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## CONTRIBUTIONS OF GAME THEORY TO UNDERSTAND THE FLOW OF KNOWLEDGE WITHIN AN ORGANIZATION

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**ABSTRACT:** *The word "knowledge" is increasingly being joined - in contemporary economic and social environment- to terms such as management, society, economy, and politics. The word "knowledge" is increasingly being joined - in contemporary economic and social environment- to terms such as management, society, economy, and politics. This reveals that, for example organization's key resource is the knowledge hold by individuals operating within it, and their ability to use this knowledge in the activities and processes within the organization. It is almost intuitive known that the stock of knowledge represents the key element in almost every organization. Indeed, the research presented in this article aims to show that game theory is an effective tool in the study of organizational dynamics.*

*The article will illustrate, through game theory, situations in which individuals interact with one another, considering the results of those situations where individuals have different preferences regarding the exchange of knowledge and also the consequences of these interactions on the organization, at the aggregate level Methodology includes the assumption, as a fundamental scientific assumption, used most commonly on the theoretical description of the context. The results will provide information on strategies that players must take in their interactions, the consequences for both individuals and the organization after the interaction between them and last but not least, about the strategy "tit-for-tat" which can be applied to maximize an employee's own results and to increase overall cooperation. This study may represent a starting point for researchers interested in analyzing the flow of knowledge within an organization, through game theory. The article will provide a better understanding of the motivations underlying the decision to share knowledge with individuals or within organizational surrounding. It is noted that a limitation of the approach presented in the article is that it does not facilitate predictions, and therefore is highly advantageous in complementary use of other approaches and methods - for example, agent-based modeling.*

**Key words:** *international organization; game theory; prisoner's dilemma; knowledge management;*

### INTRODUCTION

For organizations to function efficiently, individuals and teams within organizations has to coordinate efforts and activities in this regard. In 1988, Peter Drucker (1988) stipulated the exchange of knowledge between organizations, as an essential point of competitive advantage. Knowledge management has become a primary concern and was the subject of numerous academic studies and organizing

projects. Defined as "the idea of capturing and disseminating knowledge of individuals was obtained by others in organizations" in the last decade it has become an extremely fertile source of inspiration for both research and for practitioners.

### Problem Statement

This article applies game theory tools, examining the results of interactions between different individuals within organization, with

distinct preferences in terms of knowledge sharing. Brown and Duguid (2000) advocate the importance of this process and its critical dependence on the environment, but especially the social work situation. Studies have shown that individuals may be motivated to share knowledge in some cases and not share in others. (Ardichvili, Page& Wentling, 2003). Starting from organizations objectives and their organizational behavior, questions arise and the present study attempts to answer: "What is the dynamics of interpersonal relationships in an organization"; "Which are the compatibilities / contradictions that exist between individuals and the organization's" and "What might management do in order to enhance knowledge sharing?"

### **Organization's classic and modern theories**

The classical theories are: classical scientific management, bureaucracy and human relations theory. Scientific management principles formulated by Frederick Taylor, in his book of the same name published in 1911 reveals the following attributes: developing science-accumulation of all knowledge about effective methods of production-, scientific selection and progressive development of workers, incentives given to selected scientific worker, principle of cooperation between workers and management and the division of responsibilities / work. Bureaucratic organization, has been defined by one of the classics of sociology, Max Weber as the ideal form of organization. Considering authority as the three-charismatic, traditional and rational-legal-Weber said that the latter type is one who can produce the most effective form of organization: bureaucracy. She appeared in Weber's acceptance a formal type of organization, with a specific structure of statuses and roles in which the power to influence the actions of others grows forwarding to the top of hierarchy of the organization. Theory of human relationships (Hawthorne experiment) was a completely unintentional result of a discovery, made by American scientists in '20 years. George Elton Mayo and Fritz Roethlisberger were two

reputed specialists in psychology, respectively sociology, who initially tested the influence of illumination level of the workspace in two groups: one in which conditions were kept unchanged (control group) and another in which the light intensity was changed periodically. To general surprise, labor productivity has remained constant and was not reduced, as scientists had expected. In work published in 1933, "The Human Problem Of An Industrial Civilization" Elton Mayo described and explained, among other things, what happened when Hawthorne experiment: that the group of five young women worked together for a long time created friendship and collaboration between them and between them and between them and managers and researchers; being in the spotlight, feeling important and being treated properly, they had superior performance. Constant and size of the group were also positive.

