solution, strategy.

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Invited paper

1. Introduction

The topic of negotiation has been the subject of a vast amount of research based on several approaches. Among these, game theoretic tools which most of the time assume that the interaction between the parties takes place in a context of complete information. Such is the case for instance for the Nash Bargaining Solution [8], the Kalai & Somorodinsky solution [6], the Brams & Taylor Adjusted Winner Solution [3], or the Rubinstein Bargaining Solution [9]). On the other hand heuristic approaches aim at taking into account information incompleteness as well as the limitation of computational capacities. Another approach is the one of the argumentation based negotiation which aims at taking into account the possibility for the parties to exchange information that might influence their respective behaviours. This information can be comprised of several categories of elements like raw data or arguments. In the latter case one party may through an appropriate argumentation lead another party to accept an agreement proposal which the latter had earlier refused. Thus for Amgoud, Dimopoulos and Moraitis "an offer supported by a good argument has a better chance to be accepted by an agent, and can also make him reveal his goals or give up some of them" [1]. On the other hand, whatever the proposal that such argumentation supports, it may increase the confidence between the parties.

Argumentation models have also been widely explored, in dialog games [4, 11], but also within the framework of a particular class of qualitative games[1] called games of deterrence [18, 19], which on the other hand have also been used to model negotiations [16, 17]. The aim of then present paper is to show how these games of deterrence can serve as a supporting basis for connecting argumentation and negotiation. To that end the first part will recall the basic properties of matrix games of deterrence[2]. The second part will deal with the use of games of deterrence for argumentation purposes. The third part will similarly address the issue of games of deterrence for negotiations. The fourth and last part will then use the formalism of games of deterrence to bridge argumentation and negotiations.

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[1] In the sense of Game Theory

[2] For the sake of simplicity, the present paper will only consider argumentation and negotiation between two parties, given that all properties can be extended to the case of N parties (N> 2)

2. Matrix games of deterrence basic properties.

In games of deterrence players have only two possible outcomes:

- *Acceptable* ones noted 1
- *Unacceptable* ones noted 0

The players' aim is to get an acceptable outcome. In that respect, players look, not for optimal strategies but for *playable* ones, possibly leading to satisficing outcomes in the sense of Simon [20].

To define playability let us consider the following 2x2 game

Fig.1: Matrix game, example 1

Roger

Erwin

	r_1	r_2
e_1	(1,1)	(1,0)
e_2	(1,1)	(1,1)

The two strategies of Erwin and the strategy r_1 of Roger provide the player who selects them an acceptable outcome, whatever the strategy selected by the other player. These strategies will be termed *safe*. On the opposite, strategy r_2 does not guarantee an acceptable outcome to Roger. Therefore r_2 will be termed *dangerous.* In this elementary example it seems obvious that safe strategies are playable while dangerous strategies are not playable.

But this is not always the case as the next example shows.

Fig 2: Matrix game, example 2

Roger

Erwin

	r_1	r_2
e_1	(1,0)	(1,0)
e_2	(1,0)	(1,0)

While nothing has changed for Erwin with respect to example 1, all strategies of Erwin are dangerous and equivalent[3]. So there is no criterion according to which these two strategies can be differentiated. Now as in a game a player *must* play, it follows that both are playable although dangerous. But of course the nature of the playability of Roger's strategies is not the same than the one of Erwin's strategies. Therefore we shall distinguish between:

- *Positively playable* strategies that guarantee the player who selects them an acceptable outcome as soon as the other player plays rationally
- *Playable by default* strategies that are the strategies of a player who has no positively playable ones

A strategy which is either positively playable or playable by default will be termed *playable.*

Now a strategy e of Erwin will be termed *deterrent vis-à-vis* a strategy r of Erwin if the three following conditions apply:

1. e is playable
2. implementation of strategic pair (e,r) implies an unacceptable outcome for Roger
3. Roger has an alternative strategy e' which is positively playable

In example 1 strategy e_1 of Erwin is deterrent vis-à-vis strategy r_2 of Roger. Indeed:

1. e_1 is safe hence positively playable
2. implementation of (e_1,r_2) leads to an unacceptable outcome for Roger
3. strategy r_1 of Roger is safe, hence positively playable.

On the opposite, in example 2, no strategy of Erwin is deterrent vis-à-vis r_2, since Roger has no alternative strategy which is positively playable.

More generally, it has been shown [15] that a necessary and sufficient condition for a player's strategy to be playable is that there is no strategy of the other player which is deterrent vis-à-vis the former. This result enables to analyze strategies playability through deterrence, and hence provide a quite important extension to the possible applications of games of deterrence.

Let us now associate with every strategy x of a given player an *index of positive playability J(x)* which equals 1 if s is positively playable, and 0 if not.

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[3] These strategies are termed equivalent because they provide the same outcome to Roger whatever Erwin's strategy.

