

What is Power ?

Perspectives from sociology, multi-agents systems and network analysis.

Matthias Mailliard¹ and Christophe Sibertin-Blanc²

Abstract. Although power is a core and well debated concept in sociology and political sciences, its definitions remain fuzzy and partial in both the fields of multi agents systems (MAS) and social network analysis (SNA). *Power on, power of, influence, coercion, centrality* : What is *power* ? We propose a complex perspective on *power* principally based on the French sociology: *the strategic analysis*. We argue that *power* has a transactional nature based on the action triptych: *to give, to receive, to concede*, and expose some limits and extents about the use of *power* in sociological, MAS, and SNA organizational analysis.

1 INTRODUCTION

Multi-agents systems (MAS) and social network analysis (SNA) are cross-disciplinary fields, kinds of pivots exchanging concepts between a large range of scientific areas. This two fields also produce tools to formalize, to measure, and to understand various objects. The problem, that can be an advantage, is that that cross-disciplinary concepts are often suffering from mutations due to their reification. It is especially the case with social sciences. Sometimes it is a positive evolution of a term, like the minimalist definition of agent proposed by Ferber [1] that meets an agreement in many disciplines. Sometimes it is damageable because the formalization reduction only focuses on parts of the addressed concept or problem. This is what we want to develop here concerning the sociological notion of power.

On this topic, the long time relationship between social sciences and SNA, has certainly advantaged this later. Indeed, from Moreno [2], to Molm [3], Freeman[4] or Grosseti [5], passing by Granovetter [6], Blau [7] or Burt [8], there is, since a few decades, a very strong bond between these disciplines. This dynamic has begun to tie up in the USA, and it is grounded in the sociology of organizations and social exchange theories.

We continue this section by exposing the, maybe, common root of all these works (in sociology of organization, MAS, and SNA) on power: Max Weber [9], [10]. Then we develop power perspective in social exchange theories and, after that, how social exchange theories has been developed in MAS.

We are not sure that lineage: exchange theory (Homans [11], Blau [7]) → power-dependence theory (Emerson [12]) → network dependence theory in MAS ([13], [14], [15], [16]), is the only and complete way to catch the concept of power, even if it is very fruitful.

So, we propose to climb down the tree until Blau and Crozier meeting and to explore another branch of the sociology of organizations: the French *sociology of organized action* also known as *strategic analysis* ([17], [18], [19]). We introduce and formalize it in section 2.

Section 3 introduces several indices aiming at seizing power in a complex perspective and providing many points of view on power: dyadic, systemic, relative, strategic - that can be interpreted in many theories as strategic analysis or gift-giving paradigm [20].

We conclude by showing the limits of our work, and propose a way to combine it with other measures of power from SNA.

1.1 The sociological roots

So, what is the starting point? As a part of each political ideology, power, its forms, its expression, and its management, has been thought as far as human beings had to think the organization of the city, the society. We thus don't pretend here, and are not legitimate, to cover authors as Platon, Machiavelli, Hobbes, Marx or Rousseau, who have deeply spoken on power. We modestly want to start our argumentation with modern sociology, beginning with the political sociology of Weber, because : (1) "every organizational approaches found their roots in the work of Weber" [21], (2) as we will show, MAS and SNA are (partially) founded on sociology of organizations and actively take part to its construction, and (3) these three research fields address more or less directly the notion of power.

Lawyer, historian, economist and sociologist Max Weber (1864-1920) is considered to be one of the founders of modern sociology. As such, its work has been well studied, and one can refer for example to [9] or [10].

In its studies of social phenomena, Weber gives the primacy of explanation of the actors' actions, in a posture known as *methodological individualism*. That is, he tries to explain the structure and the evolution of some social facts by questioning the actors' motivations, and, in a somewhat empathic way, by understanding what are the causalities of their actions.