Modern theories, appeared in the second half of last century, addresses the organization a more complex perspective, holistic, taking account of individuals, groups, relationships, organizational culture, organizational processes, organizational environment, etc. One of the researchers who helped develop the modern theory of human resources (*adapting to human nature*) is that in 1960, Douglas McGregor published "*The Human Side of The Enterprise*", which starts from two theories:

- **Theory X** - the managers are pessimistic about the employees

- **Theory Y** - the managers are optimistic, the author considering more useful the assumption of theory Y.

Contingency theory (*to adapt to the context*) is a theoretical approach saying that there isn't a certain recipe for driving people in an organization and the optimal solution for obtaining performance must be adapted to the context of organizational context. Fiedler's theory believes that managers must adapt their leadership styles and behaviors to group members and to situation. Performance is a good combination between the group members, situation and leader.

Specific styles of this theory are:



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- management based on objectives
- management based on relationships

*Gareth Morgan and metaphorical approach of organizations* supports their characterization using metaphors. The eight organizations are used to describe situations:

- cars
- living organisms
- brains
- cultures
- political system
- prisons of the psyche
- flows and transformation processes
- instruments of domination

Using metaphors facilitates understanding of complex entities by using the like. The problem of using metaphors is that there is a perfect similarity between the object and its image analysis. The problem of using metaphors is that there is a perfect similarity between the object and its image analysis. In Gareth Morgan's perception of the organization as a car or as a mechanic way of thinking, reflects the use of organization forms during the scientific classic management period, with fixed structures and rules, in which employees function as commodities, ways which are rotated positions within the machine is the organization. Mechanistic way of thinking, presented by the author in Chapter II of the paper "*Organizations like cars*" says mechanization lead to increased economic performances, but the side effects adversely affect certain aspects of people's lives and organizations.

Some side effects are:

- Occurrence of stress
- lack of attractiveness and satisfaction in work, family life;
- reducing creativity and innovative spirit;

From the perspective of human relations theory, organizations are seen as living organisms that respond to human needs to

motivate individuals and groups. Morgan sustained the idea to integrate the needs of individuals and organizations.

### **The role of knowledge management in organizations**

Management is the process of exercising control and facilitation and coordination within and between departments of an organization. Being a relatively new management, knowledge management is focused on process and resources. Accordingly, knowledge management regards not only "relations of production", but rather the relationship between people and their work results, oriented towards creation, dissemination and knowledge, necessary for the evaluation of development strategies. The process of acquiring knowledge presupposes the existence of information sources and other sources from which, according to specific methodologies or technologies may obtain or extract ("data mining") "raw" data, choosing them, encoding them according to some well-defined standards. Evolutions in theoretical and applied knowledge management are in congruence with the defining elements of the competitive game and the type of competition prevailing in the economic life of the world. Many scholars, businessmen, and politicians appreciate that the kind of society that awaits mankind is a society of knowledge, supported by a knowledge economy.

Social developments have shown that the main features of the knowledge society are (Draganescu, 2004) relating to: the expansion and deepening of scientific knowledge, management and use of existing knowledge in the form of technological and organizational knowledge, production of new technological knowledge through innovation, the emergence of a new economy in the process of innovation becomes crucial; unprecedented dissemination of knowledge to

all citizens through new media (internet, e-books, e-learning); shaping the global community, producing a cultural revolution based on knowledge, need environmental sustainability through rapid technological adaptation.

In this type of society, new economy, the so called knowledge-based economy, owes its appearance to a number of important forces that act today in terms of changing the rules of business and national competitiveness: globalization, the intensity of knowledge and information, computer networks and connectivity, and increasing the share of workers with skills in more than 80% of the employed population. Foundation of the knowledge economy concept was created by Peter Drucker.