One can show [ibid] that the indices of positive playability of all strategies are connected through a set of equations called the *playability system.*

We shall call *solution* of the game of deterrence any solution of the playability system. Thus in example 1, the solution is:

S: $\{J(e_1)=1; J(e_2)=1; J(r_1)=1; J(r_2)= 0\}$

Then we shall call *equilibrium* of the game of deterrence any playable strategic pair. So the game in example 1 displays one solution to which two equilibriums are associated: (e_1,r_1) and (e_2,r_2). These two equilibriums are comprised of positively playable strategies and therefore are termed *positively playable equilibriums.* If the two strategies composing an equilibrium are playable by default, then the equilibrium will also be termed *playable by default*. It has been shown [ibid] that every game of deterrence has at least one solution and one equilibrium.

Solving the playability system may be a lengthy task. Therefore one may resort to an alternative approach based on graphs. More precisely we shall associate with every matrix game of deterrence a bipartite graph termed *graph of deterrence* and defined as follows:

- the graph vertices are the players' strategies
- there is an arc of origin e (respectively r) and extremity r (respectively e) if implementation of strategic pair (e,r) leads to an unacceptable outcome for Roger (respectively for Erwin).

Now it has been shown [ibid] that every graph of deterrence can be broken down into connected parts, each one being a path or a graph without root. More precisely, we shall define:

- an *E-path* (respectively an *R-path*) as a path which root is a strategy of Erwin (respectively of Roger)
- a *C-graph* as a graph without root

It has been shown (ibid) that:

- If the graph of deterrence reduces to a path, the only positively playable strategy is the root, all other strategies of odd rank are not playable, and all strategies of even rank being playable by default.
- If the graph of deterrence is a circuit, all the players' strategies are playable by default
- More generally there are 7 types of matrix games of deterrence: E,R,C, E/R, E/C, R/C, and E/R/C , and the game type defines the properties of the solution set.

Let us consider the following example:

Fig 3: Matrix game, example 3

Roger

Erwin

	r_1	r_2
e_1	(1,0)	(1,1)
e_2	(0,1)	(1,0)

The corresponding graph of deterrence is the following path

Fig 4: Graph of deterrence, example 3

$$e_1 \rightarrow r_1 \rightarrow e_2 \rightarrow r_2$$

Let us then consider that the strategic pair (e_1, r_2) is now associated with the outcome pair (0,1) instead of (1,1)

Fig 5: Matrix game, example 4

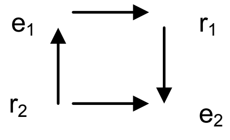
Roger

Erwin

	R_1	r_2
e_1	(1,0)	(0,1)
e_2	(0,1)	(1,0)

The corresponding graph of deterrence is the following circuit:

Fig. 6. Graph of deterrence, example 4



Now, it is a little more than common sense to consider that the parties should have opportunities to make moves rather than to be compelled to select a strategy once for all. This can be done through resorting to *sequential games of deterrence* characterized by the fact that each player is associated with a *preference order* taking into consideration the situation of both players. It has been shown (ibid) that given that a player will always prefer a 1 to a 0 there are four possible preference orders:

- P_1 : (1,0) ≥ (1,1) ≥ (0,0) ≥ (0,1) (*prudent malevolence*)
- P_2 : (1,0) ≥ (1,1) ≥ (0,1) ≥ (0,0) (*partial malevolence*)
- P_3 : (1,1) ≥ (1,0) ≥ (0,0) ≥ (0,1) (*partial benevolence*)
- P_4 : (1,1) ≥ (1,0) ≥ (0,1) ≥ (0,0) (*prudent benevolence*)

So starting from an initial strategic pair, the players may change their decisions till the game comes to a state in which no player has an interest to move. The strategic pair under consideration is called the *sequential equilibrium* of the game[4]. Now it is obvious that the sequential equilibrium (if there is one) depends on the preference orders of the two players. These preference orders reflect the respective *postures* of the two players. Now these postures may be rigid, reflecting the perception of each player vis-à-vis the other one. In that sense they are similar to the "positions" defined by Fisher and Ury [5]. But they can also reflect strategic *postures*, in which case they can be the object of a choice by each player, within the framework of a meta-game called the *posture game*, in which each pair of postures is associated with the outcome pair resulting from the sequential equilibrium found for this pair of postures (when such sequential equilibrium exists). An example of such meta-game will be detailed in the section devoted to negotiations.

Last but not least, in real life the interacting parties may have to select not one decision at the time but several ones. This can be done through resorting to *multi-strategy games of deterrence*. In such games the players have to select not a single strategy but a subset of their strategic set, called an *isotropy*. To that end they must be able to assess how the different strategies composing the isotropy interfere.

Let S_E and S_R be the strategic sets if Erwin and Roger respectively. Given a pair of isotropies $(\varepsilon, \rho) \subseteq S_E \times S_R$, the isotropy ε (resp. ρ) is said to be;

[4] In this respect the sequential equilibrium has similarities with the Nash Equilibrium in non cooperative games.