In the field of political sociology, he establishes a *theory of legitimate domination*, where the *domination* is a special social relation between actors, where one is *ordering* another and the other one orients his behavior toward this order according to its *validity*. The validity is assessed depending on the order *legitimacy*, and it will likely determine a conforming behavior, an avoidance behavior or a disobedience one. Following the methodological individualism posture, Weber propose four typical reasons for a subject to legitimate an order: the tradition, the affective or emotional belief, the value-rational belief (*value-rationality*) and the legality ; one can also follow an order only on the base of a pure rational computation (*instrumental rationality*). Reasoning on salient features of phenomena, *ideal types*, Weber thus propose three types of domination : the *charismatic domination*, the *traditional domination*, and the *rational-legal domination* which characterize the *bureaucratic organization* of the modern state. He then exposes the routinization of organizations based on charismatic domination into a traditional or a rational-legal one. The modern times

¹IRIT – University of Toulouse, France, matthias.mailliard@gmail.com

²IRIT – University of Toulouse, France, sibertin@univ-tlse1.fr

We are thankful to our "reviewers": Paul Chapron and Samuel Thiriot.

routinization is thus based on sciences and legal rationality at the detriment of the magical, the mystical or the religious, what Weber calls “disenchantment of the world”.

To resume for our purpose, Weber gave us a notion of domination as an imbalanced relation; structuring organizations; whose maintain and evolution are ensured by rational motivated behaviors of actors. He provides a definition of domination as “*Macht bedeutet jede Chance, innerhalb einer sozialen Beziehung den eigenen Willen auch gegen Widerstreben durchzusetzen, gleichviel worauf diese Chance beruht.*”³ [22].

Following Weber, many works, in many disciplines, have been done on the organizational phenomenon, and at the very beginning they were rather focused on the mechanist theories of the contemporaries, Taylor [23] and Fayol [24], than on the sociology of Weber. As a simplification, we can say that these sociological approaches about organizations not only focus on firms; they adopt the frame of a theory of action (for example as T. Parson or R.K. Merton) which considers the organization not as an entity but as the product of the activity of social actors provided with cognitive abilities, goals that are their own, and are constantly making choices (instead of being essentially reactive, according to the school of human relations). They always integrate a view of the organization and adopt the principles of bounded rationality of Herbert Simon [25][26] (individuals are not omniscient and adopt the first solution found that lead them to a better situation than the current one) and procedural rationality (i.e. a decision is taken not because it is the best in terms of outcomes, but because the decision procedure is considered as the best available).

1.2 Power and social exchange

The issue of social exchange, it will be addressed by exchange theories or in the paradigm of gift-giving [19] (or *potlatch* [27]), has led to develop interesting concepts of power. Moreover, we will show later that authors about social exchange have also inspired many works in social network analysis and in agent-based social simulation.

1.2.1 Exchange theories

Exchange theories are mainly founded on the works of George Homans [11] and Peter Blau [7], the former more interested in the structuring of interpersonal relationships at a micro-level (groups), and the later rather in the complex structuring of macro-sociological phenomena. The theory then develops with Emerson [12], which proposes a reticular and well formalized conception of exchange. The network theory of exchange assumes that power is based on resources, access to alternative sources, frequency of interactions and connections between relations. Linda Molm summarizes and develops the theory [28] by including the dimension of coercive power [3] with an interesting reasoning on its exercise and the risk of breaking the relationship an abuse could entail⁴.

1.2.2 Gift and potlatch

³It seems there is a debate on the translation in English. Here is the translation proposed by Talcott Parsons: “*The probability that one actor within a social relationship will be in position to carry out his own will despite resistance, regardless of the basis on which probability rest.*”

⁴About this kind of process we can also refer to Hirschman [29] who expose a twofold ways to resist when loyal: voice (i.e. explicitly entering in confrontation) and exit (i.e. breaking the relation).

Potlatch is basically a ceremony in the course of which goods are distributed among rival tribes in North America during the 19th century. The more the gift offered to another was important, the more this one was obliged to reciprocity or overbidding, and had to get rid of this debt under the menace to enter in conflict, or, even, in war. This particular form of exchange was erected by Marcel Mauss as a model of gift-exchange, based on a threefold obligation *to give, to receive and to reciprocate*. It is also known as the gift-giving paradigm.

Marcel Mauss [19] has raised the potlatch as a major concept of anthropology : a *total social fact*, that is to say with: religious, morphological, legal, shamanic, aesthetic and economic features.

Due to its nature of being a total social fact, the potlatch seems furthermore interesting to understanding of power: the threefold obligation to give, to receive and to reciprocate; the waste of goods as a way to express a superior position of domination; symbolic exchanges; creation and maintenance of social links; acquisition of prestige, status and social roles; etc.

