Efficient coalition formation and stable coalition structures in a supply chain environment

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Abstract

We study a real supply chain environment from which specific information and knowledge can be extrapolated for other similar environments. We focus our research on the analysis of the interactions between members forming different teams (and between the teams themselves), and on the leader's management of the supply chain.

We note that there are many elements that contribute to the profitability of the network, which is dependent on the actions of the actors involved. We analyze certain characteristics that the actors have, such as their behavior, adaptation and learning levels, effort and willingness. Based on these components, we examine the performance of our actors and of the teams that the actors form.

We provide specific calculations that take into account most of the components determining the added value to the system. One of the advantages of our main formula is that it can be used to monitor the progress of the actors, as well as it can help in the identification of problematic aspects impeding in the creation of value for the system.

Our formula is very flexible and a modeler is able to adapt it to similar environments, providing him with great insight in the structures that he investigates.

We study certain theoretical games from which we uncover certain information and characteristics of similar environments and settings. Moreover, we provide a real life example in order to truly understand the mechanism of the network, and validate our theoretical assessments.

Moreover, we provide certain recommendations for a leader that is responsible for the supervision of actors (which have specific responsibilities) and the administration of a supply chain environment.

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Part 1
1.1. Introduction[3]

There are many theories that treat and describe (theoretically) coalitions and coalition formation (i.e., behavior theories, group dynamics, social psychology, psychological studies, evolutionary studies, etc). For the purpose of this paper, we are interested in the reality of coalition maintenance. Thus, we study a real environment from which specific information and knowledge can be extrapolated for other similar environments and situations.

Teamwork is critical for the success of any firm. Well-established companies focus on the training and education of their employees, and on the understanding of how their virtual enterprise works. In today's dynamic, multi-level segregated information and interactions, and, simply put, complex economic-society, successful companies focus on the tangible aspects of their operations, on the virtual inter-intra-connectiveness, as well as on the operations of the teams forming within the company. It is through this global performance that the overall success of the company is measured.

Any corporation must focus not only on the productivity (or revenues), but also on its employees, their development and on the interactions between the employees. In general, corporate companies focus on three aspects for the betterment of their employees:

1. Key aspects of team behaviors that are critical for the team success;
2. Diagnosing team behaviors (basically, identifying problematic behaviors);
3. Suggesting courses of action corrections, if need be.

In order to provide an adequate answer to these key components characterizing any team, we focus our research on individual agent actions, patterns of agents' interaction, and three distinct (yet correlated) models: individual, multiple, and global team model.

We analyze practical economic situations in which one cannot assume complete information for in real life situations there is no event where there is global complete information. Thus, the ability of agents to adapt to a changing environment (an environment where information is introduced sporadically and where information can change part of the setup of the environment) is essential. There are many examples where companies invest considerable time, resources and effort in order for their employees to be prepared for a change that is introduced.

The environment that we study has many aspects relating to supply chain (SC) environments. In general, SC analysis is characterized by transfers of inventory between the different networks present in the chain. Our paper focuses on the obligations of actors, how actors fulfill these obligations, the behavior of actors, either taken individually or collectively as a team, and their added value to the company.

The paper is set up in the following manner. In Part 1, we will have an overview of the literature and we will provide the basis for coalitions, as well as for supply chain environments. In Part 2, we will establish the characteristics of our game and the

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[3] The use of the masculine gender (regarding actors, players, individuals, etc.) includes the feminine gender.

responsibilities of the leader (that has certain control over the environment). Moreover, Part 2 will describe the payoff structure, provide the composition of the coalitions, and describe the different types our players' behavior. The actions of our actors and our understanding of the former are also portrayed in Part 2.

In Part 3, we will analyze the statistical data that we gathered, we will provide a further understanding regarding the payoffs to the actors, and we will describe in greater detail the core concept of a game. Moreover, we will analyze different games representing different situations that can arise in our environment. A detailed analysis of all the games that we study will also be provided in Part 3.

We end our paper with general remarks and certain recommendations regarding similar environments studied.

1.2. Overview

In human constructed environments, laws regulate social interactions and behavior (either individual or collective). Laws impose certain influence and constrains on the manner people behave in their social interactions, interactions where conflict is present between individual (or collective) interests and where the common good is at risk. As a result, laws are a mechanism of aligning individual and collective interests through operative behaviors.[4]

We observe that companies have well-established rules and regulations. Thus, we believe it is important to define and describe these vast terms. Anglo-Saxon jurisprudence tradition (Raz, 1980) refers to laws as '*obligations backed by incentives'*. Laws reflect certain rules of conduct, the obligations that are enforced by different means of penalties, and the rewards which refer to the incentives that an individual has. Obligations are people's responsibilities under the specific law, what people are asked to do (or not to do). Incentives represent the positive or negative *consequences* people face if they follow or do not follow the specific obligations. The implications of and how the latter influence individual behavior has been analyzed in different contributions of psychology and economics.[5]

The corner stone of a rule is the influence it has on individual behavior. Analysis has proven that legal rules (laws) can influence to a certain extent individual behavior through different material payoffs – incentives.[6] However, this view is limited in understanding why, for example, political parties obey legal rules if by disobeying the laws, the certain party (or actor, in our case) can relatively improve its payoff.[7]

We take special notice of certain findings that Galbiati and Vertova (2008, p 155) arrive at regarding the obligations that affect the levels of average contributions to a public good. They also explore different situations where an unexpected increase in the minimum contribution triggers a temporary re-start in the cooperation (that previously deteriorated) between the members, while an unexpected reduction in the minimum

[4] Galbiati and Vertova 2008, p 147.
[5] See Fehr and Falk, 2002.
[6] See Cooter and Ulen, 2003; Polinsky and Shavell, 2000.
[7] See Kahan, 2002; Robinson and Darley, 1997; Tyler, 1990.

contribution does not alter the descending trend of cooperation.[8] Another very interesting conclusion that Galbiati and Vertova (2008, p 159) have is that obligations have certain limits on individual behavior in social dilemmas.

It has been proven that there is an expressive function in laws. Thus, rules and laws provide a coordination device that helps in the understanding and comprehension of individual's beliefs about other's behaviors.[9] Moreover, regulations have a strong impact on psychological individual preferences. If the actors see the rules as fair (meaning that the same rules apply to all in the same manner), then the actors are 'forced' to revise their values and, subsequently, their conduct.[10],[11]

We point out that sanctions for non-cooperation could be understood through incomplete and very subtle contracts. Yet, this method is preferred with the intention to encourage a *second chance* for cooperation of the deviator (or the 'lawless') in order for the latter to have the opportunity to remedy himself.[12] However, this strategy creates certain *precedence*, and it impacts the subtleness of (other) contracts that are opened to interpretation. If the specific laws and contracts are not applied correctly, the leader[13] can be perceived as *loosing his power* (or authority) of influence because the latter creates the perception that he is inefficient. We also note that the lack of leader effectiveness or the illusion of it are almost equal in importance in a short time span.

Mainstream economic and psychology literature has shown that both intentions and incentives play a key role in the manner that sanctions unfold.[14] We also note that incentives refer to impersonal rules of law[15], while intentions revolve around human beliefs and purposes. The lack of proper incentives is the main cause why threats of sanctions fail to induce cooperative behavior. In the same time, it has been proven by many researchers[16] that intentions are deterministic elements. Furthermore, researchers pointed out that the former also has an important role in shaping decisions.[17]

One of the theories that explains certain aspects referring to the individuals' actions and restrictions is cognitive dissonance theory. The latter theory (Festinger, 1957), including self-serving biases (Babcock and Loewenstein, 1997), upholds the idea that people long to have consistent beliefs (resulting in consistent behavior)[18]. Consistent

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[8] Galbiati and Vertova 2008, p 159.

[9] See Bohnet and Cooter, 2005; McAdams and Nadler, 2005; Cooter, 1998.

[10] See Cooter, 1998; Kahan, 1997.

[11] Galbiati and Vertova 2008, p 147.

[12] The following lesson is taken from psychology: if an actor has the 'initiative' of an action, the results will be longer lasting (and the actor will believe harder in it), than if the action is imposed on him from an outside actor or the environment. Moreover, if the lawless has the initiative (not imposed by the leader), than this enterprise will help the individual build his self-esteem faster.

[13] The leader is responsible for all activity of his direct reports.

[14] Fehr and Schmidt, 2007; Fehr and List, 2004; Andreoni et al., 2003; Camerer, 2003; Fehr and Rockenbach, 2003; Fehr and Falk, 2002; Sefton et al., 2007; Dickinson, 2001; Fehr and Gächter, 2000a; Gneezy and Rustichini, 2000a, 2000b; Bewley, 1999; Falk et al., 1999; Ostrom et al., 1992; Yamagishi, 1986, 1988.

[15] Houser et al. (2008), p 510.

[16] Falk et al., 2008, 2003; Charness, 2004; Charness and Levine, 2004; McCabe et al., 2003; Charness and Haruvy, 2002; Fehr et al., 1993.

[17] Falk et al., 2008, 2003; Fehr et al., 2007; Charness, 2004; Charness and Levine, 2004; Falk and Kosefeld, 2004; McCabe et al., 2003; Charness and Haruvy, 2002; Nelson, 2002; Offerman, 2002; Brandts and Solà, 2001; Fehr and Gächter, 2000b; Blount, 1995; Gordon and Bowlby, 1989; Greenberg and Frisch, 1972.

[18] Houser et al. (2008), p 511.

behavior, consistent beliefs, self-serving biases (and other concepts of cognitive dissonance theory) can explain partly why intentions have a strong influence on the actions of individuals in economic environments.[19],[20]

We see a real need for analyzing individual behavior and the elements that influence cognition because they play an important role in today's regular interactions. Moreover, cognitive psychology literature has shown that actors have a tendency to find similarities (varying from outside environment(s) to internal cognition processes) even though there are no assurances of their existence.[21]

Alloy and Tabachnik (1984) suggest that having such consistencies helps researchers understand past behavior and predict future ones.[22] Moreover, the same authors proved that certain types of obligations influence the rate of decline of cooperation over time, an aspect that is essential in our research.

1.3. General remarks on coalition

We know that politics, economics (and economy)[23] are present in a corporation. Thus, in order to 'survive' in such an environment, one must be a member of an alliance (a coalition).

In our research, we refer to teams as coalitions of different members that have a similar interest. We differentiate between *business coalitions* (strategic level), where business interests are at stake (over which the leader has full authority) and *personal coalitions* (social level), which denote similar personal interests of the actors (over which the leader has no authority and no control over them).

In general terms, a coalition (besides being a multi-agent system) is an alliance among individuals or teams that engage in a common action for the accomplishment of a common purpose. We note that certain cooperative literature stipulates that coalition participants' self-interests must be present for there must be a valid reason for the formation of the specific coalition. In our game, there are certain personal self-interests that are tangential to the interests of the coalition.[24] However, personal interests have no relation with the formation of the work coalition. It is the leader that forms the business coalition. In our research, we focus on the latter type of the coalition, and we make the parallel between self-interests/personal interests (which may be represented in the literature as private goods) and business interests (which may reflect the public goods rational).

We refer to a private good as a benefit that is only useful for a specific individual. A public good is a reward that is applied to the entire community (and to all members of

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[19] Charness, 2004; Charness and Levine, 2004; Falk and Kosefeld, 2004; Falk et al., 2003; Charness and Haruvy, 2002.

[20] Extensive research has already been done on this topic. For some examples, see Konow, 2000; Rabin, 1994; Akerlof and Dickens, 1982; Festinger, 1957.

[21] For examples and detailed analysis, see Arkes and Harness, 1983; Allan and Jenkins, 1980.

[22] Sonsino and Sirota (2003), p 390.

[23] We make the distinction between economy and economics as in Popp, 2006b.

[24] An example of such a self-interest is the reward of the payoff given to the coalition, thus, to a member of the coalition. In this case, the personal and business coalitions are intertwined.

that community). In the same time, we do not disregard the presence of core(s) in our analysis.

Game theory (GT) does not provide specific formulas that agents can employ to form coalitions. The former focuses on asserting, verifying, and validating stability and fairness by Kernel concepts, and on calculating the corresponding (side-) payments to (and between) agents. We point out that throughout our analysis, we circumvent certain aspects and problems that mainstream coalition literature has. In our example, even if we use GT, we resolve one such difficulty of coalition formation by a mechanism through which the leader appoints the members to a specific coalition. Thus, we do not allow agents to form the teams that they desire (besides a deviation coalition – situation that we will analyze in section 2.3. and 2.4.). The coalitions are imposed. Having this approach, we simplify the coalition formation processes.

We note that there are three stages within the life of a coalition:

a) Members convey together and form a coalition;
b) Coalition maintenance, i.e. maintaining the coalition (excluding members; replacing excluded members);
c) Coalition termination: end of the coalition.

As stated before, we simplify steps a) and c) by providing the leader with control over these aspects. Our research focuses on the second step, coalition maintenance.

1.4. On supply chain environments

Game theory can help in expending the supply chain analysis (and literature), an environment where multiple agents are present and where diverging interests, objectives and directives exist.

Supply chain management (SCM) analyses mainly the integration of information and resources in the flow of a network. Yet, in this analysis, one must pay particular attention to important elements of the network, such as location, transportation and logistics, inventory and forecasting, incentives, reverse logistics, strategic alliances, and (the quality of) services. One of the goals of SCM is to provide the best distribution of resources (whatever those may be).

Even though GT is useful regarding some SCM aspects, in the same time, we acknowledge certain procedural limits when analyzing SCM using GT. One such difficulty is the fact that managers have problems in the implementation of mixed strategies, or determining what mechanisms must be utilized when determining mixed strategies. Another difficulty is the actual implementation of the specific mixed strategies.

We focus our research on the analysis of the interactions, operationalization and management of a supply chain.

We make certain distinctions between a network, a chain and a network chain. A *network* is an interconnected group that employs any method of sharing resources (may those be tangible or non tangible) between members or systems of the group in the purpose of gaining strength (of any manner). A *chain* is a well-organized structure formed by a series of nodes that are connected, forming a whole, where one node is connected to at least two other nodes (excluding the first and last nodes). A *network chain* (*supply chain* or *supply network*)[25] is a network of actors who coordinate the flow of information and resources, and cooperate in the process of converting the materials into products (or services) that are to be delivered to a client.

We note that any action that influences, may that be positively or negatively, the end result is part of the network chain (NC). Also, the end-result of any supply chain is the creation of value to either the service or the product of which the chain specializes in. Moreover, the structure of the NC plays an important role in the manner success is achieved throughout the specific network.

In order to better comprehend the characteristics of a supply network and how it applies to our game-environment, we will analyze: 1) the *process*, which identifies the mission and the procedures of the network; 2) the *performance*, which takes in consideration the variations in productivity/production and its reasons; and 3) the *institution*(*al*) *perspective* that refers to the network's configuration and structure. Moreover, we point out that there must be a strategy for the implementation and realization of the imposed mission.

One of the potential problems that a network-chain can exhibit is that some companies function in silos. A silo-company does not possess a powerful supply chain management. There is an unsynchronized decision-making process and lack of communication between silos that does not aid the company to properly face the challenges of the 21st century's complex economy. The former brings unnecessary high cost activities to the specific business, thus loosing the company's competitive advantage(s).

Another difficulty, which is challenging to grasp, is that companies must deliver to its clients a quality product, in a short time-span, at a good price. In order to accomplish this, pertinent information (accurate and adequate) must be available for those involved in the planning and execution of the different stages of the network. Yet, this information may not be accessible and/or user-friendly.

Throughout our paper, we will analyze some of the problems that corporations are facing regarding SCM, and we will try to provide certain recommendations to these difficulties.

Part 2
2.1. Characteristics of the game

As stated before, we analyze a real life situation in order to better understand the mechanics of stable coalition structures. The environment (E) of the game is representative of a particular set of supply chain procedures that form a semi-opened loop. The end-result of our NC is a set of service(s) provided to different clients.