• *conjunctive* if the outcome for Erwin $\omega_E(\varepsilon, \rho)$ (resp. the outcome for Roger $\omega_R(\varepsilon, \rho)$) of the implementation of the isotropic pair (ε, ρ) equals:

• $$\prod_{\substack{e \in SE \\ r \in SR}} (A(e,r) \quad \left(\text{resp. } \prod_{\substack{e \in SE \\ r \in SR}} B(e,r)\right)$$

• *disjunctive* if the outcome for Erwin $\omega_E(\varepsilon, \rho)$ (resp. the outcome for Roger $\omega_R(\varepsilon, \rho)$) of the implementation of the isotropic pair (ε, ρ) equals:

$$\sum_{\substack{e \in SE \\ r \in SR}} (A(e,r) \quad \left(\text{resp. } \sum_{\substack{e \in SE \\ r \in SR}} B(e,r)\right)$$

3. Argumentation through games of deterrence.

Let us consider the proposition P_x "strategy x is playable". The truthfulness of that proposition can be established through looking whether there exists a strategy y of the other player such that y is deterrent vis-à-vis x. In other words, there is here a connection between deterrence and defeasibility: $P_y \Rightarrow \neg P_x \Leftrightarrow y \rightarrow x$.

Now as seen above, one needs to distinguish positive playability and playability by default For instance, let us consider in example 4 that each strategy is an argument deployed by a player. Then we come to a strange conclusion: each argument put on the table by a party contradicts an argument of the other party, and is contradicted by another argument of that party. So the only conclusion that can be drawn is that the arguments of the two parties are contradictory. To go beyond we need to be more restrictive and require that for an argument to be true, the latter should be associated with a positively playable strategy.

To that end, starting from example 4 let us introduce a strategy e_3 of Erwin that is safe, which translated in terms of arguments means that Erwin has an argument which is considered true[5]. The game matrix becomes:

[5] This implies that the burden of proof lies not on the party that puts an argument on the table, but on the other party.

Fig. 7: Matrix game, example 5

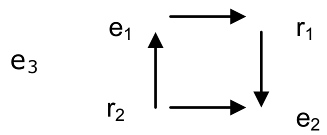
Roger

Erwin

	r_1	r_2
e_1	(1,0)	(0,1)
e_2	(0,1)	(1,0)
e_3	(1,1)	(1,1)

to which corresponds the following graph of deterrence:

Fig. 8: Graph of deterrence, example 5



The game displays a unique solution:
$S = \{J(e_1)=0; J(e_2)= 0; J(e_3)=1; J(r_1)=1; J(r_2)=1\}$

So the fact that Erwin has now a third strategy e_3 which is safe implies that his two previous strategies e_1 and e_2 are not playable, while the strategies of Roger that were playable by default are now positively playable. Translated in terms of argumentation this leads to a quite counter-intuitive result: given an initial dispute between Erwin and Roger such that all arguments of one party are being contradicted by an argument of another party, introducing in the dispute a true argument which is not related to any of the existing ones, makes now the previous arguments of Erwin false, while on the opposite the previous arguments of Roger are now true.

Let us go now one step further and introduce in the game a safe strategy r_3 for Roger, as depicted in fig 9.

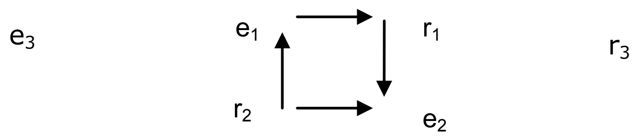
Fig. 9: Matrix game, example 6

Roger

		r_1	r_2	r_3
Erwin	e_1	(1,0)	(0,1)	(1,1)
	e_2	(0,1)	(1,0)	(1,1)
	e_3	(1,1)	(1,1)	(1,1)

to which corresponds the following graph of deterrence:

Fig. 10: Graph of deterrence, example 6



The game displays two solutions:

$S_1 = \{J(e_1)=0; J(e_2)= 0; J(e_3)=1; J(r_1)=1; J(r_2)=1; J(r_3)=1\}$

$S_2 = \{J(e_1)=1; J(e_2)= 1; J(e_3)=1; J(r_1)=0; J(r_2)=0; J(r_3)=1\}$

These two solutions reflect the symmetry between the two sides but do not enable to state comprehensively which arguments are true and which are false. These problems occur when the breakdown of the graph of deterrence into connected parts includes a circuit. They might also occur when the game type is E or R. Let us go back for instance to example 3. The game is of type E with a graph of deterrence that reduces to a simple E-path. We know that there is a unique solution:

$S = \{J(e_1)=1; J(e_2)= 0; J(r_1)=0; J(r_2)=0\}$.

To get out of the problem stemming from the fact that Roger's strategies are playable by default, the solution will be once again to introduce a safe strategy. This solution is quite general, and therefore one may question the possibility to introduce a safe strategy for each player. But this raises no difficulty: one can always find facts that are recognized as true by the two parties, and even if it were not the case, then it always possible to introduce as a strategy the argument according to which given any proposition P: $P \Leftrightarrow \neg(\neg P)$. In the framework of propositional logic, this argument is always true. So if in example 3 we suppose that this argument belongs to Roger and corresponds to a strategy r_3, the game now displays a unique solution:

$S' = \{J(e_1)=1; J(e_2)= 1; J(r_1)=0; J(r_2)=0;J(r_3)=1\}$.