1.3 Social exchange in MAS

The availability of already formalized theories lets an easier introduction of *the exchange theories* in the field of MAS and social simulation. These works are mainly founded, among others, on the work of Castelfranchi ([13], [14]), Sichman [15], Conte [16]. These authors summed up the results of the network exchange theory to produce frameworks for the representation of dynamic and open social organizations. By this way, the agents of these organizations are able to represent themselves the organizational system, and to mobilize this knowledge into decision making processes. This is for example suggested in [15], [30], [31], [32]. Social mechanisms of coordination are then proposed on the basis of these representations, as such, the engagement of agents in coalitions [15], depending on their goals and some measurement of their dependence that they compute from their knowledges or believes.

In these works, power is the counterpart of the *dependence*. It subsumes different concepts: *power to* (autonomy of action and access to resources), *power on* (an actor that is dependent to complete a goal), or the *institutional power* [33].

The MAS approach of exchange theories can in fine be viewed as a descriptive theory, more useful for (agent) decision making, than for understanding social phenomena. It is thus not a coincidence that these works are mainly used in the context of software applications such as peer-to-peer systems or auctions. If they have led to a comprehensive approach of mechanisms involving trust and reputation, we regret that the same effort was not oriented for mechanisms involving/of power, especially as the sociological exchange theories are closely interested in, especially, the work of Linda Molm about coercive power [28].

It is somewhat surprising that potlatch, which, according to [34], has greatly inspired the founders of exchange theories, has not successfully spread in MAS. However, two works in agent-based simulation deal with the gift-giving paradigm:

- The work of J. Rouchier and F. Bousquet [35] studies the construction of the reputation of individuals within a society based on trade in terms of *prestige gifts* or *share gifts*, following their desire of prestige or social integration.
- The work of [36], about an artificial market of tasks, introduces the possibility of gift exchanges to build long term dyadic relationships. They are supposed to enable alliances, to reinforce confidence, and to organize market.

2 FORMALIZING STRATEGIC ANALYSIS

2.1 Sociology of organized action

Crozier and Friedberg have developed a sociological theory of organizations, indifferently called *sociology of organized action* or *strategic analysis*, whose main objective is to unveil actors' context of action to understand why they behave as they do. They are interested in organizations more or less structured whose members are engaged in middle or long term relationships for the achievement of the organization's purpose, including organizations such as administrations, firms, institutions, etc, whose boundaries and action context are more or less well defined.

Crozier and Friedberg, define organizations as *concrete systems of action*, structured as and by interleaved games of power. Power is an imbalanced relation where actors exchange behaviors. The exercise of power is exerted by means of whatever resources, called *zones of uncertainties*. They are the ingredients of action, they mediate the interactions, and thus are the support of power relations.

Relations of power are multidimensional, n-ary, interleaved. We thus propose to decompose them into chunks, called *relations*. Each one include a (*relational*) *state* attribute whose value is *controlled* by only one actor and corresponds to the specific behavior he adopts. This behavior is constrained by his *room for manoeuvre* and will determine the access by others to the resource underlying the relation. This access is more or less valuable for the actors following their resulting *action capability*, and the amount of interest, or *stake*, they accord in accessing this resource. Finally, the state of a relation can affect the *room for manoeuvre* of another relation.

The actors are considered as bounded rational and their actions are goal oriented: in a methodological perspective (*methodological utilitarianism*) they are considered as being strategic; or in a Weber or Boudon style, they always have good reasons to do what they do. The actors' strategic rationality make them to increase or maintain their control on the resources of power (i.e. *zones of uncertainties*) in order to get a high action capability from others. Their actions are constrained by the power relation structure which in turn is affected by their actions.

2.2 Formalization of strategic analysis

On this base, we have developed a formal meta-model of organizations *à la* Crozier and Friedberg [50]. We expose here the main part of this formalization:

Relations

- R is the set of *Relations*.
- $control \subset R \times A$ denotes that an actor controls a relation. The $a \rightarrow r$ is equivalent to $a \text{ control } r$.
- R_a is the set of relations *controlled* by an actor a .
- $S_r = [-1; 1]$ denotes the space of states for a *relation* r .
- $M_r = [b_{min_r}; b_{max_r}]$ represents the space of states of a *relation* r that can be accessed by its controller, that is its *room for manoeuvre*. It is characterized by its boundaries: $-1 \leq b_{min_r} \leq b_{max_r} \leq 1$.
- $S_R = \prod_{r \in R} S_r$ is the set of state vectors of the relational structure. $s_R \in S_R$ is called a *situation*.