[25] We consider throughout the paper the terms *network chain*, *supply chain* and *supply network* analogous.

The game is characterized by three different teams, which together may form the total core (Level 0, L_0)[26]. We also examine the grand coalition specific to each team, formed by its members (Level 1, L_1). Thus, L_1 illustrates the interactions of the individuals of the teams. The NC is established in four processes (P_{ni}), which are executed by three different teams (T_n). Thus, we have[27]:

a) $T_n = \{(T_1, T_2, T_3) \mid T_n \approx\rightarrow L_0)\}$,
where $t_{ni} \rightarrow T_{ni}$ and $t_{ni'} \in T_{ni'}$;[28]

b) $P_n = \{(P_1, P_2, P_3, P_4) \mid$ $(P_{1A}, P_{1B}) \in P_1$;
$(P_{2A}, P_{2B}, P_{2C}) \in P_2$;
$(P_{3A}, P_{3B}, P_{3C}) \in P_3$;
$(P_{4A}, P_{4B}) \in P_4\}$,
where all process sets and sub-sets are specialized[29];

c) $T_1 = \{(t_{1a}, t_{1b}) \mid T_1 \int (P_1, P_2)$,
where $(t_{1a}, t_{1b}) \wr (P_1, P_2)\}$;

d) $T_2 = \{t_{2a}, t_{2b}, t_{2c}, t_{2d}, t_{2e}, t_{2f}\} \mid T_2 \int P_3$,
where $(t_{2a}, t_{2b}, t_{2c}, t_{2d}) \wr (P_{3A})$,
$(t_{2e}) \wr (P_{3B})$,
$(t_{2f}) \wr (P_{3C})\}$;

e) $T_3 = \{(t_{3a}, t_{3b}) \mid T_3 \int P_4$,
where $(t_{3a}) \wr (P_{4A})$,
$(t_{3b}) \wr (P_{4B})\}$.

We have represented in Table 2 the description of the sets (and subsets) of the teams and processes, and we have provided in Figure 1 the workflow of our NC.

In such a structure, we have two major coordination perspectives: 1. vertical (between teams); and 2. horizontal (between the members of a specific team). For this reason, dynamic interactions between the members of the teams and between the teams themselves are encouraged. Moreover, we specify that the members of a team (or sub-

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[26] We have mentioned that we are interested in business coalitions (public goods). Analysis of a public goods context regarding the non-emptiness of the core in coalition games has been provided by Demange (1994), Greenberg & Weber (1986), Guesnerie & Oddou (1981). Meanwhile, Greenberg & Weber (1993) analyze the same situation from a political economy point of view.

[27] Refer to Table 1 of the Appendix for the legend of the symbols.

[28] Members of a specific team form the specific team, and the members of the specific team belong to that specific team.

[29] A specialized set or sub-set denotes a process that is covered by a specific team. No other team can cover and execute a process which it is not specialized in.

team) have symmetric roles. However, teams do not have a symmetric role due to our NC setup.

There is a predetermined production schedule where complete information regarding the amount of the demand of the service(s) is not provided by too much time in advance. Yet, members and teams are responsible and accountable for meeting specific expectations. Even if the overall process (procedural supply chain) is imposed by the leader, members have control over sub-processes, thus creating a semi-decentralized decision making process. We observe that the dynamics of the system increase having this approach. The overall success is dependent on the decisions and actions of the members of the teams. Moreover, the leader has a supervisory role where he verifies the end result.

We note that the Service Demand Harmonization (SDH) is of two (2) hours, which means that the members of the teams have two hours to complete P_1 to P_4. The quantity of the services rendered would suffer if the SDHs were not met[30]. In the same time, all teams' members must pay particular attention to the quality of their work, which is indicated in the overall quality of the services rendered by our Administrative Services Unit (ASU).

Moreover, our game is played daily because there is a one-day business cycle (no work is left for the following day).[31]

2.2. Leader

The leader (referred also as protocol manager) plays a central role within our game set-up. He has two key responsibilities: 1. customer service (being a liaison between the members of a team, between the teams, between teams and members, and between his direct reports and the other Business Units/departments (BUs)); 2. to oversee the good operation of his teams. The last attribute is broken in different subcategories: a) provide assistance to his direct reports and to his teams; b) he is responsible for the performance of all the functions within his department.

Moreover, planning and forecasting undergone by the leader are essential in the network. The accuracy of these two elements impacts the performance and processes of the network. We note that leader effectiveness can be measured by the procedures implemented and by the level(s) at which actors follow them.

The leader must be flexible and must be able to implement customized tasks imposed by the outside system, i.e. properly respond to the demand(s) of the environment. He must adapt fast and bring the team(s) to accept and follow the specific change. Thus, the protocol manager is also responsible for the distribution and redistribution of the tasks among the members of the coalition.

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[30] This is transferred to the team through negative payoffs.

[31] This setup is a simplification of the real procedures of a *normal* day within ASU. Processing incoming mail, prepping and scanning the documents (and cheques) is done between 8.30 and 12.30. The first SDH ends at 10.30, while the second SDH ends at 12.30. As of 13.30 (to 17.00), not only that the imaging team (member wise) is reduced, but their tasks are different. In the afternoon, t_{2i}, t_{3a} and t_{3b} focus on responding to requests of internal clients from other business units. Meanwhile, T_1, in contrast with the morning where it focuses on processing incoming mail, it focuses on processing outgoing mail in the afternoon.

In order for the teams (as well as the individuals) to perform at their best capacities (and capabilities), the leader must be capable to provide adequate social engineering and instill a specific social identity in the network. The cohesion of the members of the teams as well as between the teams themselves are an important task that the leader must take in consideration and to which he must allocate the necessary time and resources.

Moreover, beliefs learning and environmental adaptation play a central role in the daily behavior of actors. It is the leader that must provide the tools that are needed for the development of both staff as well as the latter's sets of beliefs (effective and appropriate).

Specific decisions must be accurate and taken in a timely manner by the leader. Thus, because dynamics are involved, there are continuous-time processes which are important in the normal flow of operations. Dynamic optimization of interactions is essential. Therefore, the leader must create an environment that is prone to communication between the members of all teams as well as between the teams themselves.

The leader is also responsible for the payment of the payoffs (positive or negative) to the actors and to the teams for he is accountable for the overall performance (individual as well as collective). The latter can be measured through the accuracy of procedural benchmarks and follow-ups.

There are certain restrictions and conditions that the leader imposes. For this reason, the leader may be seen by the actors as dictatorial. One such example is the manner in which he assigns the members of the teams. Members of the team are pre-assigned (by the leader), i.e. actors cannot choose their own team. When creating the teams and when introducing a new member in the team, the leader must take in consideration the following aspects and characteristics of an actor (yet, not restricted only to them): the competences that he possesses, his ability (and willingness) to learn new tasks, his ability to adapt to a changing environment, the impact on the other team members, and his capability to adapt to the team that he will be a member of (and to function efficiently and effectively within that team). It is on this basis that we consider the leader as the architect of the teams. We address the basis on which the leader assigns an actor to a team in section 2.4.

The leader must always address individual challenges and must work together with the actors in order for them to surpass expectations — personal as well as the ones imposed by the team. The same rational applies also to the needs of a team.

In order to understand clearly the dynamics of the interactions, we must comprehend the system from the leader's perspective[32], as well as from the perspective of the teams' members[33].

[32] Thus, understanding the game where the leader establishes the variable(s) that influences the state of the system.

[33] Thus, understanding and analyzing differential games — using calculus of variables and optimal control theory (see Kamien and Schwartz, 2000) — where several individuals select the variables.

2.3 Payoffs

All payoffs depend on the type of coalition structure that is developed. The former rely on the efficiency of the entire team, consequently, on the effectiveness of the members and on the dynamic structural configuration that is formed. Payoffs are dependent on the feedback received by the different BUs (provided to the teams by the leader), thus creating externalities to our game set-up. Members belonging to the same team receive the same team payoff because their duties are similar. Positives and negative payoffs depend on the actions of the previous day(s) as well as on those of the current day, and they are paid by the leader as he sees appropriate.[34] Therefore, the payoff provided by the leader to the team has the following form:

$$T\varphi_\lambda = \Sigma f(\lambda\varphi_{d_x}), \qquad (2.3.1)$$

where we have payoff φ, leader λ, the function $f(\lambda\varphi_{d_x})$ denoting the payment rational, and d working days with $d \in D = \{d_1, d_2, d_3, d_4, d_5\}$[35].

The same process for payment of the payoffs applies to the actors also. Thus, the payoff received by an individual that belongs to T_n is:

$$\begin{aligned}\varphi_i = {} & [n_i/(n_i - 1)]T\varphi_\lambda + \varphi_\lambda + \delta\varphi_i + \\ & + c_1\Sigma_{t_{ni} \in T_{nx}} (\varphi_{t_{ni}}) + c_2\Sigma_{t_{ni} \notin T_{nx}} (\varphi_{t_{ni}}),\end{aligned} \qquad (2.3.2)$$

where *i* is a specific actor, t_{ni} is a member of T_n receiving the specific payoff, n_i representing the number of members in the team that t_{ni} belongs to, c_1 and c_2 are the coefficients representing the weight of the payoff[36] received by a member from other members of the same team and from members of a different team, respectively. We note that the term $[n_i/(n_i - 1)]T\varphi_\lambda$ is formed by the team's payoff and a coefficient $c > 1$ relative to how many members are in a specific team. $\Sigma_{t_{ni} \in T_{nx}} (\varphi_{t_{ni}})$ and $\Sigma_{t_{ni} \notin T_{nx}} (\varphi_{t_{ni}})$ represent the sum of all the payoffs that an actor receives from members of their team and members of diffferent teams, respectively.

Therefore, we note that the leader provides a payment to an individual, and that actor also receives other types (different sources) of payments.

We specify that payments may be granted more than once a day, depending on the outcomes of the actions of the actors/teams[37], and the payoffs are caped. In the same

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[34] Operational mistakes may not be necessarily identified immediately. They can be revealed on a latter date. After a five (5) working day period, all mistakes (if any) have been signaled and responded to.

[35] *d* is a refinement of our system. We will not use it in our analysis for simplicity reasons. Moreover, the term $\Sigma\lambda\varphi_{(d)}$ captures all payoffs provided by the leader to the team.

[36] The weight of the payoff is assigned by the actor and represents the importance that the latter attributes to the source of that specific payoff.

[37] However, we advise that after each SDH period, the leader should provide the team with the payoffs (of that specific SDH period) in order for the members of the teams to know the quality of the work that they are doing, if they require to adapt to new situations, and not to leave the members without payment for the

time, once a payment is granted, that payment cannot be retracted. Also, there are no recursive payments for the same action.

Members of teams can provide other members with side payments. However, we point out that there are non-transferable positive (or negative) payoffs allowed between the players for the formation of a coalition(s). The latter statement contradicts the basis of cooperative literature.[38] We answered in section 2.2. (and we will analyze this aspect in greater detail in section 2.4.) to a very important question: how are the teams formed if there are no payments allowed between t_ns (in order to form T_{ni})? The leader appoints actors to a specific team.

We note however that side payments between T_ns are permitted in order for the possibility to form the total core L_0 (providing greater possibilities for the core. See section 3.2.2. and 3.2.3. for a detailed description).

We consider a member of a coalition myopic if he is only concerned with his immediate payoffs. Individualistic behavior is penalized from different sides, in such a way that actors engaged in myopic strategies (aiming also at deviation), as well as nonmembers, receive negative payoffs.[39,40] These payoffs are assigned by the independent team actors (acting individually and independently of the team), by the team, as well as by the leader. This is a control that brings the coalition deviator in an 'outcast' position, situation that creates and influences the degree of his cognitive *pessimism*. At this stage, cognitive dissonance is present for the deviator, and the latter must engage in different mental processes in order to reduce the dissonance between the normal cognitions and the environmental ones.

In order to avoid myopism, deviation and the presence of acute cognitive pessimism, behavioral change mechanisms must be put in place such that actors are encouraged to be proactive members of the team(s) and must uphold their respective coalition(s) (notwithstanding different positive payoffs that represent positive reinforcement). Therefore, the leader is responsible for creating and maintaining the team spirit, the willingness of an actor to be part of the team.

Worst payoff is *to be fired*, meaning that the leader not only terminates the actor's membership to a team, but that actor is fully taken out of play. This is the greatest sanction that a leader may inflict to an individual. As Leon Petrosian (HEC 2008)[41] stated very clearly, *this payoff is characterized as 'sudden death' for the actor in the game*. This sanction is used as a last resort.

The deviation payoff function to a member of a team is the following:

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work done. The sooner the individuals receive their payoff, the better it is for the entire system, and especially for the individuals. Payment of rewards (or penalties) should occur as soon as possible.

[38] In most cooperative literature, side payments between members of a team not only that are permitted, but are essential for it is through the payment mechanism that members form coalitions.

[39] They do not have a 0 (zero) payment for this would mean there is a status quo situation. Having a negative payoff properly illustrates the impediments that the nonmember imposes on the team.

[40] These payoffs are given to the individual regardless of the team he is in. The direct payoff of the team (value of the coalition in GT format) is not affected. Yet, the congruent payoff (Coalition Factor Estimation (CFE) analyzed in section 3.2.2.) of the team is affected for the latter is composed by all individualistic payoffs of each member.

[41] *Workshop on Dynamic Games in Management Science*, 2008, Cooperation and Bargaining section.

$$\delta\varphi_i = \lambda\varphi\delta + c_1\Sigma_{t_{ni} \in T_{nx}} (\varphi\delta_{t_{ni}}) + c_2\Sigma_{t_{ni} \notin T_{nx}} (\varphi\delta_{t_{ni}}), \qquad (2.3.3)$$

where δ is the deviation weight (and δ is negative).

The leader must ensure that appropriate sanctions mechanisms are in place; if they are not present, the leader must create them. We note that sanctions must be applied as a correction method to the individual (or to the team) that is not following procedures. Moreover, the former must be proportionate to the error in question. However, we note a grey zone (in which extensive research has already been made) in which individuals must be able to acknowledge the difference between credible and non-credible threats imposed by the leader.[42] The deviation coefficient is representative of the sanctions mechanisms that either the leader creates or that the team (or individuals of a team) may impose on a deviator.

We note that there is no individual best reply strategy(ies) for deviators. Any individual player knows that if he deviates, it will be enough to precipitate a decrease in productivity of the remaining coalition. Moreover, it is common knowledge that a decrease in productivity or quality will be panelized.

The reason why the payoffs are caped is that neither teams' members, teams, not even the leader, can provide a payment that is not lawful within the system (the company).[43] Thus, the payoffs' minimum and maximum values (especially the maximum ones) are following strict rules, regulations and policies imposed by the corporation and the department. The leader does not have great flexibility in increasing the range of the payoffs (increasing the maximum payoff enforced by the system). However, we note that different systems may have different scales. Moreover, for our game set-up, all variables described in Table 3 belong to N. If one requires the values to belong to R, we see no inconvenience.

We remark that φ_λ (from (2.3.2)) and $\lambda\varphi\delta$ (from (2.3.3)) are mutually exclusive. A player cannot receive a positive payoff from the leader for a job well done and in the same time receive a negative payoff because the player is deviating. The terms c_1, c_2 are positive for a player cannot assign a negative value to a payoff that he received from other members of his team or other teams.

2.4. Coalition

Individuals are brought into the specific environment based on certain competence matrixes, on their previous experiences, on their willingness and capacity to learn new tasks. Moreover, the actor's ability to adapt to the team to which he will be allocated, as well as the willingness of the team to 'incorporate' the new member to the team, play a central role in the leader's decision to hire the candidate. The leader must analyze all the information available to him.

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[42] *Non-credible-threats* is a tool that is used more often by teams vs. teams or teams vs. individual. The leader can use this method also, however we advise not to employ it often. If the actors realize that the leader uses non credible threats, the leader might be challenged, loose power of influence, etc.

[43] Refer to Table 3 in the Appendix for the payoff regulations and values.