Beyond the presence of r_3, the main difference between S and S' , is that in the case of S r_1 and r_2 are playable by default, while in the case of S' they are not playable, which implies that e_2 which was not playable in the case of S is now positively playable in the case of S'. The translation in terms of argumentation truthfulness is that while in example 3 argument e^*_2 associated with strategy e_2 was not true, on the opposite by the mere fact of suppressing the possibility of strategies playable by default, e^*_2 becomes true.

4. Negotiations and games of deterrence

Let us consider that Erwin and Roger are the parties of an elementary negotiation including 4 possible agreements, each one defined by a strategic pair associated with an outcome pair as represented in the matrix here below.

Fig. 11: Matrix game, example 7

Roger

Erwin

	r_1	r_2
e_1	(1,1)	(0,1)
e_2	(1,0)	(0,0)

The two strategies of each player are equivalent so that playability analysis doesn't enable to discriminate between them

Several approaches are possible to find the appropriate agreement.

The first and probably most classical one is the Nash Bargaining Solution (NBS). It can be easily seen, using the Nash games of threat that the most appropriate conflict point is (e_2,r_2) leading to (e_1,r_1) as the NBS[6]. This case is very simple, but application of the NBS to binary games may not always be so easy, for instance when there is no outcome pair (0,0) or no outcome pair (1,1).

So another possibility is to consider negotiations between the two parties as a set of interactions comprised of proposals made by one

[6] which is consistent with the NBS symmetry axiom.

party and responses to that proposal by the other party, as is the case in the Rubinstein bargaining model [9]. We shall follow here a similar approach through resorting to sequential games of deterrence. Let us first assume that the preference orders of the two parties are prudent malevolence:

- For Erwin P_1^E : (1,0) ≥ (1,1) ≥ (0,0) ≥ (0,1)
- For Roger P_1^R : (0,1) ≥ (1,1) ≥ (0,0) ≥ (1,0)

Whatever the initial strategic pair – in other words the initial proposals made by the players – there is a unique sequential equilibrium which is (e_2,r_2), associated with an unacceptable outcome for each party.

Let us then consider that the preference order of each party is prudent benevolence:

- For Erwin: P_4^E : (1,1) ≥ (1,0) ≥ (0,1) ≥ (0,0)
- For Roger: P_4^R : (1,1) ≥ (0,1) ≥ (1,0) ≥ (0,0)

The game displays a unique sequential equilibrium, (e_1,r_1), associated with outcome pair (1,1). So if the players adopt a posture of prudent benevolence, they reach an agreement which is the NBS, while if they adopt partial malevolence the game ends up at the conflict point.

This example illustrates how the solution of the negotiation game may depend on the parties' preference orders, which are therefore of strategic importance. This conclusion takes us back to the famous Fisher & Ury's principle according to which one should negotiate on the basis not of one's positions but of one interests [5]. In the present case, this means that adoption of a preference order by a party should be the result of a decision taken in the posture game. In the present case the matrix representing the postures meta-game is the following:

Fig. 12: Posture game, example 7

Roger

Erwin

	P_1^R	P_2^R	P_3^R	P_4^R
P_1^E	(0,0)	(1,0)	(0,0)	(1,0)
P_2^E	(0,1)	(1,0) or (0,1)	C	(1,0)
P_3^E	(0,0)	C	(1,1) or (0,0)	(1,1)
P_4^E	(0,1)	(0,1)	(1,1)	(1,1)

In this matrix;

- (1,0) or (0,1) means that the outcome pair associated with strategic pair (P_2^E,P_2^R) is either (1,0) or (0,1) depending on which player has the initiative. here, the first shooter is the winner
- (1,1) or (0,0) means that the outcome pair associated with strategic pair (P_3^E,P_3^R) is either (1,1) or (0,0) depending on which player has the initiative. But on the opposite of the previous case, here the interests of the two players coincide, and if both are rational, the choice of the strategic pair associated with (1,1) will prevail. Hence in the sequel we shall consider that the outcome pair associated with (P_3^E,P_3^R) is (1,1)
- C means that there is no sequential equilibrium, in other words, that whatever the strategic pair under consideration, there is always a player who has an interest to defect.

The game displays a first solution S_1 in which the players' strategies are playable by default.

To find if there are other solutions, let us first assume that P_1^E is positively playable. Then no strategy of Roger is positively playable, in other terms all are playable by default. But then P_1^E is not positively playable, which contradicts the assumption. So P_1^E is not positively playable. For reasons of symmetry, the same applies to P_1^R.

Let us then assume that P_2^E is positively playable. It follows that P_2^R and P_4^R are not positively playable[7]. On the whole P_1^R, P_2^R, P_4^R are not positively playable. If P_3^R is not positively playable, Roger's strategies are playable by default, and hence P_2^E can't be positively playable, which contradicts the assumption. So P_3^R is positively playable. Now, since P_1^R is not positively playable, P_3^E and P_4^E are positively playable, which leads to the second solution:

S_2: {$J(P_1^E)=0$; $J(P_2^E)=1$, $J(P_3^E)=1$; $J(P_4^E)=1$; $J(P_1^R)=0$; $J(P_2^R)=0$, $J(P_3^R)=1$; $J(P_4^R)=0$}.