- $S_O = \prod_{r \in R} S_r^3$ is the set of the states of the organization.
- $constrain \subset R \times R$ denotes that the *room for manoeuvre* of a *relation* is determined by another one. We assume that the notation $r_1 \rightarrow r_2$ is equivalent to $r_1 \text{ constrain } r_2$. We treat cases where if $r_1 \rightarrow r_2$ then $\exists r_3, (r_3 \rightarrow r_1) \vee (r_3 \rightarrow r_2)$.
- If $r_1 \rightarrow r_2$, $M_{(r_1, r_2)}: E_{r_1} \times E_{r_2}$ is the function which determines the *room for manoeuvre* of the relation r_2 .

Actors

- A is the set of actors.
- $(E_{action_cap}, +, \cdot) = (\mathbb{R}, +, \cdot)$, is the ordered vectorial space of action capabilities. We can thus combined elements together or with a real (the *stake*, the *solidarity*).
- $E_{payoffs} = [-10; 10] \subset E_{action_cap}$ is the payoffs space.
- $E_{stake} = [0; capital_{stake}] \subset \mathbb{R}$ is the set of stakes such that $capital_{stake} = 10$.
- $E_{solidarity} = [-capital_{solidarity}; capital_{solidarity}]$ is the domain of solidarities such that $capital_{solidarity} = 1$.
- $Actions_r = [-2; 2]$ is the action set for a relation r . An action a is valid for a relation state e_r if it is in the scope of the *room for manoeuvre*: $e_r + a \in M_r$.
- $Action_a = \prod_{r \in R} Action_r$ is the action set for an actor a . It is composed by the action sets of each relation r such as $a \text{ control } r$.
- $Effect_r: E_r \times A \rightarrow E_{payoffs}$ is the function that fixes the action capability that an actor can mobilized using the resource underlying the relation r . It depends on the state of r , i.e. the behavior the controller of r adopts. The result of the effect function of r is called the *payoffs* given by r .
- $stake: A \times R \rightarrow [0; 10]$, denotes the relative importance an actor gives to a relation to fulfill its goal. The amount of stake. We assume that $a \text{ depends on } r$, $r \rightarrow a$ or $stake(a, r) > 0$ are equivalent.
- $solidarity: A \times A \rightarrow [-1; 1]$ sets the positive or negative solidarity of one actor toward another. Negative solidarity can express conflict, animosity, or concurrent goals, while positive solidarity expresses the usual definition of the terms, friendship, or a necessary structure for a successful cooperation. We assume that the amount of absolute solidarity is the same for each actor $\forall a \in A, \sum_{b \in A} |solidarity(a, b)| = 1$. Solidarity is aimed at orienting action of actor by helping or confronting others.

2.3 Organization as a social game

As demonstrated in [37], and following Crozier and Friedberg, a concrete system of action can be seen as a social game. This game is running, embedding as many models of rationality as we have hypotheses about how power transactions occur, evolve, and regulate the organization into a stabilized structure of exchanged behaviors.

3 COMPLEX MEASUREMENT OF POWER

Thanks to the mathematical structure of organization, inspired from the Crozier and Friedberg theory, we are able to define and

compute quantities that are relevant from many paradigms, such as gift-giving, cost/advantage and strategic analysis. This gives us a complex perspective on the concept of power.

3.1 Impact of the controller behavior on the action capability of the dependent actors

Impact is an index that measures the action capability a relation provides to an actor depending on its state. The *impact* of a relation represents its contribution to what is globally received by an actor, and that we called his *satisfaction*.

Impact of a relation on an actor is a combination of:

- the *effect* of the controller behavior, that is the relation's *state*, on the actor's action capability; it is the *payoffs* given by a relation;
- the *stake* of the actor for this relation.

Moreover, an actor can take into account the impact of the relation on others, following the nature and the intensity of its links of solidarity.

We thus have two ways to compute *impact* of a relation r on an actor a for a given relation state s_r :

- If we only focus on actors payoff and stake, we will speak of *ego-centered impact*, noted: $impact_{ego}$:

$$impact_{ego}(r, a, s_r) = effect(r, a, s_r) \cdot stake(r, a) \quad (1)$$

- If we take its solidarities into account we will speak of *socio-centered impact*, noted $impact$ as its the canonical form of impact we use:

$$impact(r, a, s_r) = \sum_{b \in A} sol(a, b) \cdot impact_{ego}(r, b, s_r) \quad (2)$$

As *impact* is the base of other indices, there is always an *ego-centered* and a *socio-centered* version for each index.