Once the actors are appointed to the specific team, there are two aspects to be considered: 1) old team members must accept the new addition to the team; 2) the new member of the team must understand how the team works and adapt to the new environment. Only once these two elements are accomplished, the leader can address the team as an entity by itself. The leader works closely with the team and with the new member in order to have an easy transition/integration.

The leader sets the roles, duties and responsibilities of all the actors (information that is common knowledge to all actors). Once the team is formed, the leader must be aware of how the specific coalition structure functions for he is responsible for the overall operations. Yet, he is not required to monitor *all* the team's interactions. The latter has a life of its own.[44] The reason why the leader must know the dynamics of the coalition structure is that if he is required to intervene (on an individual basis, or at the team level), he would have the necessary knowledge of the dynamics as well all the necessary information before he addresses the situation. No additional research or preparation is required for the leader. The latter can intervene very quickly to remedy the situation, if need be.

The behavior, actions and involvement of one member of the network influence (and has a direct impact on) the production and performance of all other members (or teams) in the specific network, thus he has a direct influence on the profitability of the network. Moreover, the overall value of the coalition depends upon the actions of actors in the coalition, thus on the members themselves. In the same time, the coalition strength is determined by what it can achieve on its own [$uT^* = f(m)$]; nonmembers are not taking in consideration.

The leader must implement programs that result in an efficient and effective coalition structure. These programs must induce the coalitions to be farsighted and the actors must have an attitude free of deviation (procedures). The overall success of the coalition (which is based on the final payoffs) is the principal target of coalitions.

In order to ensure a high performance level of the chain, open information exchanges are required. The information must be available to all actors as soon as it is available. Moreover, the negative implications of poor coordination can have very drastic consequences, which can bring the destruction of the individual teams, or even that of the entire network. We note that information flows both ways: top-down (leader informs the actors); and, bottom-up (actors inform the leader).

We have the subsequent definition for a coalition:

Definition 1: In order for a coalition to be possible, we need the following elements:

-there is a finite set T of players t_i, where $t_i \geq 2$;
-uT^* is the value of the coalition, where $u(\varnothing) = 0$.[45]

We specify that the value of the coalition is constant (and it is based on a typical day)[46]. uT^* would increase iff. the members of the teams are faced with difficult (out of

[44] If the leader becomes a fully active member of the team, he will loose his *leader* authority. His role is to lead the specific team.
[45] See section 3.2.2. for a detailed description of the value of the game and the core of the game.

the normal) situations and they address the latter in an adequate manner. We note that the leader would increase the payment to both the members and the teams only in *out-of-the-ordinary* situations[47]. Once the environment regains its equilibrium (normal state of affairs), uT* would come back to the original constant value.

Members of teams can deviate from their teams (from the collective unit rational; a member can isolate himself; he is not supporting the team, the members of his team, and the other members/teams, etc.). The deviation can go up to the point where the individual fully excludes himself from the team. In the case that there are two players that are deviating in the same time, they can try to form a deviator coalition (it is a psychological effect that the deviator(s) (in our case, the individual) have. They do not want to be singled out – forming singletons – thus, they look for an allegiance with another member(s)). In the situation where there is a deviator coalition, the leader would address the deviators individually, not the deviator coalition. It is easier to persuade the individual than the coalition.[48]

We had the opportunity to test the previous theoretical assessment in real live situations. Throughout our research, there were four occasions of multiple simultaneous deviations (more than one member deviated in the same time period and where the deviators formed a coalition). On three occasions, the issues were addressed on an individualistic basis; this approach resulted in the issues been resolved. Only on one occasion the leader addressed the entire deviator coalition, process that did not bring any positive results. The former then addressed the issues on an individual basis. All the problems that the actors had were fixed, and the actors re-integrated their specific teams (stopped being deviators and stopped pursuing deviation). Even though our statistical data pool was not large, we are convinced that the best course of action for the leader is to address similar situations on an individualistic basis.

We illustrate in the following manner the deviator and the remaining members of team in (2.4.1), and ΔT as the deviator coalition (2.4.2):

$$t_{n_i}\delta \in \{t_{n_i}\} \mid t_{n_i} \rightarrow T_{n_i} \therefore T_{n_i} = \{(t_{n_i}\delta), [(t_{n_i}) - (t_{n_i}\delta)]\}; \qquad (2.4.1)$$

$$t_{n_i}\delta \in \Delta T \text{ iff. } i > 1 \mid t_{n_{\forall i}}\delta \in \Delta T . \qquad (2.4.2)$$

[46] A typical day in ASU is characterized by the following events: 1) **mail** – a. an average of 520 envelopes either to be dispatched or opened for the imaging team; b. 3 address changes; c. an average of outgoing mail for Canada Post of 1250 pieces, 120 pieces for UPS, and 2 pieces for QA courier; d. a weekly average of 3 changes; 2) **imaging** – a. an average of 1200 documents prepped and scanned (including checks); b. answering queues; c. a weekly average of 4 changes. In both mail and imaging sub-departments there are 2 to 4 difficult situations. We note that not all the issues can be addressed by the players. If this is the case, then the leader is responsible for the proper handling of the specific issues.

[47] *Out-of-the-ordinary* situations refer to: complicated demands; complicated documents; players absent; spike in volumes; late receipt of mail.

[48] Different deviators have different reasons for their deviation. The leader must understand and address each individual need of the deviator(s), trying to bring him/them out of deviation. Moreover, addressing individual needs is easier than addressing the needs of the collective. Psychology and negotiation situations have provided different examples regarding this aspect.

If a deviator coalition ΔT exists, then an additional negative payoff is paid by the leader to ΔT. Moreover, uT* would decrease if one of the following conditions is present: a) if $|\Delta T_{ti}| \geq 1$; b) if the members are not following procedures, thus incurring mistakes.

We recall that if $|\Delta T_{ti}| = 1$, creating thus a singleton, the deviator has a certain degree of pessimism regarding the structure that he is a member of, or regarding the environment in which he is placed. These are the aspects that the leader must identify and address with the deviator.

We also take note that there is a possibility where the team might exclude a member in order to receive a bigger payoff[49]. However, all present members must participate to the work done, information that is common knowledge. In this situation, the leader will penalize the team (not taken in consideration the member that was excluded). The rational for the team's penalty is due to the fact that the team surpassed their role, farsighted strategies were not used, the team did not act as a collective unit, and the team did not inform the leader of the need/want/willingness to exclude a member (the team's desire). It is the leader's responsibility to exclude (thus terminate) a member of a team.

We require a coalition configuration (specific to each team) that is stable and optimal in terms of utility maximization. A core partition is stable in the sense that there is no reason for a deviation to take place.[50] However, we point out that certain problems related to incentives of cyclical coalitional deviations might be present. It is optimal in the sense that not only the members of a team work in concert in order to accomplish a specific goal, but also the actors try to maximize the dynamic function of the payoff.

We also note that one person might deviate unwillingly. This is a situation where the not-work-related environment has a strong influence on an actor. Due to human nature, one cannot fully dissociate personal-life and work-life. Because we are analyzing work situations, we have to acknowledge the fact that actors' work (and behavior) is influenced (positively or negatively) by events in their personal life. If the latter's influence is significant, then the actor would not be able to focus on his work, or he will be absent minded; the result will be an unwilling deviation (besides the procedural mistakes that the actor makes).

Any coalition requires a protocol (of specific duties), as well as strategies (that can be employed in order to achieve a specific goal). Moreover, we point out that a coalition may only be as strong as its *weakest* member. In the same time, uT* for one coalition is not dependent on uT* of another coalition. Each team has its own coalition value.

2.5. Types of behavior

There is a slight difference in the analysis undergone by cooperative GT and by non-cooperative GT. Cooperative GT analyses a game from the perspective of the value created through the cooperation of the players. Thus, it focuses on the outcome of the

[49] Let us say that one member is doing procedural mistakes; this is translated in a low uT*. If the team excludes that member ($t_x \notin T_x$), the work load is divided between the members of T_x, then uT* would increase.
[50] This refers to the Nash equilibrium (NE) where a player has a NE.

game. Non-cooperation GT aims at understanding the specific actions of players. In order to have a clear understanding of the situation, one must utilize both cooperation and non-cooperation analysis. Thus, a powerful method that a modeler might see useful is to change a cooperation game in a non-cooperation game and/or vice versa.

Once a player is assigned to a team, he can have only three different types of behavior (regarding the team that he is a member of, as well as towards other teams):

i. Cooperative behavior (C_b) – where he supports the team;
ii. Non-cooperative behavior (NC_b) – where he is either aiming at deviation or already a deviator (non-member of the team);[51]
iii. Non-adaptive behavior (NA_b) – having the same behavior as before he joined the coalition.[52]

As stated before, there are strategic and dynamic interactions between members and teams. C_b is strongly encouraged by the leader and by the other members of the team. Meanwhile, the actors know that individual prolonged NC_b (and NA_b)[53] will have the worst outcome: the person would be terminated and taken out of the game.

In order to transform NC_b into C_b (or NA_b in C_b), the actors are forced to use farsighted strategies where all actors must act as a collective unit. One of the reasons for farsightedness is that the members of the teams want to keep their membership to the team in which they belong, thus maintain their employment. We note that the individual as well as the collective payoffs are important in the type of behavior that is adopted, and players change their behavior due to incentives (either positive or negative) – i.e., the payoffs. Moreover, research has shown that obligations (supported by low incentives) cannot sustain cooperation in repeated interactions.[54]

The environmental behavior β[55] of a player *i* has the following form:

$$\beta_i = q'C_{bi} + q''NC_{bi} + q'''NA_{bi} \quad (2.5.1)$$
$$\{\equiv [1-(q''+q''')]\, C_{bi} + [1-(q'+q''')]\, NC_{bi} + [1-(q'+q'')]\, NA_{bi}\},$$

where β_i is the behavior of a player, and q', q'' and q''' are percentages that reflect the probability of the actor choosing either C_{bi}, NC_{bi} or NA_{bi}, such that $1 = q' + q'' + q'''$.

After the integration of an actor in our system, $NA_{bi} = 0$, and the term $q'''NA_{bi}$ $\{[1-(q'+q'')]\, NA_{bi}\}$ is taken out of the equation.[56]

[51] Deviation refers to his lack of support to the network (lack of support regarding T_n – thus, regarding t_{ni}) – or lack of support impeding for $T_n \approx\!\rightarrow L_0$.
[52] This type of behavior can occur after the introduction of a new player in the network.
[53] We note that prolonged NA_b is transformed in NC_b.
[54] Galbiati and Vertova (2008), p 160.
[55] This refers to the behavior of an actor regarding his environment: towards the team that he is a member of, towards members of the team, towards other teams, towards other members, etc.
[56] See section 3.1.1. for more details.

Moreover, we note that there are different forms of behavior available to the actors in each set of behaviors. Their choice is influenced by many elements (or conclusions).[57]

2.6. Actions

We note that actions and processes are not similar. Being engaged in the accomplishment of a process requires an (process-) action. However, in (2.5.1), we are referring to behavioral-actions, not to process-actions. Moreover, the beliefs of an actor shape the way the actor *sees* his environment. We also point out that the environment influences the formation, shaping and annihilation of beliefs of actors.[58]

We denote a_{it} as action *i* of player *t*, where $a_i \in$ A, A being the set of feasible actions (permitted or not by the system and leader). We point out that A is comprised of many types of actions (team related, work related, individual related, process related, etc.). Moreover, an action permutation is the vector of actions a = (a_1, …, a_i) that has the following form $a_{i:t_i}$. When all players engage in the same action, we have a uniform action combination that is translated to the progress of the team in the same direction.

We acknowledge that the action-function is also dynamic and it is dependent on the individual, his beliefs, his perceptions, his actions. Player t_i's value of action(s) (and consequently their work beliefs) should be consistent with the following linear rule:

$$\begin{aligned} a_{i:t_i} = \; & (ada_{t_i} \cdot l_{t_i})_{(ap.k)} \; + & \text{GLOQ} \\ & + \beta_{t_i} + \beta_{Tn_i} + \beta_{t_i(Tn_i)} \cdot ada_{t_i} + & \text{OBR} \\ & + \varphi_{\sigma_{ti}} \cdot (eff._{t_i} + w_{t_i})^{\varphi_{\sigma_{ti}}} \; - & \text{MOT} \\ & - s \cdot (ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i}), & \text{TAL} \end{aligned} \qquad (2.6.1)$$

where we have the player's adaptation coefficient ada_{t_i}, player's learning coefficient l_{t_i}, β_{t_i} is the player's behavior, the player's team behavior β_{Tn_i}, player's behavior demanded by his team denoted by $\beta_{t_i(Tn_i)}$, player's payoff stimulation $\varphi_{\sigma_{ti}}$, player's effort coefficient $eff._{t_i}$, player's willingness coefficient w_{t_i}, and time index s with $s > 1$.

We note that one player cannot have more than one $a_{i:t_i}$ permutation simultaneously (or during the same time period). Moreover, the cumulative actions of the players determine the Coalition Factor Estimation (CFE) (û). Thus,

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[57] See Popp (2006a) for details of conceptual conglomerates (ConCs).

[58] For further details on beliefs (their influence on the learning process and their effect of knowledge and purposes, which determine the actions of an individual), see Popp (2009) and (2006a), respectively.

$$\Sigma a_{i:t_{i\in T}} = \hat{u}T_{t_i}.^{59} \qquad (2.6.2)$$

We point out that ûT refers to the added value of the specific team to the environment, to the department, and consequently to the entire company.

We remark that there is a finite set of possibilities that a player can create. Thus, there is a set X of states and the state space X is finite. Moreover, the actions undertaken by the individuals, and thus their outcomes (the value of the actions), are related to the payoffs received by the players.

We point out that a modeler can construct different (types of) vectors for the illustration of the relationship between actions and payoffs.

GLOQ

The GLOQ term $[(ada_{t_i} \cdot l_{t_i})_{(ap.k)}]$ refers to the global quality of the work done.[60] We note that higher coefficients for ada_{t_i} and l_{t_i} will signify a higher adaptation level and a more rapid learning, respectively. The product $(ada_{t_i} \cdot l_{t_i})_{(ap.k)}$ represents the applied knowledge that a player has and is engaged in for the work (process-action) that he has to perform. Moreover, ada_{t_i} refers to the overall adaptation of the player to his environment: to the team(s), to the work necessities, to change, to demands, etc. l_{t_i} represents the player's learning capabilities that take in consideration the different methods of learning, the time required for the player to learn a topic (or a process), different approaches to the treatment of information[61].

We acknowledge that ada_{t_i} and l_{t_i} are directly correlated, and the relationship between ada_{t_i} and l_{t_i} that the leader is looking for in an actor prior to the actor's introduction to our game environment is:

$$g(ada_t, l_t) \begin{cases} l_{t_i} \geq ;ada_{t_i}; \\ 2 \geq l_{t_i} - ada_{t_i}. \end{cases} \qquad (2.6.3)$$

Table 4 illustrates the values associated to each level of learning for an individual in our game setup.[62]

OBR

The overall behavior requisites term (OBR) $[\beta_{t_i} + \beta_{Tn_i} + \beta_{t_i(Tn_i)} \cdot ada_{t_i}]$ is composed by all the behavior demands made on the player. OBR takes into account the

[59] We note that uT* is not the same as ûT*

[60] We use the assumption (Assumption 4) that a high level of adaptation and learning (which refer to the specific applied knowledge to the process in question) will result in a good quality work. See Proof 1 of the Appendix.

[61] See Popp (2009) for learning process and what elements influence the learning process.