In 1966, he described the difference between manual workers and the knowledge worker: a manual worker uses his hands to produce "things" and a knowledge worker uses his intelligence to produce ideas, knowledge and information. Knowledge economy or knowledge-based economy is a concept that refers to the use of knowledge to produce benefits. The phrase was popularized by Peter Drucker in his book "The Age of Discontinuity" (Drucker, 1969). A key principle used is that education and knowledge are considered productive assets of a business, as they may be the most valuable primary elements in making a product or service.

### **Dynamics of interpersonal relationships**

To understand interpersonal behavior within organizations we have identified two important factors: psychological contract and trust.

Psychological contract: the expectations of individuals

Whenever there is a relationship between individuals of a particular type, each will have expectations on how the relationship will progress. Psychological contract refers to the perceptions, beliefs about what a person expects to receive from others involved in a relationship. Psychological contract depends on individual characteristics and personal values of the two

actors: the employer and employee, sending a message between subliminal limits, and tacit agreement between these two, but with great importance and influence of the employer, resulting in flawless effects, after transposition psychological ideas of the contract. Rousseau (1995) presents four fundamental characteristics of the psychological contract. First, the fact that he is essentially a subjective perception which varies from one individual to another. Secondly, it is stated that a psychological contract is dynamic, meaning that changes over time during the relationship between employee and employer. Thirdly, psychological contract refers to the mutual obligations based on promises made by both parties investing in them, with the hope of a positive outcome for themselves. Another feature is the fact that psychological contracts are closely related to the context of employment relation, neither individuals or organizations being able to create them separately. Since the psychological contract is based on trust, its violation can lead to strong negative emotional reactions and the feeling of being cheated. Robinson and colleagues (1994) think that, after a breach of the contract, it becomes more transactional. The employee withdraws from the relationship and give more attention to financial and economic aspects. This idea is developed by Herriot and Pemberton (1996), referring to the fact that violation of a transactional psychological contract lead to new explicit negotiations, adjust their investment in relationship or even giving up that job. In relational contracts, amendments are primarily at an emotional level, developing the reaction of disappointment and disbelief, changes that ultimately lead to the transformation of relational contracts in the transaction.

Other effects of psychological contract violation is reflected in the decline of loyalty (as a component of trust), the loyalty to the organization, workplace satisfaction and pronounced intention to leave the organization. But so far investigated the effects were largely limited to attitudes such



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as loyalty or satisfaction at work, while the health studies have been rare. (Guest, 2000)

**Cooperation: Providing mutual knowledge**

In organizations, is common when two or more individuals, teams, or even some organizations that work together to offer their assistance to achieve their mutual common goal. These actions are known as cooperation. Cooperation is essential to organizational success. There exist some important factors that cause people to cooperate within organizations:

*Principle of reciprocity:* „Golden Rule” determine individuals not to treat others the way they wouldn't like to be treated. However, this rule does not describe exactly how individuals behave. Instead, treating the others as we would like to be treated, most people tend to treat others as they were previously treated by them. Thus, another principle comes into the scene:

„Tit-for-Tat” or „Eye-for-an-Eye”. Sociologists call this principle "The principle of reciprocity" - the tendency to treat others as they treated us in the past. Reciprocity principle describes how individuals behave when interacting with others. The main issue in establishing cooperation between individuals in an organization is the initiative. Once individuals or teams within an organization began to cooperate, the process can be self-sustaining. To encourage cooperation, managers should try to put on the wheels.

*Personal orientation.* Some individuals tend to be more cooperative than others by nature. In contrast, others tend to be more competitive, interested in making things better than others in one way or another. Scientists have classified individuals into four different categories in terms of their predisposition to work / compete with others. These are:

- competitors: people whose main goal is to make things better than others, challenging them in open competition
- individualists: people who can maximize their own gain and who do not care about the actions of others
- cooperators: people that are concerned with maximizing the benefits that result from partnerships, getting as much as possible from their team
- equalizers: people whose main goal to minimize differences between themselves and others

Despite individual differences men tend to favor the competitive orientation trying to exploit people around them. On the other hand, women tend to favor cooperative orientation, preferring to collaborate with people around them and tend to develop friendships with others. However, it would be a mistake for managers to automatically assume that men and women fall into a certain category. Managers are advised to devote their time to know their employees personal orientation and then assign them responsibilities that suit them best. For example, competitors may be effective in negotiation situations, while cooperatives are most effectively in teamwork.