3.1 Satisfaction: to receive

By estimating and combining the impacts of each relation he depends on, an actor has the ability to assess the situation, i.e. what he receives from others. We call this combination his *satisfaction*. For an observer, *satisfaction* is the whole measure of the action capability an actor can mobilize to fulfill its goals, and eventually to counterattack or to cooperate in the fulfillment of others' goals. For an actor, *satisfaction* is a way to estimate his current situation, to relate it to previous decisions and to make the next one. It is thus of first importance to assess the quality of transactions in the course of power relationships. A basic way to compute satisfaction in a situation s_R , is to add-up impacts:

$$satisfaction_{ego}(a, s_R) = \sum_{r \in R} impact_{ego}(r, a, s_r) \quad (3)$$

$$satisfaction(a, s_R) = \sum_{r \in R} impact(r, a, s_r) \quad (4)$$

It is also of interest to know the amount of satisfaction an actor provides to himself by the way of the relations he controls:

$$controlled\ satisfaction(a, s_R) = \sum_{r \in R_a} impact(r, a, s_r) \quad (5)$$

and to know the overall satisfaction of the organization. This index is a tool to guide the analysis of simulations or to detect big incoherences in organization design, but it is clearly not a measure of the vitality, or the well being inside an organization:

$$cumulated\ satisfaction(s_R) = \sum_{a \in A} satisfaction(a, s_R) \quad (6)$$

3.2 Power: to give

The *power*, as defined here, is an index of the exercised power. Following the thesis of Crozier and Friedberg, this index reveals a part of the "imbalanced exchange of behaviors". It expresses what is given to others in terms of action capabilities during, or at the end, of the exchange process, and thus it depends on the state of the involved relations. This measure takes into account the subjectivity of actors (*stake*) and their solidarities, it is thus based on *impact*. *Power* can be seen as the amount of positive or negative satisfactions an actor provides to one or many others.

If we adopt the definition of power given by R. Dahl (quoted in [19]): "*A has power over B to the extent that he can get B to do something that B would not otherwise do*", then the index we propose returns "*the means implemented by A to get B to do Y*" (without guarantee of success). In this perspective, a positive contribution of A to the satisfaction of B can be interpreted as:

- a gift forcing B to reciprocity (to do Y)
- a counter-gift to honor a debt contracted by A to B
- the fact of yielding to a pressure exerted by B
- an opportunity, due to transactions of A with other players, that benefits B.

Conversely, a negative contribution of A to the satisfaction of B can be interpreted as:

- a reaction to the non-reciprocity of B in its trade with A,
- a coercive means to constrain B to do Y
- a response to a pressure of B
- a penalty, due to transactions of A with other players, that penalizes B.

Accordingly, we define the *power* of a over b , *relative power* of a over b , *effective power*, or *cumulated power* for a given actor:

$$power(a, b, s_R) = \sum_{r \in R_a} |impact(r, b, s_r)| \quad (7)$$

$$relative\ power(a, b, s_R) = power(a, b, s_R) - power(b, a, s_R) \quad (8)$$

$$cumulated\ power(a, s_R) = \sum_{b \in A, b \neq a} power(a, b, s_R) \quad (9)$$

These indices are underlying postulates showing that, for Crozier and Friedberg, power is expressed as the way an actor knows how to be unpredictable. By using absolute *impacts* in equation (7), we thus evaluate the intensity of power for one actor, that is how things can change, for one (equation (7)) or all other actors (equation (9)), depending on his behavior. Actor's power of high intensity can be the result of high positive and negative impacts on distinct relations, and so could be considered as inconsequential in other(s)' goal fulfillment. Nevertheless, he is thus armed with high room for manœuvre, making him unpredictable^{5,6}.

A more effective version of power should also be considered as it expresses the amount of satisfaction given by an actor to another one (X) or everyone else (X):

$$eff\ power(a, b, s_R) = \sum_{r \in R_a} impact(r, b, s_r) \quad (10)$$

⁵The interpretation can differ to what we just say, and have to be validated by correlation with more observations (the number of involved relations, the previously played actions, the fact that some relations could be blocked ...).

$$cumulated\ eff\ power(a, s_R) = \sum_{b \in A, b \neq a} eff\ power(a, b, s_R) \quad (11)$$

The SocLab⁷ environment [40] shows these indices (and many others) in the form of matrices or as labels tied to edges or vertices of the organizations' network, so the cited indices of power can be rapidly compared to each other⁸.