[62] We note that the levels (as well as the values) can vary from game setup to game setup, they can depend on the environment, and also on the level of accuracy that either a modeler or a leader is looking for.

behavior of the player, the behavior of the team, and a measurement formed by the behavior demanded by the team on the behavior of the player and the player's adaptation capacity to this demand. Most of the time the team's behavior and the behavior that the team demands from the player are the same [$\beta_{Tn_i} \equiv \beta_{t_i(Tn_i)}$] Thus, we can write OBR in the following way:

$$\beta_{t_i} + \beta_{Tn_i} + \beta_{t_i(Tn_i)} \cdot ada_{t_i} = \beta_{t_i} + \beta_{Tn_i} + \beta_{Tn_i} \cdot ada_{t_i}. \tag{2.6.4}$$

The leader will always *impose* a cooperation behavior to the team (and within the team), thus cooperation from all the members of the team.[63] Therefore, we rewrite (2.6.4) as:

$$\begin{aligned}\beta_{t_i} + \beta_{Tn_i} + \beta_{Tn_i} \cdot ada_{t_i} &= \beta_{t_i} + C_{bi} + C_{bi} \cdot ada_{t_i} \\ &= \beta_{t_i} + C_{bi} \cdot (1 + ada_{t_i}).\end{aligned} \tag{2.6.5}$$

As stated before, we are aware that there are coefficient levels that determine (and characterize) how engaged the actors are in the specific type of behavior. We describe in Table 5 the different values associated to cooperation and non-cooperation behaviors.

We note that a value of zero (0) for β_{t_i} signifies that the actor is neither engaged in cooperation nor non-cooperation. However, if this is the case, then we assign the actor a value of weak non-cooperation for he is not 'helping' his environment. This is translated to an apathetic player.

Considering (2.6.5) and replacing β_{t_i} from (2.5.1), we have:

$$q'C_{bi} + q''NC_{bi} + q'''NA_{bi} + C_{bi} \cdot (1 + ada_{t_i}). \tag{2.6.6}$$

C_{bi} and NC_{bi} are of interest to us. NA_{bi} is taken in consideration only when new players are brought in the system. Let us assume for now $q'''NA_{bi} = 0$. Thus, we have from (2.6.6):

$$q'C_{bi} + q''NC_{bi} + C_{bi} \cdot (1 + ada_{t_i}). \tag{2.6.7}$$

Moreover, cooperative and non-cooperative behaviors are mutually exclusive when an actor is engaged in a specific action. A player cannot be cooperative and non-cooperative in the same time regarding the same issue. However, we note that during the course of one day, an actor can have both cooperative behaviors and non-cooperative behaviors.

Thus, if an actor is engaged in cooperative behavior, we have from (2.6.7):

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[63] Even though the leader demands cooperation from the members of the teams, they may choose not to cooperate. If this is the case, we have a ΔT.

$$q'C_{bi} + C_{bi} \cdot (1 + ada_{t_i}),\qquad (2.6.8)$$

and if the actor is engaged in non-cooperative behavior, we have:

$$q''NC_{bi}.\qquad (2.6.9)$$

We note that in (2.6.9), ada_{t_i} is not present. This illustrates correctly reality for in a situation where an individual upholds a non-cooperative behavior, he is not supporting his team, he is not adapting to the environment; thus, there is no need for that actor to adapt to anything.

Moreover, we note that in (2.5.1), the probabilities that an actor may cooperate or not cooperate are present. However, in (2.6.8) and (2.6.9), even though q' and q" are present, we can make both of them equal to 1. As stated before, cooperation and non-cooperation are mutually exclusive. Thus, we have

$$OBR \begin{cases} C_{bi} + C_{bi} \cdot (1 + ada_{t_i}) = C_{bi} \cdot (2 + ada_{t_i}); & (2.6.10) \\ NC_{bi}. & (2.6.11) \end{cases}$$

MOT

The motivation term (MOT) $[\varphi_{\sigma_{ti}} \cdot (eff._{t_i} + w_{t_i})^{\varphi_{\sigma_{ti}}}]$ is composed by the player's payoff stimulation $\varphi_{\sigma_{ti}}$, the player's effort coefficient $eff._{t_i}$, and the player's willingness coefficient w_{t_i}. We note that the payoff stimulation $\varphi_{\sigma_{ti}}$ has the following form:

$$\varphi_{\sigma_{ti}} = \varphi_{c_{t_i}} - \varphi_{r(s-1)_{t_i}},\qquad (2.6.12)$$

where $\varphi_{c_{t_i}}$ represents the payoff considered by t_i, the time index s with $s > 1$, and $\varphi_{r(s-1)_{t_i}}$ represents the payoff received by t_i in (s-1) (referring to the last payoff received).

There are three possibilities for $\varphi_{\sigma_{ti}}$:

$\varphi_{c_{t_i}} > \varphi_{r(s-1)_{t_i}} \therefore \varphi_{\sigma_{ti}} > 0;$

$\varphi_{c_{t_i}} = \varphi_{r(s-1)_{t_i}} \therefore \varphi_{\sigma_{ti}} = 0;$

$\varphi_{c_{t_i}} < \varphi_{r(s-1)_{t_i}} \therefore \varphi_{\sigma_{ti}} < 0.$

We note that $\varphi_{r(s-1)_{t_i}}$ is a fact for t_i received the payment φ_{ti}. However, $\varphi_{c_{t_i}}$ is considered from the player's perspective and is considered as a future possible event.

If $\varphi_{\sigma_{ti}} > 0$, then MOT is positive, and this signifies that the actor is motivated. If $\varphi_{\sigma_{ti}} = 0$, then the player is apathetic. If $\varphi_{\sigma_{ti}} < 0$, then MOT is negative, and it indicates the disincentive/discouragement (de-motivation) of the actor.

We point out that MOT is dependent on $\varphi_{c_{t_i}}$ and $\varphi_{r(s-1)_{t_i}}$, the payment that an actor received and the one that he is considering receiving depending on the effort and willingness that he is keen to be engaged in. We note that if $\varphi_{\sigma_{ti}} = 0$, then there is no reason for an actor to increase his effort or willingness for these coefficients will not change his motivation coefficient. However, we realize that if an actor increases $eff._{t_i}$ and w_{t_i}, he will expect $\varphi_{\sigma_{ti}} > 0$. If the player increased $eff._{t_i}$ and w_{t_i}, but $\varphi_{\sigma_{ti}} < 1$, then the actor not only that would be de-motivated, but also his demotivation would be proportionate to the effort and willingness that he had.

Moreover, we specify that there are different levels of players' effort and willingness. We also note that an actor's levels may not necessarily be equivalent with those of another actor (ex. t_{2a} may consider an effort/willingness of 2, while t_{2b} would consider an effort/willingness of 3 for the performance of the same task). For simplicity reasons, we will consider the effort and willingness levels being applicable to all players in the same manner. Table 6 provides the values and the levels breakdown of our coefficients.

Individual as well as team moral are essential. If moral is low, then the players would have a tendency to be de-motivated, and MOT would be negative.

For all these reasons, we believe that our formula (and thus, our understanding) for MOT is correct and adequate in representing reality.

TAL

The time-adaptation-learning term (TAL) $[s \cdot (ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i})]$ represents an indicator composed by the ability to adapt, the capacity to learn, and time. Having a time component, the term illustrates accurately reality: all individuals need time to adapt and to learn. Moreover, the term is negative because time influences negatively the actions of a player.[64] A simpler version of the term is:

$$s \cdot (ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i}) = (s \cdot ada_{t_i})/(ada_{t_i} \cdot l_{t_i}) + (s \cdot l_{t_i})/(ada_{t_i} \cdot l_{t_i}) = s / l_{t_i} + s / ada_{t_i}. \quad (2.6.13)$$

As l_{t_i} (ada_{t_i}) increases, the term s / l_{t_i} (s / ada_{t_i}) decreases. We also note that if the learning and adaptation coefficients increase, then the TAL's[65] value will decrease[66]. Thus, for higher values of the two coefficients, time does not play an important role; it is

[64] The time component refers to how many time units a player needs to adapt or to learn. One can set the time units to any time period, depending on the game situations and the environment of the game.
[65] Note that process-action quality is present by itself, as GLOQ.
[66] See Proof 2 of the Appendix.

minimal. However, for small values of l_{t_i} (ada_{t_i}), this term increases (not only in value, but also in importance).

We can conclude from (2.6.13) that adaptation, as well as learning, are inverse proportionate to time. Our conclusion illustrates nature adequately for one can observe that high adaptation (or learning) skills require modicum time for the person to adapt (or to learn).

Having [$s/(ada_{t_i} \cdot l_{t_i})$] (time / process-action quality) is counterintuitive due to the fact that we usually calculate the employee's 'productivity' by how many processes he can perform in a unit time (# processes / unit time). However, ($ada_{t_i} \cdot l_{t_i}$) (which is equivalent to $(ada_{t_i} \cdot l_{t_i})_{(ap.k)}$) represents the adaptation and learning levels regarding the work applied knowledge of the employee.

We must take in consideration the fact that players' past experiences influence their behavior, and the former can increase ada_{t_i} and l_{t_i}. Moreover, if an actor is familiar (in any way) with the protocols to be learnt, ada_{t_i} and l_{t_i} will increase furthermore. This aspect is part of the intrinsic characteristics of humans (actors in our case): to draw necessary connections (and conclusions) regarding similarities between situations. However, more research needs to be made regarding past experiences with similar situations and their degree of influence on the actors' behavior.

Part 3
3.1. Statistical data

Table 7 describes different situations where the leader is present (or not present) in the direct supervision of the actors. We have the following labels: setting λ_1 – the leader is present; setting λ_2 – the leader is absent; event α_1 – SDH met; event α_2 – SDH not met (by more than 5 minutes); event α_3 – time to spare; event α_4 – usage of time to spare; event α_5 – work related communication; event α_6 – no-work related communication.

Our data was collected over a 100 non-consecutive day span where the leader was present and supervised directly the players and their work (50 non-consecutive days), and where the leader was not present (50 non-consecutive days) while the players were engaged in their roles and duties.

The manner in which the leader gathered the data was: 1) present – close contact with his direct reports[67]; 2) not present – the leader observed from a distance.

The SDH are applicable only to the imaging team. Moreover, we point out that each BU (documents for that specific BU) has its own SDH. Therefore, the SDH does not apply to the overall volumes, but to the specialized processes in Imaging. There were two (2) SDH shifts (shift 1: 8.30-10.30; shift 2: 10.30-12.30), for a total of 4 hours duration.

[67] The leader helped the players in their duties. We believe that our data is correct due to the fact that for more than 80% of the time, one member of the team was absent, thus the leader replaced the missing member. We note that the leader is familiar with all the processes that his direct reports are responsible for.

Meeting the SDH refers to all processes (P_1 to P_4) being completed in each of the SDH shift for all BUs. On the occasions when the SDHs were not met, it was due to increase of volumes, machinery break-down or mistakes of the players (i.e., the players were not proficient in their tasks).

We point out that missed SDHs have important consequences for the good operation of the department and especially, work implications for the BUs that ASU services.

Time to spare (calculated in minutes, 'm.') refers to how much time the actors had before their SDH shift was over, yet they had finished all processes (P_1 to P_4). We also looked at how this time was utilized by the actors.

Communication (Com.) was measured by how many communicative interactions the players had. We make the distinction between work related communication (strategic level) and no-work related communication (social level). The communication interactions refer to how many times actors respond to a specific subject.[68]

Moreover, we also analyzed different scenarios. Our statistical data (9 situations out of a total of 11) shows that if negative payoffs persist for a period of five (5) continuous payments, the leader looks ineffective. If this is the case, the leader gets challenged both by actors and by the leader's direct manager.

3.1.1. Interpretation of statistical data

Event α_2's percentages refer to the 11% of the SDH not met when the leader was present (setting λ_1), and to the 19% of the SDH not met when the leader was not present (setting λ_2).

We note that when the leader is present, the SDHs are met with a higher percentage than in the cases when he is absent (a difference of 8%). Moreover, the percentage of $\alpha_2\lambda_2$ is more than double than that of $\alpha_2\lambda_1$.

Observing event α_3, we see an average time that is almost double when the leader was present in comparison with λ_2 setting. Finishing faster, certain actors can help other teams (and members) in their duties, thus reducing the latter's work load.[69]

Beside the work responsibilities, the players have certain administrative duties as well. We note that 5% of time to spare (in setting λ_1) was used for administrative purposes (i.e., team meetings, team building exercises, cleaning, reorganizing, etc.). Having 'spare-time' at disposal, accomplishing the former does not impact the daily operations, thus affecting negatively the SDHs.

We also note a 23% difference for work related interactions depending on the leader's presence. This could be explained by the fact that the actors do not want to look incompetent in front of the leader. Thus, they make 'judgment calls' when dealing with

[68] There may be only 1 subject, but 25 interactions between the players.

[69] It is this aspect that is considered by members for side payments from other members, i.e., $\Sigma_{t_{ni} \in T_{nx}}(\varphi_{t_{ni}})$, and respectively $\Sigma_{t_{ni} \notin T_{nx}}(\varphi_{t_{ni}})$.

difficult documents (or when they need assistance). We point out that their decisions could be wrong. However, we did not monitor how many problems were present (problems that were reported by other BUs) during the time we performed our research. The latter information could provide additional insight in the understanding of our environment.

We see an important decrease in the number of communication interactions (no-work related) when the leader was present. Analyzing the fact that talking and working in the same time increases the time required for the preparation of documents, we believe that we have a lower $\alpha_2\lambda_1$ percentage due to the decrease in time of communication. Moreover, this resulted also in actors finishing faster, thus helping others in their duties.

The reasons for the difference in event α_3 refer to the power of the leader (position/function wise) manifested by externalities to our game. The players do not wish to be observed by the leader for more than one reason. One of them is that there are 1:1 (leader:direct report) monthly meetings where the leader can address certain issues that he observes in the player's communication or attitude with others. The players do not want to provide the leader with too much personal information.

We note that interactions between members are important for the well being of the actors, of the teams, and of the entire department. We specify that no-work related communication between actors is essential in order to have a relax and pleasant atmosphere. However, the leader must be able to balance a good working environment having a good social atmosphere as well as a good productivity.

To have a general characterization, when the leader is present, the players have a semi-controlled behavior due to the fact that at the end of the day, the players still want to be a member of the SC.[70]

We conclude, based on the statistical evidence, that the leader's presence has a direct impact on the work that his teams perform in all aspects that we analyzed. However, we note that if the former setting (λ_1) becomes a habit, it could result in the deterioration of the work atmosphere because the actors have the impression (and sometimes rightfully so) that they are watched; a feeling that is translated in their distrust towards the leader.

Moreover, we observed throughout our research that after a maximum of a two (2) week period, the non-adaptive behavior fades out completely. Thus, NA_{bi} drops to 0. As stated before, the leader is responsible of choosing appropriate individuals that are able to adapt quickly to the team, and that the team incorporates them fast. If NA_{bi} continues after one week period (there is no change, i.e., $NA_{bi}^{s-5} \equiv NA_{bi}^{s}$), then the leader must address the situation with his new employee.

[70] Moreover, there are different (possible) payments provided by the leader to the player that the latter want to receive (salary increase, end-of-year bonus, promotion, individual recognition, etc.). The players want to maximize their chances of receiving the additional payoffs.

3.2. Situations estimations

3.2.1. Payoffs situations

A) Normal day – No deviation – No side payments

Let us assume a normal payoff situation, where a player performs his duties, having the following payoff structure ($T\varphi_\lambda$, φ_λ) = (3, 5)[71]. We note that in this structure, the player does not receive side payments from members of his team or members of other teams. Table 8 shows the amount of the payoff for members of different teams.

We realize that any side payment from other members (of the same team or different team(s)) will increase the payoff that the player receives.

The maximum payment that a player can receive (under the conditions where there are no side payments and the maximum payment is given to the teams) is the following: for players belonging to T_1 and T_3 a payment of 21, and for players belonging to T_2, a payment of 16.2. If side payments are present, φ_i will increase.

B) Normal day – Deviation – No side payments

Based on (2.3.3) and the fact that there are no side-payments from other members, the deviation payoff will be that of the deviation payment provided by the leader. If however, deviation side payments are present, the value of $\delta\varphi_i$ will decrease.