If we now assume that P_2^E is not positively playable, P_3^R and P_4^R are positively playable. Then, if P_2^R is positively playable, P_4^E is not positively playable, and then it follows that P_3^E must be positively playable[8]. Whence the third solution:

S_3: {$J(P_1^E)=0$; $J(P_2^E)=0$, $J(P_3^E)=1$; $J(P_4^E)=0$; $J(P_1^R)=0$; $J(P_2^R)=1$, $J(P_3^R)=1$; $J(P_4^R)=1$}.

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[7] whatever the outcome pair associated with the strategic pair (P_2^E,P_2^R)

[8] Were it not the case, Erwin would have no positively playable strategy, and hence all his strategies would be playable by default. Consequently P_2^R could not be positively playable which would contradict the assumption

If P_2^R is not positively playable, then P_3^E, P_4^E, P_3^R, and P_4^R are positively playable, whence the fourth solution of the game:

S_4: $\{J(P_1^E)=0; J(P_2^E)=0, J(P_3^E)=1; J(P_4^E)=1; J(P_1^R)=0; J(P_2^R)=0, J(P_3^R)=1; J(P_4^R)=1\}$.

On the whole, the posture meta-game displays four solutions implying a number of possible equilibriums. So now the question for each party is on which solution and which equilibrium should the decision be based? To answer that question let us first notice that some equilibriums occur in more than one solution. This is in particular the case for strategic pair (P_3^E,P_3^R) which is an equilibrium in any solution of the game. So selecting partial benevolence carries no risk, and if both parties do the same they come to a sequential equilibrium, i.e. an agreement acceptable for both, and which in the present case is the Nash Bargaining Solution.

The same result is obtained if the two parties select prudent benevolence.

5. From argumentation to negotiations

In the framework of negotiations, arguments are deployed by each party to support the agreement or the sets of agreements that this party considers acceptable. In the elementary case where each party deploys a single argument, one can associate with each pair of arguments (e*,r*) a set Â(e*,r*) of agreements A(e*,r*) that are consistent with these two arguments. In turn, which each agreement A(e*,r*) one can associate an outcome pair.

Let us consider for instance that Erwin and Roger are the CEOs of two companies E and R, preparing a merger.

The negotiation concerns the allocation of shares in the new company. Let us assume that prior to the present negotiation the two parties have signed a code of conduct according to which:

1. E will contribute to the joint venture by bringing in its production facilities and its R&D department, while R will bring the financial resources required for the development of the new company, and its commercial network
2. an independent consulting firm will be appointed in order to assess the value of each contribution
3. the new firm’s shares will be allocated between the two parties according to these values

Let us furthermore assume that the consulting firm has completed its analysis and concluded that the contribution of E is worth 30 million Euros, while the contribution of R is worth 20 millions.

Each party wants in fact to re-negotiate the shares allocation on the basis of the following arguments:

- for Erwin:
  - argument e^*_1: The share of R should be based on the evaluation made by the consulting firm
  - argument e^*_2: the production facilities will need to be extended due to the new markets brought by R, with as a consequence a further investment of 30 millions that should be taken into account in the total value brought by E
- for Roger:
  - argument r^*_1: The share of E should be based on the evaluation made by the consulting firm
  - argument r^*_2: due to the extension of E's production capacity, R will have to further develop it's marketing and commercial team which amounts to an extra investment of 10 millions which should be taken into account in the total value brought by R

The agreements that stem from the arguments are then:

- $\hat{A}(e^*_1,r^*_1)$: the share allocation is done according to the evaluation done by the consulting firm which amounts to 60% for E and 40% for R
- $\hat{A}(e^*_1,r^*_2) = \phi$[9]
- $\hat{A}(e^*_2,r^*_1) = \phi$
- $\hat{A}(e^*_2,r^*_2)$: the share allocation is 2/3 for Erwin and 1/3 for Roger

The argumentation game is then represented by the following matrix:

Fig. 13:Argumentation game, example 8

Roger

Erwin

	r^*_1	r^*_2
e^*_1	(1,1)	(1,0)
e^*_2	(0,1)	(1,1)

[9] Where ϕ denotes the empty set

The game displays a single solution in which e^*_1 and r^*_1 are safe while e^*_2 and r^*_2 are not playable, and hence a unique equilibrium: (e^*_1, r^*_1). In other words, the agreement object of the negotiation must be consistent with both arguments e^*_1 and r^*_1. Hence the only possible agreement is 60% for E and 40% for R.

Now one could question the method since it seems that no negotiation process has really taken place. If we want to switch from the game of argumentation to the game of negotiations we need to make some extra assumptions on the acceptability of the various possible situations.

Let us assume for instance that:

- both parties want to come to an agreement and consider therefore that an absence of agreement is unacceptable
- Likewise any agreement which is based partially or totally on arguments that are not playable in the argumentation game is unacceptable for both parties.