3.3 Concession: to concede

The notion of concession appeared as soon as we have addressed the construction of a measure of the strategic use of power, following the *methodological utilitarianism* and the strategic nature of actors [19]. We remind that we are not in a one move game: in social game, the end is, for each actor, to find a behavior that is satisfactory for himself and for others, so that the organization can go on in this way. This sustainable behavior is what we call his strategy.

Whether the equation is based on: "I'm as strategic as I give little and receive plenty", so the equation becomes easy: *strategic* = *receive* – *give* = *satisfaction* – *power*. But what is given is not what is lost⁹.

The giving of action capabilities through *relations* also has an effect on the actor's own capabilities. He is ready to concede (that is, literally, to cede in a relationship) something because he expects a (positive) social reaction (reciprocity, obedience, ...). We thus propose to measure what an actor concedes, by comparing how he could have satisfied himself by its own, let's call this *autonomy*, with how he effectively satisfies himself, let's call this *controlled satisfaction*.

3.3.1 Autonomy

Let's first reason on only one relation *r*. Taking into account potential constraints on *r*, we can compute the best impact the controller of *r* can obtain only by himself, in order to maximise his satisfaction (this is his Nash-equilibrium behavior). Being careful about the cases where he is also the controller of *r'* such as *r* → *r'* or *r'* → *r*, we can compute *autonomy* as:

$$autonomy(a) = \sum_{r \in R_a} \max_{certain\ impact}(r) \quad (12)^{10}$$

3.3.2 Concession

We are now able to propose two concession indices: a dyadic one, and a systemic one. Concession of on actor *a* to an actor *b* is the difference, regarding the relations he controls and *b* depends on, between what he could have and what he actually has:

$$concession_to(a, b, s_R) = \sum_{r \in R_{a \rightarrow b}} \max_{certain\ impact}(r) - \sum_{r \in R_{a \rightarrow b}} impact(r, a, s_R) \quad (13)$$

We can assess, in a dyad, the difference between the concession of each actor. This *relative concession* is, in some way, the dual of the *relative power*. *Relative power* is founded

⁶A good way to measure the potential unpredictability of an actor *a* is to measure its *structural power*:

$$structural_power(a) = \max(power(a)) - \min(power(a))$$

⁷<http://sourceforge.net/projects/soclab/>

⁸We thus don't need to use a *mean power* ((power(a, b) + power(b, a)) / 2) to seize the whole intensity of power between two actors, as in [38].

⁹Indeed, social games are not zero sum games (while some economic games are).

¹⁰*max certain impact* is a measure of the maximum impact an actor can obtain by his own. It is too long to be exposed in the present paper.

on a difference of gifts, while *relative concession* is founded on a difference of losses. The first index enlightens gift-giving logic of power, the one who has power is the one who gives the most and proceeds to the creation of a debt that will take its full potential over time, while the second enlightens a cost / advantages logic:

$$relative\ concession(a, b, s_R) = concession(a, b, s_R) - concession(b, a, s_R) \quad (14)$$

In the systemic version, concession is not computed by adding the dyadic version for each actors:

$$concession(a, s_R) = autonomie(a) - controlled\ satisfaction(a, s_R) \quad (15)$$

It is because *relations* can impact many actors, so, if for example *a* → *r*, *r* → *b*, and *r* → *c*, then what *a* concedes to *b* is the same value as when *a* concedes to *c*. So we cannot distinguish to which actor, *b* or *c*, *a* is conceding.

This reveals a problem in many sociological attempts to define power, as the ones of Crozier or Dahl¹¹. These definitions consider power as having a dyadic nature, although it has a system wide extent.

The counterpart of this not dyadic nature is that actors can use opportunistically *concession_to* as an argument in negotiation with several actors at once.