We note that the players will always strive to increase their payoffs. In the context of our model, the actors have four such opportunities: 1) ability to handle difficult situations (which are dependent on the presence of out-of-the-ordinary situations); 2) side payments from other members, thus helping other members; 3) increase the effort coefficient; 4) increase the willingness coefficient.

3.2.2. The Core

We use the following definition for the core of a game:

Definition 2: The utility vector π_{t_i}, ..., π_T is in the core of the game if it satisfies

$\pi(T) = u(T)$, and for $\forall C$ we have $\pi(C) \geq u(C)$,

where T is the set of players, having as subsets/coalitions $C \subseteq T$, u(C) is the characteristic function that specifies the value created by any subset of players in T.

The core, the set of un-dominated strategies, is the most utilized solution concept in cooperative game theory. From GT perspective, having an empty-core game, therefore the absence of the core, signifies that there are no stable coalitions.

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[71] We will assume a uniform action combination and we will use the structure ($T\varphi_\lambda$, φ_λ) = (3, 5) as a normal day payoff.

In section 2.4, we refer to uT* as the value of a coalition T. It is our understanding that in the GT format, the value of a coalition and the payoff provided to the coalition are analogous. However, we believe that these two concepts should not be the equivalent.

We make a great distinction (and a great contribution to cooperative literature) by specifying that the value of the coalition does not refer only to the payoff to the specific coalition.[72] GT analyzes the payoff(s) of the team, the members' portion of the team's payoff, thus what the player gains being (or becoming) a member of the coalition versus what he can achieve by himself (as a non-member of that coalition), as a singleton, or part of another coalition.

In order to distinguish between the GT term of *value of the coalition* (uT, uC, uT*) and our understanding of the term, we will refer to the latter as the Coalition Factor Estimation (CFE) that is denoted by ûT*.

We make a further distinction between CFE and the payoff to a coalition. A coalition should be considered as a (collective) unit for it has a life of its own. Therefore, the payment of the coalition cannot be split between the members of the coalition (an aspect that is common in cooperative literature) because it is not the members that receive the payoff, but the coalition itself.[73]

CFE comprises all elements and features of the coalition's contribution, and it is determined by different aspects that conventional cooperative literature does not take in consideration except as special games (where most of the time these components are introduces as externalities): payment of the coalition (as a coalition); payment to the members of the coalition (as members of the coalition and as individuals); the value that the coalition brings to its environment; value of the output of the coalition, etc. All these ConCs form an estimation factor.

We also have the following assumptions:

Assumption 1: As CFE increases, the area of the core (if any) will increase.[74]
Assumption 2: As CFE decreases, the area of the core (if any) will decrease.

We also provide a mechanism that provides a specific members' coalition weight, depending on the size of the coalition, thus depending on their overall contribution to their team. This is measured by the term $[n_i/(n_i - 1)]$ that multiplies $T\varphi_\lambda$. We note that in our game set-up (Table 8) the players of T_1 and T_3 receive a higher payoff in comparison with the players of T_2 due to the size of the coalition.

Moreover, based on Definition 2, the core concept cannot apply in our game set-up at L_1 due to the fact that the coalitions are not formed by the will of the members. The leader appoints the members to a specific coalition. Moreover, members cannot change their coalition once they are assigned to one. Thus, being dictatorial in the assignment of

[72] In some situations and certain games, the payoff is split between the members of the coalition.
[73] The following is an example of GT split payoff: having N = {x, y, z} with a coalition (x, y) that maintains v {(x, y), (z)} = (1, 0), and assuming that x and y split equally the payment, we have (x, y, z) = (½, ½, 0).
[74] We will use the following format $v(AC)_{gx}$ when referring to the value of the core's area for a specific game.

the teams, we hinder the usage of the core concept. At L_1, there is no bargaining set; therefore, there is no grand coalition in our game.

Game 1

Let us analyze a game at L_0 level, where the payoff is the same for all players (thus assuming that it is a normal day), and we have a uniform action combination. Having T_1, T_2, and T_3, we note that $u\{(T_1), (T_2), (T_3)\} = 0 = \{\varnothing\}$. The reason behind this assumption is that all three teams work in a supply chain environment where a team is dependent on the (work of the) previous team. Taken individually, out of context, neither team can exist. Moreover, $u\{(T_1, T_2, T_3)\} = 3 = T\varphi_\lambda$.

As it is the nature of any environment in a supply chain context, a node is dependent on its previous node. Also, this dependence decreases as the distance between the nodes increases. We have the following values of the possible coalitions:

$$u\,(T_1, T_2) = T\varphi_\lambda\ ¾ = 9/4; \qquad u\,(T_1, T_3) = T\varphi_\lambda\ ½ = 3/2;$$
$$u\,(T_2, T_3) = T\varphi_\lambda\ ¾ = 9/4.$$

where ¾ and ½ represent the dependence coefficients between two adjacent nodes and between two nodes that are not consecutive, respectively.[75]

The imputation (T_1, T_2, T_3) is the core of the game if:

$$T_1 + T_2 \geq u\,(T_1, T_2) = 9/4 \quad \text{iff } T_3 \leq 3/4;$$
$$T_1 + T_3 \geq u\,(T_1, T_3) = 3/2 \quad \text{iff } T_2 \leq 5/2;$$
$$T_2 + T_3 \geq u\,(T_2, T_3) = 9/4 \quad \text{iff } T_1 \leq 3/4.$$

We can also find all pairs of the core using Figure 2. The core, having $T\varphi_\lambda = 3$ at L_0, is defined by the pentagon with the vertices [(0.75, 2.25, 0), (0.5, 2.5, 0), (0, 2.5, 0.5), (0, 2.25, 0.75), (0.75, 1.5, 0.75)]. Every pair in this pentagon is not dominated by any other pair in the inside of the (T1, T2, T3) triangle and the outside of the core pentagon. Moreover, the core in Game 1 has a total area value of 0.438.

Game 2

Let us analyze the same game characterized by a uniform action combination, however using the CFE as substitute to the value of the coalition. We represent the values of the CFE in the following form:

$$T_n \mid \{(ada_{t_i}, l_{t_i}, \beta_{t_i}, \beta_{Tn_i}, \beta_{t_i(Tn_i)}, \varphi_{c_{t_i}}, \varphi_{r(s-1)_{t_i}}, eff._{t_i}, w_{t_i}, s) \Rightarrow$$
$$\Rightarrow (GLOQ, OBR, \varphi_{\sigma_{ti}}, MOT, TAL)\} = v\,(a_{i:t_i}) \qquad (3.2.2.1)$$

Therefore, we have:

[75] We will use the same dependence coefficients in all the games that we will study.

$T_1 \equiv T_3 \mid \{(3, 3, 4, 4, 4, 11, 11, 3, 3, 1) \Rightarrow$

$$\Rightarrow (9, 20, 0, 0, 0.667) = 28.333 \quad (3.2.2.2)$$

$T_2 \mid \{(3, 3, 4, 4, 4, 8.6, 8.6, 3, 3, 1) \Rightarrow$

$$\Rightarrow (9, 20, 0, 0, 0.667) = 28.333 \quad (3.2.2.3)$$

(3.2.2.2) and (3.2.2.3) provide us with the exact calculation of the CFE for each team:

$$\Sigma a_{i:t_i} = \hat{u}T_1 = \hat{u}T_3 = 56.666 \qquad \Sigma a_{i:t_i} = \hat{u}T_2 = 169.998$$

which creates the overall value $\hat{u}(G_2) = \hat{u}\ \{(T_1, T_2, T_3)\} = 283.33$.

Using the same rational and providing the same node distance-influence values, we have:

$$\hat{u}\ (T_1, T_2) = (56.666 + 169.998) \cdot 3/4 = 169.998;$$
$$\hat{u}\ (T_1, T_3) = (56.666 + 56.666) \cdot 1/2 = 56.666;$$
$$\hat{u}\ (T_2, T_3) = (169.998 + 56.666) \cdot 3/4 = 169.998.$$

The imputation (T_1, T_2, T_3) is the core of the game if

$$T_1 + T_2 \geq \hat{u}\ (T_1, T_2) = 169.998 \qquad \text{iff } T_3 \leq 56.666;$$
$$T_1 + T_3 \geq \hat{u}\ (T_1, T_3) = 56.666 \qquad \text{iff } T_2 \leq 169.998;$$
$$T_2 + T_3 \geq \hat{u}\ (T_2, T_3) = 169.998 \qquad \text{iff } T_1 \leq 56.666.$$

We realize that the values can be factored (1ü = 56.666), thus creating a unit of 56.666. This provides us with:

$$T_1 + T_2 \geq 3 \quad \text{iff } T_3 \leq 2; \qquad T_1 + T_3 \geq 1 \quad \text{iff } T_2 \leq 4;$$
$$T_2 + T_3 \geq 3 \quad \text{iff } T_1 \leq 2.$$

Figure 3 illustrates the core of our game. The core is the pentagon that has the vertices [(2, 3, 0), (1, 4, 0), (0, 4, 1), (0, 3, 2), (2, 1, 2)]. Every pair in this pentagon is not dominated by any other pair in the inside of the (T1, T2, T3) triangle and the outside of the core pentagon.

We notice that the use of the CFE increased the core. The core in Game 2 has an area of $3.5ü^2$. Thus, the total value of the area of the core is 198.331.

One may argue that Game 2 has a coalition value of 5 in comparison with Game 1 that has a value of 3, and this would be the reason why $v(AC)_{g2} > v(AC)_{g1}$. However, we point out that in Game 1, the value of the coalition is 'equally' split between the teams (also taking in consideration the node distance effect). In the previous statement, we have the following assumption:

Assumption 3: In Game 1, the three teams contributed equally to the value of the total coalition.

Using the CFE, we notice that this is not the case. T_1 and T_3 contributed equally to $\hat{u}(G_2)$, whereas T_2 contributed more than T_1 and T_3 (individually).

Game 3

We notice that the MOT term was not present in $\hat{u}G_2$. MOT might affect the core by influencing the CFE. Moreover, taking in consideration Assumption 1, there is a possibility that by amplifying the CFE, then the core of the game (using CFE) increases. Let us analyze the following game (where we still have a uniform action combination), having the same form as in (3.2.2.1):

$$T_1 \equiv T_3 \mid \{(3, 3, 4, 4, 4, 12, 11, 4, 4, 1) \Rightarrow$$
$$\Rightarrow (9, 20, 1, 8, 0.667) = 36.333 \qquad (3.2.2.4)$$
$$T_2 \mid \{(3, 3, 4, 4, 4, 9.6, 8.6, 4, 4, 1) \Rightarrow$$
$$\Rightarrow (9, 20, 1, 8, 0.667) = 36.333 \qquad (3.2.2.5)$$

We notice that $eff._{t_i}$ and w_{t_i} have increased to an above average level, thus also increasing $\varphi_{\sigma_{ti}}$ to 1. Therefore, we have:

$$\Sigma a_{i:t_i} = \hat{u}T_1 = \hat{u}T_3 = 72.667 \qquad \Sigma a_{i:t_i} = \hat{u}T_2 = 217.998$$

which creates the overall value $\hat{u}(G_3) = \hat{u}\ \{(T_1, T_2, T_3)\} = 363.332$, where

$$\hat{u}\ (T_1, T_2) = (72.667 + 217.998) \cdot ¾ = 217.998;$$
$$\hat{u}\ (T_1, T_3) = (72.667 + 72.667) \cdot ½ = 72.667;$$
$$\hat{u}\ (T_2, T_3) = (217.998+ 72.667) \cdot ¾ = 217.998.$$

The imputation (T_1, T_2, T_3) is the core of the game if

$$T_1 + T_2 \geq \hat{u}\ (T_1, T_2) = 217.998 \qquad \text{iff } T_3 \leq 145.334;$$
$$T_1 + T_3 \geq \hat{u}\ (T_1, T_3) = 72.\ 667 \qquad \text{iff } T_2 \leq 290.665;$$
$$T_2 + T_3 \geq \hat{u}\ (T_2, T_3) = 217.998 \qquad \text{iff } T_1 \leq 145.334.$$

We realize that the values can be factored (1ü = 72.667), thus creating a unit of 72.667. This provides us with:

$$T_1 + T_2 \geq 3 \quad \text{iff } T_3 \leq 2; \qquad T_1 + T_3 \geq 1 \quad \text{iff } T_2 \leq 4;$$
$$T_2 + T_3 \geq 3 \quad \text{iff } T_1 \leq 2.$$

Figure 4 illustrates the core of this game. The core is the triangle that has the vertices [(2, 3, 0), (1, 4, 0), (0, 4, 1), (0, 3, 2), (2, 1, 2)]. Every pair in this triangle is not dominated by any other pair in the inside of the (T1, T2, T3) triangle and the outside of the core pentagon.

The core in Game 3 has an area of $3.5ü^2$, which give us a total value of the core's area of 254.335. We notice that

$$v(AC)_{g3} > v(AC)_{g2}, \quad (3.2.2.6)$$

which confirms Assumption 1. Moreover, we notice that the core pentagon in Game 2 has the same vertices as the core pentagon of Game 3. However, ü is not the same in the two games.

Game 4

Let us analyze a game where we still have a uniform action combination, however, it is characterized by a weak cooperation, negative payoff stimulation, thus a negative motivation for the players, minimal effort and willingness. The game has the following form:

$$T_1 \equiv T_3 \mid \{(3, 3, 1, 1, 1, 10, 11, 2, 2, 1) \Rightarrow$$
$$\Rightarrow (9, 5, -1, -0.25, 0.667) = 13.083 \quad (3.2.2.7)$$
$$T_2 \mid \{(3, 3, 1, 1, 1, 7.6, 8.6, 2, 2, 1) \Rightarrow$$
$$\Rightarrow (9, 5, -1, -0.25, 0.667) = 13.083 \quad (3.2.2.8)$$

Therefore, we have:

$$\Sigma a_{i:t_i} = \hat{u}T_1 = \hat{u}T_3 = 26.167 \qquad \Sigma a_{i:t_i} = \hat{u}T_2 = 78.5$$

which creates the overall value $\hat{u}(G_4) = \hat{u}\ \{(T_1, T_2, T_3)\} = 130.834$, where

$$\hat{u}\ (T_1, T_2) = (26.167 + 78.5) \cdot ¾ = 78.5;$$
$$\hat{u}\ (T_1, T_3) = (26.167 + 26.167) \cdot ½ = 26.167;$$
$$\hat{u}\ (T_2, T_3) = (78.5 + 26.167) \cdot ¾ = 78.5.$$

The imputation (T_1, T_2, T_3) is the core of the game if

$$T_1 + T_2 \geq \hat{u}\ (T_1, T_2) = 78.5 \qquad \text{iff } T_3 \leq 52.334;$$
$$T_1 + T_3 \geq \hat{u}\ (T_1, T_3) = 26.167 \qquad \text{iff } T_2 \leq 104.667;$$
$$T_2 + T_3 \geq \hat{u}\ (T_2, T_3) = 78.5 \qquad \text{iff } T_1 \leq 52.334.$$

We realize that the values can be factored (1ü = 26.167), thus creating a unit of 26.167. This provides us with:

$T_1 + T_2 \geq 3$ iff $T_3 \leq 2$; $T_1 + T_3 \geq 1$ iff $T_2 \leq 4$;
$T_2 + T_3 \geq 3$ iff $T_1 \leq 2$.

Figure 5 illustrates the core of this particular game. The core is the triangle that has the vertices [(2, 3, 0), (1, 4, 0), (0, 4, 1), (0, 3, 2), (2, 1, 2)]. Every pair in this triangle is not dominated by any other pair in the inside of the (T1, T2, T3) triangle and the outside of the core pentagon.

The core in Game 4 has an area of $3.5ü^2$, which give us a total value of the area of the core equal to 91.585. We notice that

$$v(AC)_{g2} > v(AC)_{g4}, \quad (3.2.2.9)$$

which confirms Assumption 2.