Associating a proposal with each argument leads to the following negotiation game:

Fig. 14: Negotiation game, example 8

Roger

Erwin

	r_1	r_2
e_1	(1,1)	(0,0)
e_2	(0,0)	(0,0)

The game displays two sequential equilibriums (e_1,r_1) and (e_2,r_2). The first one is of course preferred by both parties . Whence, if rational the two parties will choose (e_1,r_1) which is the agreement stemming directly from the argumentation game. Moreover, it can be seen that this conclusion is entirely independent from the parties' postures. This result is general, and stems from the assumption according to which an agreement is either acceptable for both parties if it corresponds to positively playable arguments or unacceptable for both if not. This result in fact states that if both parties refer exclusively to logic, their postures are irrelevant, and that the agreement to be looked for is simply the one stemming from the true arguments exchanged by the parties.

This example is of course a quite elementary one in which:

- the two parties play symmetric roles and in particular have the same assessment of each possible agreement

- each pair of arguments is associated with one agreement at most.

So let us relax some of the above assumptions, and firstly let us assume that everything else being equal, Erwin considers now that the agreement (e_2, r_2) is acceptable for him given that under such agreement company E will get more than under agreement (e_1,r_1). Then the matrix game writes:

Fig. 15: Negotiation game, example 9

Roger

Erwin

	r_1	r_2
e_1	(1,1)	(0,0)
e_2	(0,0)	(1,0)

One can establish that the corresponding posture game is:

Fig. 16: Posture game, example 9

Roger

Erwin

	P_1^R	P_2^R	P_3^R	P_4^R
P_1^E	(1,1)	(1,1) or (1,0)	(1,1)	(1,1) or (1,0)
P_2^E	(1,1)	(1,1) or (1,0)	(1,1)	(1,1) or (1,0)
P_3^E	(1,1)	(1,1) or (1,0)	(1,1)	(1,1) or (1,0)
P_4^E	(1,1)	(1,1) or (1,0)	(1,1)	(1,1) or (1,0)

All postures of Erwin are equivalent and safe, while Roger's postures can be gathered in two groups:

- P_1^R and P_3^R which are safe and lead directly to a confirmation of the allocation share according to the code of conduct

- P_2^R and P_4^R the playability of which cannot be determined straightforwardly.

The outcome pairs corresponding to the last two postures depend on:

- the players' initial choice
- who will play first if both players consider that they have an interest to defect from that initial choice
- If the players are myopic or not[10]

Thus assume for instance that the players' initial choice is (e_1,r_1). Then no one has an interest to defect from it, and the conclusion is the same than for P_1^R and P_3^R.

If the players' initial choice is (e_1,r_2), and if both are myopic, then both have an interest to defect. There are then three possibilities:

1. Both players move simultaneously and then the next strategic pair to consider is (e_2,r_1) unacceptable for both and from which both have an interest to defect. If both move again simultaneously, the game is then back to the pair (e_1,r_2), and so on. The sequential dynamics reminds of the blinker in Conway's Game of Life.
2. Ernest moves first, in which case the new strategic pair is (e_2,r_2) associated the outcome pair (1,0) and which constitutes a sequential equilibrium
3. Roger moves first and then the next strategic pair is (e_1,r_1) which is associated with an acceptable outcome for both and is a sequential equilibrium of the game

Similar conclusions will be drawn if one considers (e_2,r_1) as the initial choice of the two players.

Last, if the initial strategic pair is (e_2,r_2), this pair is the sequential equilibrium

If the players are non-myopic, things might be different, depending on the parties' initial choices and postures. To proceed to a comprehensive analysis of al cases is out of scope. Let us just consider as an example the case where Erwin is myopic while Roger is not, and assume that the initial strategic pair is (e_2,r_1). Then, Roger should let Erwin switch from e_2 to e_1. The agreement will be the one stemming

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[10] A player is said to be myopic if, when taking his decision, he / she considers only the next possible step

from the code of conduct. So it is clearly in the interest of Roger not to be myopic[11].

Let us then again modify the game and assume that Roger also finds it acceptable to have a share allocation determined according to the pair of arguments (e^*_2, r^*_2). It can be easily shown that whatever the pair of postures adopted by the parties, the negotiation may lead to two agreements (e_1,r_1) and (e_2,r_2) depending once again on the initial pair of proposals of the parties, and on who moves first when the two have an interest to defect. The conclusion is here quite obvious: since the two possible agreements are equivalent in terms of their acceptability for the parties, there is no reason to make a distinction between the two. From the perspective of the connection between the game of argumentation and the game of negotiation, this conclusion shows that the agreement selected during the negotiation process may be different from the one that is directly associated with the equilibrium in the argumentation game. Although weird and possibly disappointing at first view, the conclusion is in fact common sense. Indeed, both parties are here assumed to consider that a joint defection from the arguments pair corresponding to the equilibrium in the argumentation game may be acceptable. So there is no wonder that an agreement built on such defection may be adopted.