Not only the differences between people make them to cooperate but also differences in the nature of *reward organizational systems*. Despite good intentions, companies often create reward systems that lead his employees to compete against each other. With an eye towards the elimination of such problems and encouraging cooperation, more of today's companies adopt the rewards systems for teamwork.

Cooperation and competitiveness can occur at the same time. This is because people may have different motivations that

operate simultaneously. In business competition is the natural order of things. Employees from the same company are competing for a promotion, companies compete for government contract and retail businesses compete for the same customers.

## Game Theory Analysis

### *Prisoner's Dilemma*

This implies that the two suspects were arrested and charged with committing a crime. They are interrogated in separate rooms, and each has two response options: either to remain silent, that is to deny that he committed the crime or to accuse the other prisoner. If the suspects are accusing each other, then they will receive as punishment 7 years in prison. If both deny, then the punishment will be imprisonment for one year each, and if one denies and the other accuses, then the complaining will be released, and the one who denies will be punished with 10 years in prison. Suppose that there are two employees (players) who have the perception that controlling their own knowledge and decline sharing knowledge is in their interest.

### *Elaborating the statement:*

Motivations for and against the exchange of knowledge

- ⊙ The desire for recognition as an expert
- ⊙ Considering his own knowledge a public asset
- ⊙ Feeling a moral obligation to share knowledge
- ⊙ "Generalized reciprocity"- sharing knowledge in community, in order to be rewarded by someone else in the same way in the future
- ⊙ Individuals may believe that their knowledge is a competitive advantage over their peers
- ⊙ They may fear of loss of power or control
- ⊙ They may fear ridicule or criticized

We consider two employees with perception that not sharing their knowledge is in their best interest. Whether or not they share their knowledge, it is a type of prisoner's dilemma; If the first player decides not to share their

knowledge and player 2 decides to do, the benefit (utility) of the player 1 will be 6 (max), and the player's 2 will be 1. In this case we assume that player 1 gets the player 2 knowledge, and at the same time it keeps its own confidential.

If none of the players do not share the knowledge, they will both gain utility 2, and player 1 will be in a disadvantaged situation from the previous one, because he no longer holds the player 2 information.

Figure 1. Matrix of benefits if players do not share knowledge

	Share	Not share
Share	(5,5)	(1,6)
Not share	(6,1)	(2,2)

If player 1 share, and player 2 not share, this situation provides the greatest benefit for player 1.

If none of the players do not share their knowledge, then they will find themselves in a bad situation because of lack of knowledge they would be gained due to an exchange of knowledge.

If player 1 share, and player 2 not, utility of player 1 will be minimum, because he no longer has control over his own information, as opposed to player 2, which accumulates knowledge and keep them confidential.

If both players share the knowledge, they will both have the utility 6. The reason that the organization can encourage the exchange of knowledge between employees is to obtain profit. Sharing knowledge can be in the benefit of all by helping to achieve corporate objectives.

This game in normal form can be represented as matrix.

Rows and columns of the matrix indicates the player's feasible strategies (pure strategy) and matrix cells will contain the earnings of each player, depending on the strategies chosen, the first number indicating the benefit of player 1 and the second the benefit of player 2. We assume that rational players (we mean by rational player that player who always seeks to maximize its gain



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depending on the choice of strategies by other players) will never choose to play a dominated strategy.

Figure 2. Matrix of benefits if players share knowledge

	Share	Not share
Share	(5,5)	(6,1)
Not share	(1,6)	(2,2)

But when a player with a predisposition to share knowledge will meet a player with a predisposition to gain knowledge and not to share, then the benefits will be as shown in the Fig. 3 matrix..