Game 5

Let us analyze a game[76] that is more complex, where we do not have a uniform action combination. Table 9 provides all the values of our game. Moreover, we point out that t_{2a} is not present in our table. This is due to the fact that t_{2a} is absent, not present at work.

We have an overall value $û(G_5) = û\{(T_1, T_2, T_3)\} = 527.13$, where

$û(T_1, T_2) = (476.464) \cdot ¾ = 357.348$;
$û(T_1, T_3) = (110.964) \cdot ½ = 55.482$;
$û(T_2, T_3) = (466.832) \cdot ¾ = 350.124$.

The imputation (T_1, T_2, T_3) is the core of the game if

$T_1 + T_2 \geq û(T_1, T_2) = 357.348$ iff $T_3 \leq 169.782$;
$T_1 + T_3 \geq û(T_1, T_3) = 55.482$ iff $T_2 \leq 471.648$;
$T_2 + T_3 \geq û(T_2, T_3) = 350.124$ iff $T_1 \leq 177.006$.

Figure 6 illustrates the core of our game. The core is the pentagon that has the vertices [(177.006, 350.124, 0), (55.482, 471.648, 0), (0, 471.648, 55.482), (0, 357.348, 169.782), (177.006, 180.342, 169.782)]. Every pair in this pentagon is not dominated by any other pair in the inside of the (T_1, T_2, T_3) triangle and the outside of the core pentagon. Moreover, the total value of the area of the core is 28719.506.

[76] We note that this game models a real life situation. All the previous theoretical games provided us with a framework for the understanding of our environment. We will try to compare the theoretical findings with a real life situation, and understand the differences (if any) between them.

Data for Game 5									
Variables	**Values**								
Players	t_{1a}	t_{1b}	t_{2b}	t_{2c}	t_{2d}	t_{2e}	t_{2f}	t_{3a}	t_{3b}
n_i	2	2	*5*	5	*5*	5	*5*	2	2
$(n_i - 1)$	1	1	*4*	4	*4*	4	*4*	1	1
$T\varphi_\lambda$	3	3	*4*	4	*4*	4	*4*	2	2
φ_λ	6	5	*2*	5	*4*	6	*5*	4	6
δ	0	0	*-2*	0	*0*	0	*0*	0	0
c_1	1	1	*2*	2	*1*	1	*2*	2	1
$\Sigma_{t_{ni} \in T_{nx}}(\varphi t_{ni})$	2	0	*-1*	0	*0*	2	*1*	0	1
c_2	2	2	*1*	2	*1*	2	*2*	2	2
$\Sigma_{t_{ni} \notin T_{nx}}(\varphi t_{ni})$	2	1	*0*	0	*0*	1	*0*	0	0
$\varphi_{r(s-1)t_i}$	18	13	*4*	10	*9*	15	*12*	8	11
ada_{t_i}	3	2	*2*	3	*2*	3	*2*	1.5	3
l_{t_i}	4	3.5	*2*	3	*3*	3	*3*	2	4
β_{t_i}	4	4	*-3*	4	*1*	6	*4*	4	1
β_{Tn_i}	4	4	*4*	4	*4*	4	*4*	4	4
$\beta_{t_i(Tn_i)}$	4	4	*1*	4	*4*	4	*4*	4	4
$\varphi_{c_{t_i}}$	19	12	*6*	11	*11*	16	*14*	8	12
$eff._{t_i}$	4	1	*4*	4	*4*	3	*4*	3	4
w_{t_i}	3	2	*4*	3	*3*	5	*2*	2	3
s	1	1	*1*	1	*2*	1	*1*	1	2
GLOQ	12	7	*4*	9	*6*	9	*6*	3	12
OBR	20	16	*3*	20	*13*	22	*16*	14	17
$\varphi_{\sigma ti}$	1	-1	*2*	1	*2*	1	*2*	0	1
MOT	7	-0.333	*128*	7	*98*	8	*72*	0	7
TAL	0.583	0.786	*1*	0.667	*1.667*	0.667	*0.833*	1.167	1.167
Total value	38.417	21.881	*134.000*	35.333	*115.333*	38.333	*93.167*	15.833	34.833
ûT	**60.298**		**416.166**					**50.666**	
	$ûT_1$		**$ûT_2$**					**$ûT_3$**	

Table 9

Interpretation of results

We note that $\hat{u}(G_5)$ is calculated for an entire SDH period. Thus, s = 1 SDH = 120 minutes. All the actions of one player are considered for this specific time unit. We can ilustrate this by the following :

$$\Sigma a_{i:t_{i\in T}} = a_{i:t_{i\in T}}^{(s=1SDH)}$$

$$\Sigma a_{i:t_{i\in T}}^{(s=1SDH)} = \hat{u}T_{t_i}$$

We notice that $\hat{u}(G_5) > [\hat{u}(G_2), \hat{u}(G_3), \hat{u}(G_4)]$ individually. The reason for this high value is the contribution of three players (t_{2b}, t_{2d}, t_{2f}) belonging to T_2.

We observe that the three players have a very high MOT. In our case, the high MOT is characterized by a high payoff stimulation ($\varphi_{\sigma_{ti}} = 2$). Having a high MOT, and thus having a substantial contribution to $\hat{u}T_2$, we remarked that the three players created a suitable work atmosphere (which was characterized by their willingness (or effort) to increase their payoffs). Moreover, the players were more involved and focused in the accomplishment of their duties and, in the same time, they helped other members.

In addition, t_{2b} is the most interesting player to analyze. He is a deviator, yet he has the strongest contribution to $\hat{u}T_2$. We point out that the leader provided him with a deviation payment of -2, and his own team provided a deviation payment of -1. Moreover, he has a normal non-cooperation behavior (a value of -3). His team did not want him (at this stage)[77] to have the same team behavior value (of normal cooperation – a value of 4), but just to minimaly cooperate, having a value of 1.

Even though there were negative components that contributed to t_{2b}'s lower payoff ($\varphi_{r(s-1)_{t_{2b}}} = 4$, which is the lowest of all the players), as well to a lower OBR, it is the payoff stimulation ($\varphi_{\sigma_{ti}}$) that makes the greatest difference.

We have some conclusions drawn from this example :

- the player's previous payoff ($\varphi_{r(s-1)_{t_i}}$) is important as much as it is taken in consideration with the desired player's payoff ($\varphi_{c_{t_i}}$), thus creating the payoff stimulation;
- even though GLOQ, OBR, TAL have some influence on the value added by a player, they are not the most important elements if $\varphi_{\sigma_{ti}} \geq 2$;
- If $\varphi_{\sigma_{ti}} \geq 2$, then MOT becomes the most important term in $a_{i:t_x}$;
- Having a strong positive MOT (and we believe it is the case for a strong negative MOT as well), it influences the atmosphere of the team;
- If a player has a strong positive MOT, then he will be more focused in the accomplishment of his duties;

[77] It is better to demand from a player small incremental changes – may those be operational or behavioral. Demanding a higher requirement from an individual might result in a strong resistance to the demand.

- If a player has a strong positive MOT, then he will be more willing to help other members, thus increase their payoffs.

We specify that this game is a snapshot in time and space (Popp, 2002) where it refers only to one specific instance (in space and time). It does not take in consideration the full extent of what happened in the previous period or what will happen in the next one. Our (game-) environment evolves and is dependent on what happens in s-1. It would be interesting to analyze a continuum of periods that are sequential, having the same structure.

3.2.3. OVERALL UNDERSTANDING OF THE GAMES

We clarify that β_{t_i} is the behavior of the player at the beginning of his action. During the course of the action, his behavior can change. This is how t_{2b} started having a normal non-cooperative behavior, but still helped other members. His performance would be reflected in the next period (where we would have a cooperation behavior, an increase of his payoff, etc.).

We have noted in section 2.6. (OBR) that cooperative and non-cooperative behaviors are mutually exclusive when an actor is engaged in a specific action. However, an actor changed his behavior during the same action (period) in Game 5. We note that in this specific game, we have a $\Sigma a_{i:t_{i \in T}}^{(s=1SDH)}$, which represents all the actions that the actors were engaged in for a period of 120 minutes. Within this 'long' period of time that we analyzed, we note that there were many different actions in which the players were involved in.

We still maintain that a player cannot have conflicting behaviors during the course of the same action. However, we point out that the behavior of the player can change if the period analyzed is long – situation that arrived in Game 5.

In all the games that we analyzed, we have the presence of the total core. We believe that this is normal in a supply chain environment, due to the nature of the NC's output that is a common service (or product) where different teams handle sequential processes.

However, we point out that the domain of the core is larger when using the CFE in comparison with the first game in which we used the value of the coalition. Actors have different methods (and circumstance available) to form the total core using the CFE, û(C). Regarding this aspect, the value of the coalition u(C) has only limited interpretations and representations, and it does not properly illustrate reality.

Having a greater core area (v(AC)) the teams (and especially certain members of the team(s)) have the possibility to adapt to new situations (having dynamic interactions). Moreover, some members of a team can compensate for a lower $a_{i:t_x}$ value (of other members) in order either to maintain the total core or to increase it.

If the players have a MOT of 1 or -1, then they require side payments from other members in order to increase their added value and thus, the ûT*. Moreover, we note that if we have $\varphi_{\sigma_{ti}} \geq 2$ in one period for one actor, and the latter does not receive the desired payoff, then he might be de-motivated in the following period.

In Game 5, we notice that $\hat{u}T_2$ greatly dominates those of the other teams. We also point out that T_2 has more players in comparison with the other teams. This can play to its advantage (as in Game 5), or to its disadvantage (if for example, the players are demotivated, therefore $\hat{u}T_n$ would be negative).

A possible approach for the understanding of such situations would be to have a *common average contribution* (the average contribution of the players, denoted by đ) for the teams. This is represented by

$$đT_n = (\hat{u}T_n)/n_{t_{ni} \in T_n}. \tag{3.2.3.1}$$

In the context of Game 5, we would have

$$đT_1 = 60.298 / 2 = 30.149; \quad đT_2 = 416.166 / 5 = 83.233;$$
$$đT_3 = 50.666 / 2 = 25.333.$$

This is translated to: on average, T_2 players contributed more to the CFE than the players of the other teams; and, T_1 players contributed more to the CFE than the players of T_3. Moreover, we notice that $đT_2$ has a more than double value than those of the other teams.

Using this method, a modeler can compare the average contributions of players belonging to different teams. Moreover, a different approach would be to have a common average contribution of each player, independently of the team to which he is a member of, an approach that does not take in consideration the fact that different teams contribute differently (different amounts) to ûT. This is represented by:

$$ĐT = (\hat{u}T_n)/n. \tag{3.2.3.2}$$

In the context of Game 5, we would have

$$ĐT = 527.13 / 9 = 58.57.$$

Even if these methods (described in (3.2.3.1) and (3.2.3.2)) do provide some insight into the matter (and a lot of statistical and inference analysis can be performed), they can create other problematic (and questionable) situations where different biases might be present.

Based on the four CFE games that we analyzed, we can conclude that Assumption 1 is accurate. Moreover, taking the previous statement in consideration as well as the fact that Assumption 1 is directly linked with Assumption 2 (being opposite to it), we stipulate that the latter is also accurate. Thus, the value of the CFE does influence the area of the core ($\hat{u}T_n \# v(AC)$).

We observe that T_2 in Game 5 has the most members and is sided by two teams that have less members (i.e., $T_1 = T_3 = 2$). Moreover, we notice that in all the games that we analyzed, $\hat{u}T_2$ dominates those of the other teams. Dominating the other teams, and also being the middle node, $\hat{u}T_2$ greatly influences the v(AC).[78]

We note that in the three team supply chain environment that we studied, Assumption 1 and Assumption 2 may not hold, if the team that provides the greatest $\hat{u}T_n$ is the first or last node. Thus, there is a possibility where v(AC) may not be dependent only on the CFE, but also on the closeness coefficient between the nodes.

4. Conclusion

Supply chain environments

Due to their nature, supply chain environments have a very interesting setup. General GT can help in their understanding; however, external elements (from psychology, sociology and management) must be employed in order to have an appropriate comprehension of the proper management of a supply chain environment (SCE). However, we point out that a specific set of games, stochastic games (or Markov games), are widely used in SCE precisely for their applicability in such settings[79]. Even though stochastic games are a more appropriate tool to be utilized in SCM, we note that the former still have limitations.

We have analyzed different aspects related to the environment of a supply network. Our games provide a description of a specific setup where the processes are representative of a setting that provides both services and public goods. The latter need to be offered in a timely manner and at great quality. It is for this reason that we have examined the performance of our actors and of the teams that the actors form. The manner in which we monitored the activity of our environment was by observing the interactions and the productivity of the players on a 100 days non-consecutive span, where we analyzed certain reasons for the variations in the productivity of the system. We also took note of the institution(al) perspectives that refer to the network's configuration and structure. We have considered different theoretical games, and we compared these findings with a game that models the exact setting and environment of the actors. Based on our analysis and our inference, we have suggested different courses of action that a leader could employ in order to implement different strategies for the (improved) fulfillment of the mission of his department.

Characteristics of the game

Our game setup provides certain constraints, which were introduced only for simplicity reasons: a specialized process set (or sub-set) denotes a process that is covered only by a specific team; no other team can cover and execute a process which it is not specialized in. However, in reality, all our actors are cross-trained on other players' tasks (tasks that are not part of the actors' daily responsibilities). Thus, players can replace (or

[78] This is also caused by the closeness coefficient between the nodes, i.e. T_1- T_2: ¾, T_1- T_3: ½ , T_2- T_3: ¾.

[79] See Majumder and Groenevelt (2001) for the analysis of deterministic time-dependent multi-period games in reverse logistics supply chains.

help) other players belonging to different teams when required (ex. one member absent, spike in volumes, etc), situation in which duties and/or tasks are (re)distributed to the members present. Taking this aspect in consideration, one can create a more comprehensive game in which externalities are introduced such that members of one coalition are cross-trained.

Non-cooperative literature upholds that there must be competition between certain (or all) members of a coalition. However, there is no competition between the teams and between the members in our environment. The latter is set up in such a way that competition is not permitted, and in the same time, the actors (or teams) do not gain anything from any type of competition. We point out that in a supply chain environment, where everything is connected (and dependent) to a previous node, there cannot be any competition present.

Leader

The leader plays a central role in our NC for he is responsible to plan, to organize, to lead, and to control. There are a lot of variables that he has to take in consideration when making decisions regarding his direct reports and when trying to maximize the functionality of the operations that he is accountable for. In general terms, the leader is engaged in continuous planning and forecasting.

He must cover the functional strategies (the planning of the activities of the ASU) in addition to the operation strategies (which refer to the day-to-day tasks, and coordinating efforts and resources). His ability to foresee any change(s) that would affect his environment is as important as his ability to adapt to the change(s). Therefore, he must modify his supervisory styles in order to adjust to the different situations (external or internal to the ASU).

We also note that the leader pays close attention to continuous improvements both for his direct reports as well as for the operations that he is responsible for. These enhancements must follow the same trend as the corporate culture of the company.

The leader must analyze on a regular basis the productivity of his direct reports by benchmark exercises, in addition to the situational system by conducting different types of investigation (ex. SWOT). However, we caution that just gathering the data and analyzing it is not enough. The leader should implement the findings as much as he can. Combining these results, all the players involved (including the leader, the department, as well as the company as a whole) will have everything to gain. There would be an appropriate work atmosphere where moral would be high.

People are complex and their needs change over time. There are different conditions (socio-cultural, technological, gender, age, etc.) which determine the dynamics and complexity of the department's environment. The leader must be aware of these conditions and he must always take them in consideration.

To summarize, the leader must accomplish organizational objectives and he must verify that his direct reports meet them also. He should have close interactions with his employees in order for him to know their needs (and to be supportive of them), to build good working relations, and create a climate that is prone for productivity, yet keep a relax atmosphere.