3.4 Transactional advantage

Going one step further, it is possible to propose a measure of the negotiation quality of an actor *a*, involved in transactions with *b*, by counting the difference between what *b* gives to *a* and what *a* concedes to *b*, and by removing the minimum that *b* must give to *a*. This gives a measure of the strategic exercise of power of an actor, we call *transactional advantage*. The dyadic version is given as follows:

$$transactional_advantage_{(a,b,s_R)} = power(b, a, s_R) - \min_{s_R}(power(b, a, s_R)) - concession_to(a, b, s_R) \quad (16)$$

This definition suffers from the same shortcomings as indicators of dyadic concession so we will prefer the systemic version, *global transactional advantage*, based on the systemic version of the *concession*:

$$transactional_advantage_{global}(a, s_R) = (\sum_{b \in A, b \neq a} power(b, a, s_R)) - concession(a, s_R) \quad (17)$$

4 CONCLUSIONS

To support our considerations about power, we have propose an index toolkit that permits to construct one's own definition of power, following the considered organization and topic. We have exposed major issues in sociological and network exchange theory definitions of power:

- considering power in a dyadic way lead to approximations: power is systemic,

¹¹I set apart their definitions from their overall works that covers far more than we discuss here.

- in social exchange, what is given must be think in conjunction with what is conceded.

Considering these two points, the strategic exercise of power can be evaluated accurately.

Agent-based social simulation could benefit of the proposed indices:

- analysis of organization: they enable a precise and multi-level analysis of power games and could be complete with social network analysis (see next subsection),
- analysis of organization design: they enable to validate the global coherence of organizational model. Usage in mechanism design must be considered (see last section).
- agent rationality: indices can be used in the decision making process of strategic agent ([39], [49]), or as arguments in negotiation process. Imprecision of dyadic indices make them good candidates for bound rational agent ([39], [49]).

4.1 Articulating MAS and SNA perspectives on power in sociological analysis

The proposed multi-agents formalization of *concrete systems of action* and our indices are expressive enough to handle the main types of resource of power. Due to the amount of informations needed to feed such models, they are dedicated to organizations with a small number of (individual or collective) actors ([40], [41]). We thus introduce the possibility of a smart joint use with SNA. First, SNA have some indices good at handling communicative type resources of power, such as *betweenness centrality* [4] or *closeness centrality* [42]. Second, these indices don't need large amount of informations, so that they can be used on large scale representations of social organizations. For these reasons, we think that there are two possible ways to articulate our proposal with SNA:

- *Strategic zoom*: a SNA where we zoom in a subset of the network to make a strategic analysis.
- *Reticular zoom*: a strategic analysis where we zoom in a collective actor to make a SNA analysis [43].

4.2 Mechanism design

Other works could be of interest to our ones, especially *mechanism design*. *Mechanism design* is often used in economics, political science or theory of votes to define rules ensuring a fair operating, no abuse from ones at the expense of others. Mechanism design is at the crossroads of social choice and equity theories ([44],[45],[46]), game theory, and has reached computer sciences and MAS ([47], [48]). These works are particularly interested in coalitions, their formations, and power.