Let us then relax the assumption according to which with each pair of arguments is associated at most one agreement. To that end let us modify the previous scenario as follows: every else being equal, the code of conduct that was earlier signed by the two parties now stipulates that "the allocation of shares in the new company will be done according to the respective contributions of the parties to the new company". The formulation is less accurate than in the previous case, and therefore is expected to leave more room for negotiation[12].

The global set of arguments is comprised of three different subsets:

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[11] One could question the added value of the statement: isn't it always the case that one should not be myopic? In reality many counter-examples exist especially in the field of international relations where myopic players may have an advantage linked to deterrence, over non myopic ones.

[12] This is often the case in international negotiations that the parties may reach an agreement if and only if the statements conveyed by the agreement are vague enough so that every party can interpret it its own way.

- the set A*of arguments on which the parties agree. A* is comprised of the following arguments:
- e*1 or r*1 (depending on who uses the argument):
- the share allocation must respect the code of conduct
- at the time of negotiations, the value of company E's contribution, as determined by the consulting firm, is 30 million Euros
- at the time of negotiations, the value company R's contribution, as determined by the consulting firm, is 20 million Euros
- the set E* of arguments brought only by Erwin. In the present case this set is comprised of:
- e^*_2: the production facilities will need to be extended due to the new markets brought by R, with as a consequence a further investment of 30 millions that should be taken into account in the total value brought by E
- the set R* of arguments brought only by Roger: In the present case this set is comprised of:
- r^*_2: due to the extension of E's production capacity, R will have to further develop it's marketing and commercial team which amounts to an extra investment of 10 millions which should be taken into account in the total value brought by R

If, according to the assumptions each party agrees with the code of conduct, any agreement that is not consistent with that code can be discarded. Indeed such agreement would translate into a share allocation that is either unfeasible (for instance each party would get more than 50%) or in which one of the parties gets less than what it could get according to the code of conduct. So, one can reasonably expect that this party will reject the agreement. Now there are four possible agreements that do not violate the code of conduct. They are characterized by the following share allocations:

- (60%, 40%) which corresponds to the fact that the only contributions taken into account are those assessed by the consulting firm, and which are limited to the present situation.
- (75%, 25%) which corresponds to the situation in which the only future investments that are taken into account are those of company E
- (50%,50%) which corresponds to the case where the only future investments taken into account are those of company R

- (2/3, 1/3) which corresponds to the case where the future investments of both parties are taken into account.[13]

So the first conclusion is that one can associate more than one agreement with a pair of arguments. Indeed if we consider the pair of arguments (e^*_1,r^*_1), it stems straightforwardly from the above that this pair of arguments can be associated with four possible agreements.

Suppose now that, while Erwin sticks to e^*_1, Roger adds r^*_2 to the set of his arguments. Then obviously, out of the four initial agreements, two remain feasible[14], i.e. (50%, 50%) and (2/3, 1/3). Suppose then that in turn Erwin adds e^*_2 to his arguments set. Then one agreement remains feasible: (2/3,1/3). So, adding arguments reduces here the number of feasible agreements[15]. But this will happen only if the arguments put on the table are considered true by both parties, and if the parties display good faith, in the sense that they make proposals that are always compliant with true arguments. For the sake of building our model step by step, we shall assume that this is the case here[16]. Nevertheless, for instance Roger may refuse to take into account further investments of company E for the following reason:

- r^*_3: the code of conduct doesn't mention future investments

The argument of Erwin in response can be:

- e^*_3: the code of conduct doesn't specify that the contributions of the parties must be assessed once for all and hence the code accepts that new contributions be taken into account

If we assume that there is no counter-argument of Roger, then the argumentation game matrix becomes:

[13] Theoretically, one could also imagine that only future investments are taken into account, but such a case is hardly credible, since the consulting firm has already assessed the present contributions of the parties

[14] where feasibility refers here to the arguments put on the table by the parties

[15] Let us observe that it is not always the case. Thus for instance an agreement which initially was not feasible due to an argument of Roger, may eventually be feasible if Erwin finds an argument defeating Roger's argument

[16] in real life negotiations, parties may not recognize a true argument as such, resorting to an abuse of Logic in order to defend their positions [10]

Fig. 17: Argumentation game, example 10

Roger

Erwin

	r^*_1	r^*_3
e^*_1	(1,1)	(1,1)
e^*_2	(1,1)	(0,1)
e^*_3	(1,1)	(1,0)

The game displays a unique solution:

S: $\{J(e^*_1)=1; J(e^*_2)=1; J(e^*_3)=1; J(r^*_1)=1; J(r^*_3)=0\}$

The truthfulness of of Erwin's argument e^*_2 is established through the argument e^*_3 which defeats r^*_3. In games of deterrence terms, e^*_3 is deterrent vis-à-vis r^*_3, which makes e^*_2 positively playable.