Payoffs

We point out that team payoffs represent a public good. Team payments are paid to the team and they should not (and most of the time they are not) be split between the members of that team. It is the team (the unit) that receives those payments. Moreover, we point out that players do receive individual payments, which provides a mechanism (incorporated in our game in the CFE) to safeguard against the split of the team's payoffs.

In a team environment, we believe that direct payments to the members of the team(s) as well as payments to the team(s) are equal in importance.

Coalition

In our system, an agent disposes of a very short time to adapt to the coalition that he is assigned to. In case that he does not adapt, he will become a non-member of the coalition (a singleton). Thus, it is very important that the leader appoints the appropriate individuals to the appropriate coalition.

Besides the negative payoffs that the leader (or other members) has the ability to inflict on actors that do not follow the ASU culture, there are other mechanisms that can be implemented in order to deter members from deviation:

1. increased communication – through communication, there is interaction; the teams know beforehand what is happening and what is expected of them;
2. team building exercises (having as end result the fact that actors increase their trust of other members; members have a different setting in which they interact, thus learning more about each other and about themselves as teams);
3. team recognition programs (leader recognizes good work of the members acting as a collective unit and of the team);
4. individual recognition (either the leader or another individual recognize a specific actor for a job well done).

We have noted that an actor has a direct impact on the productivity and performance of all other members (or teams) in our network. This results in a direct influence of one member on the success and affluence of the entire system. In a SCE, not only that all actors should be aware of this characteristic, but they should also understand the consequences of their actions.

Behavior

We make the distinction between environmental behavior, the behavior that an actor has at the work place, and the personal behavior, which represents the state of mind of the actor. The leader must determine (as soon as possible) the intrinsic behavior in which the actor is engaged in.

Moreover, we note that behavior is dynamic[80] and it depends on many elements. The leader (or a modeler) has only partial control over some of these components. In our case, the leader can impose certain behavior characteristics from the members and from the teams (i.e., cooperation). However, this does not entail that the actors will actually behave in the manner that the leader desires. A modeler must take this aspect in

[80] See Popp, 2006a, 2009.

consideration when developing a game that tries to comprehend the effects of behavior on the actions of the players.

If the NA_{bi} is the intrinsic behavior of the player, then that player will not be able to adapt to the work environment, to the members and to the different teams. In order not to affect negatively the atmosphere and the moral of the players, it is better to take that player out of the game. Thus, the leader will terminate that player's contract.

We also note that a player can change his behavior during the course of an action. The player can have a cooperative (or uncooperative) behavior at the beginning of the action, and at the end of the action to have an uncooperative (or cooperative) behavior. However, we point out that his performance would be reflected appropriately in his next payoff (information that the player is aware of).

Actions

Our formula for the value of actors' actions (and the value that is created) is quite complex. We realize that there are many elements that are taken in consideration. However, we require all these variables in order to build a comprehensive model for the interactions of players in a supply chain environment and the consequences of these interactions.

Furthermore, we point out that beliefs are imbedded in all terms related to the actor (ada_{t_i}, l_{t_i}, β_{t_i}, β_{Tn_i}, $\varphi_{\sigma_{ti}}$, $eff._{t_i}$, w_{t_i}). Beliefs correspond to certain precepts, elements or situations of reality. They are derived from certain evidence or information. This process requires time in order for beliefs to consolidate.

It must be pointed out that when referring to a belief, there are two aspects:

1. the subject (the actor who is engaged in believing);
2. the object (the ConC that the specific belief is pointing to).

Models that incorporate beliefs in their operationalization must look at both these aspects.

We note that multitasking is not taken in consideration in $a_{i:t_i}$. In reality, multitasking is an important quality and attribute that all the members of the ASU must have. Being cross-trained on different tasks, actors can alternate between processes (and duties) depending on their priorities.

We note that if multitasking is allowed in our game setup, then a modeler must permit more then one $a_{i:t_i}$ permutation simultaneously. This would change the setup of our setting.

Statistical data

Based on our statistical data, we conclude that the leader's presence within the team increases the productivity of the team. There were different studies (in psychology and management) that confirm the same results. However, we point out that even if the leader's presence has a *positive* impact on the productivity of his direct reports (and thus on the output), his presence should not become a habit due to the fact that actors dislike it when they are watched and their work is verified[81] on a continuous basis. This aspect influences the team moral and the actors' dignity (because they see the leader doubting their ability to do their job properly).

Games

In our games, there is no bargaining set at L_1, thus there is no core at L_1. This results in the absence of a grand coalition of the members of the ASU. This is due to the nature of the environment that we studied (leader dictatorialship regarding the formation of teams). However, we note that the core is present at L_0, and therefore teams can cooperate in order to maintain (or increase) the value added to the system. Business coalitions are essential in an environment that is dynamic and where changes are introduced periodically.

We perceived a great difference between the use of the value of the game (uT*) and that of the CFE (ûT*). It is our opinion that using the CFE provides a better understanding in the reality of team cooperation in a supply chain environment.

Our game setup provides a stable configuration for the players at L_1 because there is no reason for a deviation to take place. However, even if a player engages in deviation, the other members of the ASU can compensate for the lower $a_{i:t_x}$ created (thus covering for the deviation in certain instances). However, prolonged deviation will result in the removal of that player from the game. As mentioned before, dynamic interactions are present (and essential) in our game at many levels and in many forms.

Moreover, the L_0 coalition configuration is optimal for the members of the teams, and thus the teams themselves, must work together in order to, not only accomplish a specific goal, but also to maximize the manner in which the latter is accomplished (may that be faster or better, or both).

The area of the core (v(AC)) provides us with a clear understanding of the space of the core. Using this method of measurement, we can easily compare the cores of different games. This is important in the understanding of the same game that is played at different points in time. Comparing the v(AC), a modeler can monitor variations within the game and pinpoint areas of interest.

As $\hat{u}T_{n1}$ increases, other coalitions loose their perceived 'contribution' (lower $\hat{u}T_{n+i}$), and T_{n1} becomes the most 'important'. Other teams (T_{n+i}) might see this effect in a negative way. We note that if this situation continues and becomes customary, the moral of the others teams would decrease.

However, we provide certain safety measures for such situations. If $\hat{u}T_{n1}$ becomes dominant, one has the choice to break T_{n1} in smaller teams. Another way to deal with it is to incorporate the other teams in T_{n1}. Thus, there would be only one team in the department. However, we note that there would be no coalitions to form the total core at L_0 due to the manner in which the members are assigned to the team (leader's dictatorialship).

[81] We are not referring to the confirmation of the actors' effort status. *Verify* in this situation refers to constant validation done in an authoritarian manner.

We also remark that there was no pessimism in Game 5 for t_{2b}. The state of mind of our player was attributed to personal issues. Moreover, the leader did not have to address the 'deviation' with t_{2b}. The latter's performance (and attitude) was only temporary, and it improved in the following payoff period. This is an example of a player's unwilling deviation.

We also note that MOT is a very good indicator of the players' moral, which is reflected in the moral of the team. Game 5 demonstrated this aspect very well.

General

Our (2.6.1) formula has many utilities. Not only that an actor can monitor his own progress regarding the input that he has to the system, but also it can help the leader to pinpoint problematic situations. It allows the modeler to observe the progress of the actors, depending on a specific term (GLOQ, OBR, MOT, TAL), and to isolate challenging elements.

Using the same formula, one can construct numerous situations in order to reflect a specific environment either by varying the individual terms or by constructing different settings with multiple teams (that vary in the number of their members). This flexibility provides the modeler with great input in the situations that he endeavors to study.

We point out that if low moral is present (within the teams and within a department), personnel quits.[82] This would result in a high turnover. New players would need to be introduced to our system, and the former need to adapt to the latter. Moreover, the new employees need to be trained. We acknowledge that there are a lot of resources invested in the actors. It is our opinion that it is better to keep moral high and avoid all other consequential problematic situations related to the implications of low moral of the teams and members of the teams.

Actors must be effective and efficient – attain the objectives by a high productivity and with the least resources wasted. In the same time, teamwork is very important and actors must sustain the team of which they are part of.

We have studied some aspects of the interaction(s) between members of teams in an environment that is characterized by the presence of a leader (which holds a position of responsibility) that has direct reports (which have operational responsibilities). We specify that the latter do not have any direct reports. A very interesting topic of research would be to analyze the environment and the interactions between the leader and his direct manager. In this game, the two players would have direct reports and have a position of power/authority. We believe that the interactions between the two players would provide significant and noteworthy results.

[82] This is a valid statement in today's workplace environment where employees have the ability to choose from a wide range of options.

Appendix

Proofs omitted in the main text

Proof 1

Assumption 4: High levels of ada_{t_i} and l_{t_i}, meaning $(ada_{t_i} \cdot l_{t_i})_{(ap.k)}$, will result in a high quality work.

Proof. By definition, high quality work implies two aspects – efficiency and effectiveness: 1. the work is done fast; and 2) the work is done well (proficient).

In order for the work to be proficient, a player needs specific knowledge to perform the tasks at hand. This involves learning abilities. If the player's learning abilities are high, then that player can acquire the specific knowledge more efficiently and in a shorter time span (call this Argument 1).

The adaptation of a player refers to his ability to have three types of reasoning: inductive, deductive, and abductive. A high adaptation level represents a high reasoning ability (of the three types, and a faster ability to alternate between them depending on the situation at hand). The faster this reasoning is, the higher the adaptation level (call this Argument 2).

Argument 1 refers to the fact that if learning (thus, the acquisition of knowledge) is faster, then one has a higher learning ability. Argument 2 indicates that if one knows what to do faster (he has the knowledge of faster execution), then that actor has a higher adaptation ability.

From Argument 1 and Argument 2 results the following: if one has the knowledge and is able to apply it to a specific situation, where less time is required to perform the specific duty, then the quality of the work performed by that actor is good.

Therefore, higher ada_{t_i} and higher l_{t_i} signify high quality work.

We point out that the definitions used in the paper for ada_{t_i} and l_{t_i} are very limited and they reflect only the environment of our game set-up. The true understanding and applicability of these terms has great complexity.[83]

Proof 2

We need to prove that if $ada_{t_i} > 1$ and $l_{t_i} > 1$, then $(ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i})$ will decrease.

Proof. For simplicity reasons, let us call AL of TAL the term $(ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i})$. Moreover, let us have $x = ada_{t_i}$ and $y = l_{t_i}$.

[83] For a small introduction to learning, see Popp (2009).

$$\text{If } x > 2, \text{ then } 1/x < 1/2; \qquad \text{if } y > 2, \text{ then } 1/y < 1/2.$$

Adding the two inequalities, we have:

$$1/x + 1/y < 1/2 + 1/2.$$

Having as common denominator *xy* on the left hand side:

$$x/xy + y/xy < 1 \equiv$$
$$\equiv (x + y)/xy < 1 \equiv$$
$$\equiv x + y < xy \equiv$$
$$\equiv (ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i}) < 1.$$

Table 10 provides us with certain values for $(ada_{t_i} + l_{t_i})/(ada_{t_i} \cdot l_{t_i})$. Moreover, we use the condition that $ada_{t_i} = l_{t_i}$ when we constructed the values of Table 10. In the same time, we specify that $x + y < xy$ is valid only if $(x; y) > 2$.

Tables

Legend of symbols used	
Symbol	**Interpretation**
≈	may
→	form
⎧	covers
}	comprehends and executes
╬	influence

Table 1

Explanation of teams and processes		
Processes	P_{1A}	Distribute unopened mail
	P_{1B}	Open and separate documents by BU
	P_{2A}	Department A (Dep. A) documents
	P_{2B}	Department B (Dep. B) documents
	P_{2C}	Department C (Dep. C) documents
	P_{3A}	Prepping Dep. A documents
	P_{3B}	Prepping Dep. B documents
	P_{3C}	Prepping Dep. C documents
	P_{4A}	Document scanning
	P_{4B}	Cheques scanning
Teams	T_1	Mail team
	T_2	Imaging prepping team
	T_3	Imaging scanning team

Table 2

Payoff Regulations	
Variable	**Scale**
$T\varphi_\lambda$	[0, 6]
φ_λ	[0, 9]
c_1, c_2	[0, 3]
$(\varphi t_{ni\,(t_{ni} \in T_{nx})}), (\varphi t_{ni(t_{ni} \notin T_{nx})})$	[0, 3]
δ	[-3, 0]

Table 3

Values of Learning and Adaptation Levels	
Values	**Level**
0	non existent
[1, 2)	beginner
[2, 4)	normal
[4, 5]	expert

Table 4

Behavior Values				
Cooperation	6	4	1	Value
Non-cooperation	-4	-3	-1	
Level	Strong	Normal	Weak	

Table 5

Effort and Willingness Values and Levels	
Values	**Level of effort and willingness**
0	Non existent
1	Negligible
2	Minimal
3	Normal
4	Above average
5	Major

Table 6

Statistics for 100 non-consecutive day span			
		λ_1	λ_2
		Leader present	**Leader not present**
α_1	**SDH met**	89 %	81%
α_2	**SDH not met (by more than 5 m.)**	42 %	88 %
α_3	**Time to spare**	30 m. – 40 m.	15 min.
α_4	**Usage of time to spare**	Helping afternoon staff (94%)	Socializing (72 %)
	Daily Com.	**Average of Interactions**	
α_5	**Work related**	10	13
α_6	**No-work related**	49	73

Table 7

Total Payments Received by t_i (without side payments)			
T_n	T_1	T_2	T_3
n_i	2	6	2
Normal φ_i	11	8.6	11
Maximal φ_i	21	16.2	21
Minimal φ_i	0	0	0

Table 8

Values for AL of TAL					
$v(ada_{t_i} = l_{t_i})$	v(AL)	$v(ada_{t_i} = l_{t_i})$	v(AL)	$v(ada_{t_i} = l_{t_i})$	v(AL)
0	∅	1	2	2	1
0.1	20	1.1	1.818	2.1	0.952
0.2	10	1.2	1.667	2.2	0.909
0.3	6.667	1.3	1.538	2.3	0.870
0.4	5	1.4	1.429	2.4	0.833
0.5	4	1.5	1.333	2.5	0.8
0.6	3.333	1.6	1.25	2.6	0.769
0.7	2.857	1.7	1.176	2.7	0.741
0.8	2.5	1.8	1.111	2.8	0.714
0.9	2.222	1.9	1.053	2.9	0.690