5 REFERENCES

[1] Ferber, J., 1999. *Multi-Agent Systems*. Addison-Wesley.
[2] Moreno, J. L., 1986. *Théâtre de la spontanéité*.
[3] Molm L. 1997. *Coercive power in social exchange*. CU Press
[4] Freeman, L. C., 1977. A set of measures of centrality based on betweenness. *Sociometry*, 40:35-41.
[5] Grossetti, M. 2004. *Sociologie de l'imprévisible*., PUF.
[6] Granovetter, M., 1978. *Threshold Models of Collective Behavior*. The American Journal of Sociology, Vol. 83, No. 6. (May, 1978).
[7] Blau P. 1964. *Exchange and Power in Social Life*, J. Wiley & Sons.
[8] Burt R. 1992. *Structural holes. The Social Structure of Competition*, Cambridge, Harvard University Press, 310 p.
[9] Aron, R., 1976. *Les étapes de la pensée sociologique*, Gallimard.
[10] Boudon R., 2005. *Pouvoir*. In *Dictionnaire de la pensée sociologique*. PUF, Paris.
[11] Homans G. 1958. *Social Behavior as Exchange*. Am. Jo. Sociology.
[12] Emerson R. 1976. *Social Exchange Theory*. An. Rev. Sociology.
[13] Castelfranchi C. 1990. *Social Power: a missed point*, in DAI, MA and HCI. In *Decentralized AI*. Y. Demazeau & J.P. Mueller.
[14] Castelfranchi C., Cesta A., Miceli M., *Dependence relations among autonomous agents*. Decentralized A.I.3: Elsevier., 1992.
[15] Sichman, J., 1994. *Du Raisonnement Social Chez les Agents: Une Approche Fondée sur la Théorie de la Dependence*. PhD Thesis.
[16] Conte, R., Sichman, J., 1995. *DEPNET: How to benefit from social dependence*. Journal of Mathematical Sociology. Vol.20. 2--3.
[17] Crozier, M. *Le phénomène bureaucratique*, Paris, 1963.
[18] Crozier, M., Friedberg, E., 1977. *L'acteur et le système*, Seuil, Paris
[19] Frieberg, E., 1993. *Le Pouvoir et la Règle*, Seuil, Paris.
[20] Mauss, M., 1924. *Essai sur le don. Forme et raison de l'échange dans les sociétés archaïques*. Année Sociologique, 1923-1924
[21] Crozier, M., 2005. *Organisation (Théorie des)*, Dictionnaire de la pensée sociologique, PUF, Paris.
[22] Weber, M. (1971 [1921]) *Économie et société*, Paris, Plon.
[23] Taylor, F.W., 1902. *Shop Management*, A.S.M.E., vol. XXIV, 1902.
[24] Fayol, H., 1916. *Administration industrielle et générale*, Dunod.
[25] Simon H., Newell A., 1972. *Human problem solving*, Prentice-Hall.
[26] Simon, H., A., 1969. *The Sciences of The Artificial*.
[27] Malinowski B., 1922. *Argonauts of the Western Pacific*. Dutton.
[28] Molm, L., 1997. *Coercive Power in Social Exchange*, CU Press.
[29] Hirschman, A., 1970. *Exit, Voice and Loyalty*, Harvard Univ. Press.
[30] Lopez y Lopez F, Luck, M., *Empowered Situations of Autonomous Agents*, in *Advances in Artificial Intelligence IBERAMIA 2002*.
[31] Hübner J., Sichman J. S., Boissier O., 2004. *Using the MOISE+ for a Cooperative Framework of MAS Reorganization*.
[32] Herzig & al., *Prolegomena for a logic of trust and reputation*. NorMAS'08, Luxembourg, 2008.
[33] Jones A, Sergot M., 1996. *A formal characterisation of institutionalised power*. Journal of the IGPL.
[34] Cook K., Mauzet M., 2005. *Echange social*. In *Dictionnaire de la pensée sociologique*, PUF, Paris.
[35] Rouchier J., Bousquet F., O'Connor M., 2001, *Emergence of reputation in an artificial society*. JASSS, vol 4 issue 2.
[36] Alam S. J., Hillebrandt F. and Schillo M. (2005) *Sociological Implications of Gift Exchange in Multiagent Systems*, JASSS, v.8.3.
[37] Mailliard M., & al., *Cooperation is not always so simple to learn....* AESCS IV. Springer-Verlag, p. 147-154, september 2007.
[38] Molm L., 1990. *Structure, Action, and outcomes: the dynamics of power in social exchange*. American Sociological Review.
[39] Mailliard, M., Roggéro, P., Sibertin-Blanc, C., 2006. *Un modèle de la rationalité limitée des acteurs sociaux*. JFSMA'06, Hermès.
[40] Mailliard M. 2008. *Formalisation Multi-Agents de la Sociologie de l'Action Organisée*. PhD Thesis, Toulouse, december 2008.
[41] Vautier C., Roggero P., Adreit F., Sibertin-Blanc C., 2009. *Evaluation by simulation of the social acceptability of agricultural policies for water quality*, 4th Int. ICSC Symposium on Information Tech. for Environment Engineering, ITEE'09, Springer-Verlag.
[42] Sabidussi, G., 1966. The centrality index of a graph. *Psychometrika*.
[43] Sturma, A., 2007. *Expertise et interdisciplinarité*. Master Thesis.
[44] Arrow K., 1963. *Social Choice and Individual Values*. J. Wiley & S.
[45] Coleman J., 1990. *Foundations of Social Theory*, Harvard U. Press.
[46] Sen A., 1979. *Equality of What?* Stanford University.
[47] Rosenschein & Zlotkin, 1994. *Rules of Encounter*, MIT Press.
[48] Dash R.K., Parkes D., Jennings, N.R., 2003. *Computational Mechanism Design : A Call to Arms*. IEEE Intelligent Syst. 18(6)
[49] Chapron P., El Gemayel J., Sibertin-Blanc C., 2009. *Impact of tenacity upon the Behaviors of Social Actors*. Applied Agent based simulator Engineering for Complex System study, Nagoya, Japan.
[50] Sibertin-Blanc C., Amblard F., Mailliard M., 2006. *A Coordination Framework based on the Sociology of Organized Action*. COIN'06.