Figure 3. Matrix of benefits if players share knowledge

	Share	Not share
Share	(5,5)	(6,6)
Not share	(1,1)	(3,3)

This is a non-conflict game in which both players have dominant strategies. Both players will be happy with the decision either to share or not share knowledge.

**Infinitely Repeated Prisoner's Dilemma**

If infinitely repeated games are considered, the balance will be determined by the results presented by the folk theorem

**Analysis through folk theorem:** Given the G stage-game and infinitely repeated  $G(\infty)$  game and  $\underline{u}_i$  minmax gain of player  $i$ , then for any vector of gains  $v$  with  $v_i > \underline{u}_i, \forall i$ , there is  $\delta < 1$ , so that  $\forall \delta \in (\delta, 1)$  there is a Nash equilibrium of game  $G(\infty)$  given by repeated strategies that ensures the gain  $v$ .

Suppose there is a pure strategy such that  $u(a) = v$  (cu  $v > \underline{u}$ ) and for any player  $i$  the following strategy: "i will play  $a_i$  in period 0 and i will continue to play  $a_i$  as long as in previous period was played  $a$ . If not,

will be played  $m_i$  (minmax gain appropriate strategies) for the rest of the game."

It is possible that the player  $i$  win because of the deviation from this strategy?

The answer is yes, but today's gain from deviation will be far below of gains from cooperation in the future.

**Demonstration**

- We will note  $G=(XA_i U)$  the stage-game and  $A_i$  the space of distributions of probabilities on  $A_i$  actions of player  $i$ ;
- The games are held in perfect and complete information and at the end of each stage every player knows the game and earnings history.
- We will note  $a^t = (a_1^t, a_2^t, \dots, a_n^t)$  the choosen action of the  $n$  players at the moment  $t$ , and the game history will become  $h^t = (a^0, a^1, \dots, a^{t-1})$
- A pure strategy in repeated games is represented by a sequence of pure strategies of the game-step, from beginning to end the game.
- A mixed strategy  $P_i$  will be described by a sequence of mixed strategies  $\alpha_i \in \Lambda_i$
- Gain function will be described by  $U_i = E_p (1 - \delta) \sum_{t=0}^{\infty} u_i (p^t(h^t))$   
 $E_p$  = strategy  $p$  expected gain;  
 $\delta$  = intertemporal discount factor  
 $\delta = 0$  – represents players who don't have the patience to continue playing and stop after first stage;  
 $\delta = 1$  – players are perfectly patient, for that the earnings of each period are equivalent.
- The criteria in choosing the strategies followed by the players is to maximize the average earnings (expected) per unit time, respectively

$$\max_{T \rightarrow \infty} \liminf E \left( \frac{1}{T} \sum_{t=0}^T u_i (p^t(h^t)) \right)$$

Suppose there is a pure strategy so that  $u(a) = v$  cu ( $v > u$ ).

At the time he will deviate he will win, and after that he will win  $\underline{ui}$  (minmax, strategy that brought gains), so by the end of each round will win  $\underline{ui}$  in each stage.

In conclusion, the gain brought be the deviation in  $t$  stage will be:  $\underline{\delta_i}$

$$uD = (1 - \delta_i^t)ui + \delta_i^t (1 - \delta) \max ui (a) + \delta_i^{t+1} \underline{ui}$$

Note: Among the gains we have the following equation:  $\max ui (a) > ui > \underline{ui}$

Acest castig este mai mic decat  $ui$  cat timp se depaseste nivelul este  $\underline{\delta_i}$ , definit prin:

$$(1 - \delta_i) \max ui (a) + \delta_i \underline{ui} = v_i \quad (*)$$

If  $v_i > \underline{ui}$ , then solution  $\underline{\delta_i}$  of equation (\*) is  $< 1$ .

If  $\underline{\delta_i} = \max_i \delta_i$ , so there is  $\delta$  so that  $\forall \delta > \underline{\delta_i}$ , game balance is given by the strategies that ensure winning v. q.e.d.