Table 10

Figures

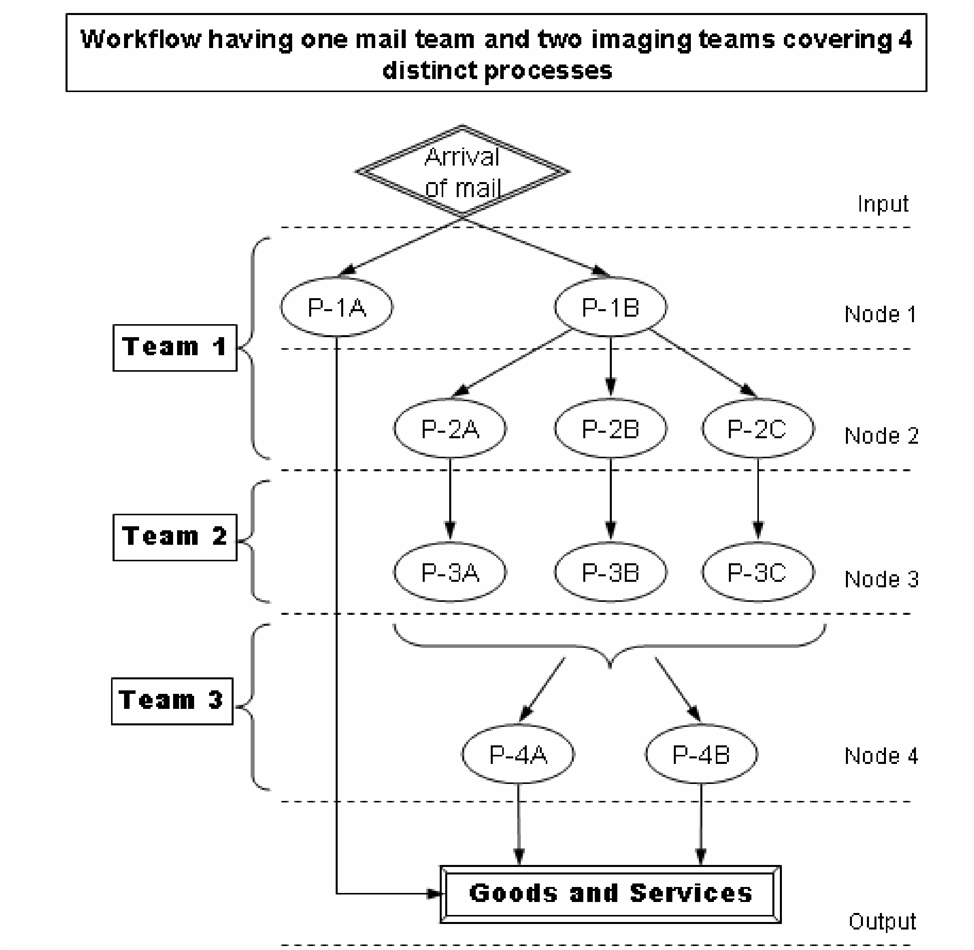

Figure 1

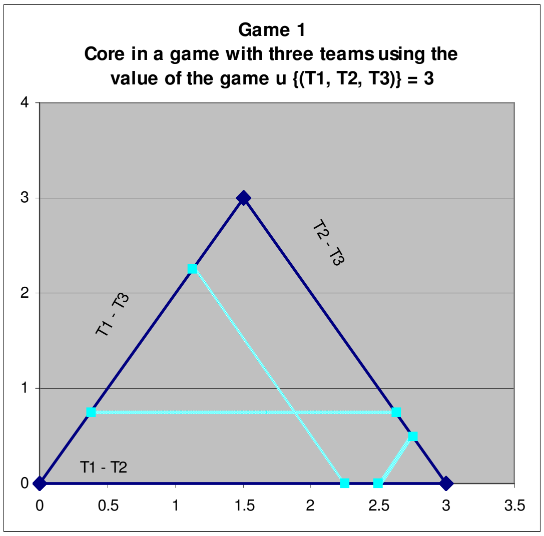

Figure 2

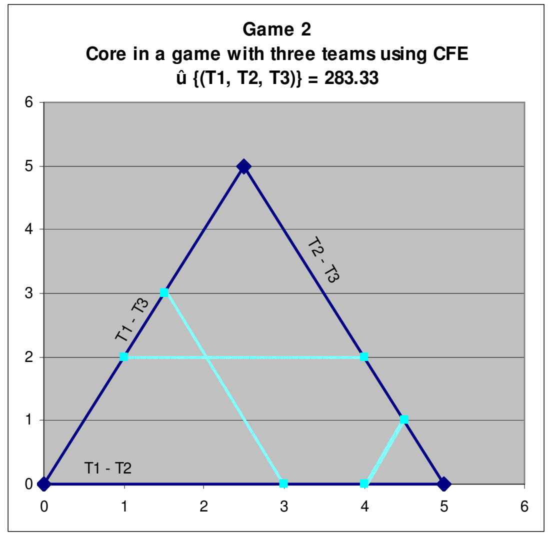

Figure 3

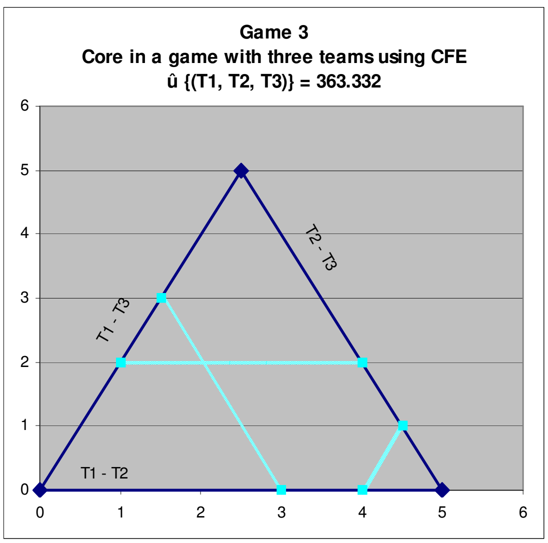

Figure 4

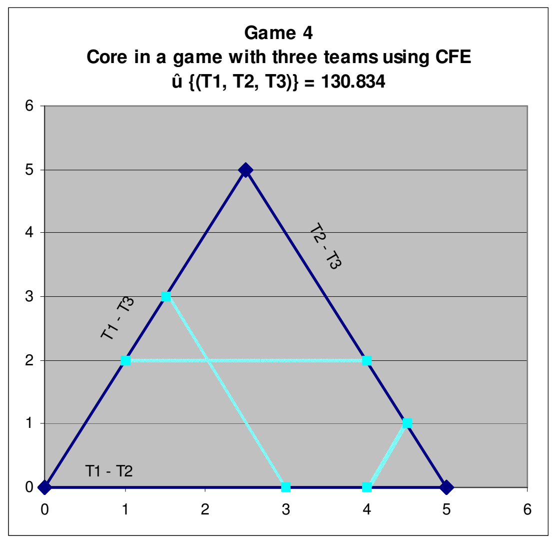

Figure 5

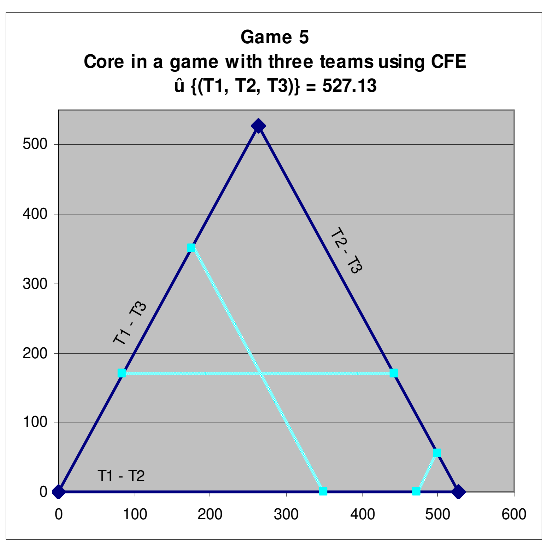

Figure 6

Bibliography

- Akerlof, G. A., Dickens, W., 1982. The economic consequence of cognitive dissonance. Amer. Econ. Rev. 72 (3), 307-319.
- Allan, L. G., Jerkins, H.M., 1980. The judgment of contingency and the nature of the response alternatives. Can. J. Psych. 34, 1-11.
- Alloy, L. B., Tabachnik, N., 1984. Assessment of covariation by humans and animals: the joint influence of prior expectations and current situational information. Psych. Rev. 91, 112-149.
- Andreoni, J., Harbaugh,W., Vesterlund, L., 2003. The carrot or stick: Reward, punishment and cooperation. Amer. Econ. Rev. 93 (3), 893-902.
- Arkes, H. R., Harness, A. R., 1983. Estimates of contingency between two dichotomous variables. J. Exper. Psych. General 112, 117-135.
- Aumann, R. J., 1961. The core of a cooperative game without side payments. Transactions of the American Mathematical Society 98, 539-552.
- Badcock, L., Loewenstein, G., 1997. Explaining bargaining impasse: The role of self-serving biases. J. Econ. Perspect. 11 (1), 109-126.
- Bewley, T., 1999. Why Wages Don't Fall During a Recession. Harvard Univ. Press.
- Blount, S., 1995. When social outcomes aren't fair: The effect of causal attributions on preferences. Organ. Behav. Human Dec. Proc. 63 (2), 131-144.
- Bohnet, I., Cooter, B., 2005. Expressive law: framing or equilibrium selection? Working paper, UC Berkeley.
- Brandts, J., Solà, C., 2001. Reference points and negative reciprocity in simple sequential games. Games and Economic Behavior 36, 397-409.
- Cachon, G. P., Netessine, S. 2006. Game Theory in Supply Chain Analysis. Tutorials in Operations Research-Models, Methods, and Applications for Innovative Decision Making. Johnson, M. P., Norman, B., Secomandi N., eds. Institute for Operations Research and the Management Sciences.
- Camerer, C., 2003. Behavioral Game Theory: Experiments in Strategic Interaction. Princeton Univ. Press.
- Charness, G., 2004. Attribution and reciprocity in an experimental labor market. J. Lab. Econ. 22, 665-668.
- Charness, G., Haruvy, E., 2002. Altruism, fairness, and reciprocity in a gift-exchange experiment: An encompassing approach. Games Econ. Behav. 40, 203-231.
- Charness, G., Levine, D., 2004. The road to hell: An experimental study of intentions. Working paper.
- Cooter, R., Ulen, T. 2003. Law and Economics. Addison-Wesley.
- Cooter, R., 1998. Expressive law and economics. J. Legal Stud. 27, 585-608.
- Davis, M., Maschler, M. 1965. The kernel of a cooperative game. Naval Research Logistics Quarterly 12, 223-259.
- Demange, G. 1994. Intermediate Preferences and Stable Coalition Structures. Journal of Mathematical Economics 23, 45-58.

- Dickinson, D., 2001. The carrot vs. the stick in work team motivation. Exper. Econ. 4, 107-124.
- Falk, A., Kosefeld, M., 2004. Distrust – The hidden cost of control. Discussion paper 1203. IZA.
- Falk, A., Gächter, S., Kovács, J., 1999. Intrinsic motivation and extrinsic incentives in a repeated game with incomplete contracts. J. Econ. Psych. 20 (3), 251-284.
- Falk, A., Fehr, E., Fischbacher, U., 2008. Testing theories of fairness: Intentions matter. Games Econ. Behav. 62 (1), 287-303.
- Falk, A., Fehr, E., Fischbacher, U., 2003. On the nature of fair behavior. Econ. Inquiry 41 (1), 20-26.
- Fehr, E., Falk, A., 2002. *Psychological foundations of incentives*. Europ. Econ. Rev. 46, 687-724.
- Fehr, E., Gächter, S., 2000a. Cooperation and punishment in public goods experiments. Amer. Econ. Rev. 90 (4), 980-994.
- Fehr, E., Gächter, S., 2000b. Fairness and retaliation: the economics of reciprocity. J. Econ. Perspect. 14 (3), 159-181.
- Fehr, E., Klein, A., Schmidt, K., 2007. Fairness and contact desigh. Econometrica 75, 121-154.
- Fehr, E., List, J., 2004. The hidden costs and rewards of incentives. J. Europ. Econ. Assoc. 2 (5), 743-771.
- Fehr, E., Rockenbach, B., 2003. Detrimental effects of sanctions on human altruism. Nature 422, 137-140.
- Fehr, E., Schmidt, K. M., 2007. Adding a stick to the carrot? The interaction of bonuses and fines. Amer. Econ. Rev. Papers and Proceedings 97, 177-181.
- Fehr, E., Kirchsteiger, G., Riedl, A., 1993. Does fairness prevent market clearing? An experimental investigation. Quart. J. Econ. 108, 437-460.
- Festinger, L., 1957. A Theory of Cognitive Dissonance. Stanford Univ. Press.
- Galbiati, R., Vertova, P., 2008. Obligations and cooperative behavior in public good games. Games and Economic Behavior 64, 146-170.
- Gneezy, U., Rustichini, A., 2000a. A fine is a price. J. Legal Stud. 29 (1), 1-17.
- Gneezy, U., Rustichini, A., 2000b. Pay enough or don't pay at all. Quart. J. Econ. 115 (2), 791-810.
- Gordon, M., Bowlby, R., 1989. Reactance and intentionality attribution as determinants of the intent to file a grievance. Personal Psych. 42, 309-329.
- Greenberg J., Weber, S. 1986. Strong Tiebout Equilibrium under Restricted Preference Domain. Journal of Economic Theory 38, 101-117.
- Greenberg J., Weber, S. 1993. Stable Coalition Structures with Unidimensional Set of Alternatives. Journal of Economic Theory 60, 62-82.
- Greenberg, M., Frisch, D., 1972. Effect of intentionality on willingness to return a favor. J. Exper. Soc. Psych. 8, 99-111.
- Guesnerie, R., Oddou, C. 1981. Second Best Taxation as a Game. Journal of Economic Theory 25, 67-91.

- Houser, D., Xiao, E., McCabe, K., Smith, V., 2008. When punishment fails: Research on sanctions, intentions and non-cooperation. Games and Economic Behavior 62, 509-532.
- Kahan, D. M., 1997. Social influence, social meaning and deterrence. Virginia Law Rev. 3, 349-395.
- Kahan, D. M., 2002. The logic of reciprocity: Trust, collective action, and the law. Mimeo. Working paper Series NO. 281, Yale Law School.
- Kamien, M. I., Schwartz, N.L., 2000. Dynamic Optimization: the calculus of variations and optimal control in economics and management. North-Holland.
- Konow, J., 2000. Fair share: Accountability and cognitive dissonance in allocation decisions. Amer. Econ. Rev. 90 (4), 1072-1091.
- Majunder, P., Groenevelt, H., 2001. Procurement competition in remanufacturing. Working paper, Duke University School of Business.
- McAdams, R., Nadler, J., 2005. Testing the focal point theory of legal compliance: The effect of a third-party expression in an experimental hawk/dove game. J. Empirical Legal Stud. 2, 87-123.
- McCabe, K., Rigdon, M., Smith, V., 2003. Positive reciprocity and intention in trust games. J. Econ. Behav. Organ. 52 (2), 267-275.
- Modi, J., Jung, H., Tambe, M., Shen, W., Kulkarni, S. Dynamic Distributed Resource Allocation: A Distributed Constraint Satisfaction Approach. Intelligent Agents, VIII Proceedings of the International workshop on Agents, theories, architectures and languages (ATAL'01).
- Nelson Jr., W. R., 2002. Equity and intention: It's the thought that counts. J. Econ. Behav. Organ. 48 (4), 423-430.
- Ostrom, E., Walker, J., Gardner, R., 1992. Covenants with and without a sword: Self-governance is possible. Amer. Polit. Sci. Rev. 86, 404-417.
- Offerman, T., 2002. Hurting hurts more than helping helps. Europ. Econ. Rev. 46, 1423-1437.
- Owen, G., 1968. Game Theory. W. B. Saunders Company.
- Polinsky, M., Shavell, S., 2000. The economic theory of public enforcement of law. J. Econ.Lit. 38, 45-76.
- Popp, W. A., 2009. An understanding of influence on human behavior. APOC Services. Working paper.
- Popp, W. A., 2006a. The Epistemic value of rationality. The 12th International Conference on Foundations and Applications of Utility, Risk and Decision Theory. Working paper.
- Popp, W. A., 2006b. On Economy. Economics, Management and Financial Markets 1 (2), 54-79.
- Popp, W. A., 2002. Systemic game theory: Werterian approach. Topics in Game Theory, The 3rd APET International Conference on Public Economics.
- Rabin, M., 1994. Cognitive dissonance and social change. J. Econ. Behav. Organ. 23 (2), 177-194.
- Raz, J., 1980. The Concept of a Legal System. Oxford Univ. Press.
- Robinson, P.H., Darley, J.M., 1997. The utility of desert. Northwestern Univ. Law Rev. 91, 453-499.

- Sefton, M., Shupp, R., Walker, J., 2007. The effects of rewards and sanctions in provision of public goods. Economic Inquiry 45 (4), 671-690.
- Sonsino, D., Sirota, J., 2003. Strategic pattern recognition – Experimental evidence. Games and Economic Behavior 44, 390-411.
- Tyler, T., 1990. Why People Obey Law. Yale Univ. Press.
- Yamagishi, T., 1986. The provision of a sanctioning system as a public good. J. Personality Soc. Psych. 51 (1), 110-116.
- Yamagishi, T., 1988. Seriousness of social dilemmas and the provision of a sanctioning system. Soc. Psych. Quart. 51 (1), 32-42.