This means that, for Erwin to defend the interests of company E, it is necessary to deploy not one but several arguments. It is therefore relevant to model the issue through a multi-strategy game. If we consider conjunctive isotropies, the matrix representing this game is the following:

Fig. 18: Argumentation multi-strategy game, example 10

Roger

Erwin

	$\{r^*_1\}$	$\{r^*_3\}$	$\{r^*_1, r^*_3\}$
$\{e^*_1\}$	(1,1)	(1,1)	(1,1)
$\{e^*_2\}$	(1,1)	(0,1)	(0,1)
$\{e^*_3\}$	(1,1)	(1,0)	(1,0)
$\{e^*_1, e^*_2\}$	(1,1)	(0,1)	(0,1)
$\{e^*_1, e^*_3\}$	(1,1)	(1,0)	(1,0)
$\{e^*_2, e^*_3\}$	(1,1)	(0,0)	(0,0)
$\{e^*_1, e^*_2, e^*_3\}$	(1,1)	(0,0)	(0,0)

While Erwin has two safe isotropies, $\{e^*_1\}$ and $\{e^*_3\}$, Roger has one: $\{r^*_1\}$. Furthermore, $\{e^*_3\}$ is deterrent vis-à-vis $\{r^*_3\}$ and $\{r^*_1, r^*_3\}$, which makes all isotropies of Erwin positively playable, while Roger has only one positively playable isotropy: $\{r^*_1\}$.

To interpret these results from the perspective of argumentation based negotiation, let us define a *true set of arguments* as a set such that the corresponding isotropy is positively playable.

Firstly, while Roger has only one argument set which is true (the singleton $\{r^*_1\}$), all arguments sets of Erwin are true. Suppose that Erwin selects $\{e^*_1\}$. The pair of arguments sets selected by the parties is then $(\{e^*_1\}, \{r^*_1\}$. Since no reference is made to e^*_2,, one can consider that the set of agreements associated with the pair under consideration reduces to the singleton {(60%, 40%)} This means that Erwin doesn't claim to have his future investments taken into account. Suppose then that Erwin selects $\{e^*_2\}$. The result here is less straightforward. Indeed the pair of arguments sets selected in this case is $(\{e^*_2\}, \{r^*_1\})$. One could a priori consider that since Erwin doesn't use the argument e^*_1, he doesn't refer to the code of conduct, and hence cannot claim any allocation share based on that code. But since the reference to the code of conduct is an argument used by Roger, and which is not put into question by Erwin, there is one agreement that is consistent with the pair of arguments: (75%, 25%). Then for the same reasons than for $(\{e^*_1\}, \{r^*_1\}$, the pair $(\{e^*_3\}, \{r^*_1\})$ is associated with the agreement (60%, 40%). Now if we consider the remaining arguments of Erwin, when paired with $\{r^*_1\}$, they are all associated with agreement (75%, 25%).

So the negotiation game stemming from the arguments used will consider two possible agreements: (60%, 40%) and (75%, 25%). Let us call these agreements A_1 and A_2 respectively assume that for Erwin the first agreement is unacceptable since it doesn't take into account company's E future investments, while they should be according to the conclusions of the argumentation.

Then all other assumptions being kept, the matrix representing the negotiation game is:

Fig. 19: Negotiation game, example 10

Roger

Erwin		A_1	A_2
	A_1	(0,1)	(0,0)
	A_2	(0,0)	(1,1)

The corresponding posture game is:

Fig. 20: Posture game, example 10

Roger

Erwin

	P_1^R	P_2^R	P_3^R	P_4^R
P_1^E	(1,1)	(1,1)	(1,1)	(1,1)
P_2^E	(1,1) or (0,1)	(1,1) or (0,1)	(1,1) or (0,1)	(1,1) or (0,1)
P_3^E	(1,1)	(1,1)	(1,1)	(1,1)
P_4^E	(1,1) or (0,1)	(1,1) or (0,1)	(1,1) or (0,1)	(1,1) or (0,1)

So the posture game resembles the one of example 9, but the two parties have exchanged their roles. While the posture of Roger has no effect on the negotiation, Erwin postures' set can be broken down into two subsets:

- P_1^E and P_3^E which lead directly to the agreement A_2
- P_2^E and P_4^E for which the conclusion is less straightforward

So it is undoubtedly in the interest of Erwin to adopt a posture of either prudent malevolence or partial benevolence.

6. Conclusions

Although argumentation cannot by itself entirely solve negotiations issues, its importance has nevertheless dramatically increased in the last decades. Among the main factors underlying such increase, on the one hand the general evolution toward societies in which actions require more and more justifications, and on the other hand, the ever increasing role of information technologies, that aim to successfully replace human beings in a number of activity fields. In that respect dialogs between artificial autonomous agents including possible negotiations have been the subject of significant developments. The present paper has proposed to bridge argumentation and negotiation through the use of a common tool for the analysis of the two issues: games of deterrence. On the basis of these games, the paper has explored in the case of several elementary examples the relations than may exist between the results of an argumentation process, the possible agreements that stem from it, and the acceptability of these agreements for the parties concerned. Of course this paper doesn't pretend to have exhaustively covered the issue, but has paved the way for future developments in different directions like N-party negotiations or negotiations in which different assumptions about the relation between the results of argumentation and possible agreements will be made.

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