Suppose the situation in which two employees (players) are placed in a situation where both are threatened with losing control of a situation, matter fact their job, if they decide to share their knowledge. Being a normal game, we represent the matrix form:

Figura 4. Matrix of benefits if players do not share knowledge

	Share	Not share
Share	(-4,-4)	(-5,-2)
Not share	(-2,-5)	(1,1)

If  $G(T)$  is the sequence that is repeated in each stage dynamic game  
 $s^*$  = strategy that ensures Nash equilibrium of the stage game

$\underline{U_i(s^*)}$  = minimum gain if players play the best possible

Suppose that  $\exists s^{**} a.l. U_i(s^{**}) > \underline{U_i(s^*)}, \forall i, s^{**} =$  **strategia de cooperare a jucatorilor** cooperation strategy of both players

Suppose that  $\exists s^i a.l. U_i(s^i) \geq U_i(s^{**}), \forall i, s^i =$  **strategia de deviere** deviation strategy

Infinitely repeated game equilibrium will be strategy  $s^{**}$  repeting throughout the game,  $\forall \delta_i > \delta$

Castigurile asteptate:

$$E(U_i^C) = \sum_{t=0}^{T-1} \delta_i^t u_i(s^{**}) + \delta_i^{T-1} U_i(s^{**}) + \sum_{t=T+1}^{\infty} \delta_i^t U_i(s^{**})$$

$$E(U_i^D) = \sum_{t=0}^{T-1} \delta_i^t u_i(s^{**}) + \delta_i^{T-1} U_i(s^i) + \sum_{t=T+1}^{\infty} \delta_i^t U_i(s^i)$$

$$E(U_i^C) \geq E(U_i^D)$$

Comparing

$$\delta_i^T U_i(s^{**}) + \sum_{t=T+1}^{\infty} \delta_i^t U_i(s^{**}) \geq \delta_i^T U_i(s^i) + \sum_{t=T+1}^{\infty} \delta_i^t U_i(s^i)$$

$$\sum_{t=T+1}^{\infty} \delta_i^t (u_i(s^{**}) - u_i(s^i)) \geq \delta_i^T (u_i(s^i) - u_i(s^{**}))$$

$$\delta_i^{T+1} \frac{1}{1 - \delta_i} \geq \delta_i^T \frac{U_i(s^i) - U_i(s^{**})}{U_i(s^{**}) - U_i(s^i)}$$

$$\frac{\delta_i}{1 - \delta_i} \geq A; \delta_i \geq A - A\delta_i; \delta_i + A\delta_i \geq A;$$

$$\delta_i \geq \frac{A}{1+A}$$

$$\delta_i \geq \frac{u_i(s^i) - u_i(s^{**})}{u_i(s^{**}) - u_i(s^i)} (0,1) = \underline{\delta_i}$$

In other words the threshold  $\delta$  from which players will adopt a cooperative behavior will be  $\underline{\delta} = 0,5$ , respectively for any

$\delta \in (0,5, 1)$ , the players will cooperate.

The game is symmetric we get  $\underline{\delta_1} = \underline{\delta_2} = 0,5$

**Observations**

If the optimum is reached for a pure strategy, then it can be for a mixed strategy too, and the demonstration will remain the same. In the demonstration we considered the





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fact that one stage of the game only one player deviates.

In other words, if  $\delta > \delta$  then a player will not be tempted to deviate because the gain from deviation does not cover future losses.

### Conclusions

For organizations, the results suggest that techniques to promote a culture that encourages knowledge sharing proves to be very beneficial. Furthermore, organizations should promote measures to encourage clusters of employees, in order to increase opportunities for knowledge flow.

This study may represent a starting point for researchers interested in analyzing the flow of knowledge within an organization, through game theory. The paper presents the motivations underlying the decision to share knowledge with individuals or within organizational surrounding. It is noted that a limitation of the approach presented in the article is that it does not facilitate predictions, and therefore is highly advantageous in complementary use of other approaches and methods - for example, agent-based modeling. Article demonstrates that game theory can be an important aid in the analysis of organizational phenomena.

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