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# The Use of Game Theory for Making Rational Decisions in Business Negotiations: A Conceptual Model

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**ABSTRACT**

**Objective**: The objective of this paper is a comparative analysis of the world literature on game theory and its applicability for rational decision-making in negotiations and creation of a model supporting strategic decisions in negotiations.

**Research Design & Methods**: Systematic, comparative, logical analysis and synthesis of the scientific literature. In order to create an algorithm of negotiations statements on theory of graphs, game theory and theory of heuristic algorithm were applied.

**Findings:** The article proposes an algorithm which combines the game theory approach with heuristic algorithms in order to reflect the specifics of negotiations better. Such an algorithm can be used to support strategic decisions in negotiations and is useful for better understanding of the strategic management of negotiating processes.

**Implications & Recommendations:** The proposed mathematical algorithm for the strategy formulation of international business negotiations can be used in electronic business negotiations, both as a standalone tool, or as partially requiring support by the negotiator.

**Contribution & Value Added:** The game theory methods support rational solutions in business negotiations, as they enable to analyse the interacting forces. This is particularly relevant in international business negotiations, where participants from different cultures can be faced with numerous uncertainties.

| | |
|---|---|
| **Article type:** | conceptual article |
| **Keywords:** | game theory; negotiation; rational; strategic decisions and negotiations support; heuristic negotiation model |
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## INTRODUCTION

The main objective of negotiations is to reach an option that would be acceptable to both parties – to find equilibrium points of mutual needs and opportunities. In order to understand better the relationships between participants of the negotiation process, it is necessary to use mathematical methods to facilitate the search of alternatives and decision-making. Game theory is regarded a useful framework for supporting negotiations, as it is a method suitable for the analysis of interactions between objects which have their own goals. This is particularly important in international business negotiations, where a number of inconsistencies can arise between the representatives of different cultures. The problem of inconsistencies – is still insufficiently analysed in the scientific literature. The applicability of game theory in strategic decision making during international business negotiations does not provide a universal negotiation support model based on heuristic approach. The object of this research is to describe the strategic decision-making process of negotiations by applying the game theory methods. The aim is to provide a comparative analysis of the world literature on game theory and its applicability for strategic decision-making in negotiations and the creation of a model supporting strategic decisions in negotiations. The research methods rely on a systematic, comparative, logical analysis and synthesis of the scientific literature in order to create an algorithm of negotiations statements on theory of graphs. Game theory and theory of heuristic algorithm were used for this.

In the modern business world, decision-making becomes an extremely important activity. Furthermore, it is common that individuals or organisations are creating coalitions when they are negotiating on projects and carry out contracts. Negotiations cover a wide range of activities which include the prior negotiation and post-negotiation analysis, at both local and social levels. Effective decision making in negotiations might ensure the company's future. Major decisions require a detailed analysis of future negotiations interactions, which would allow to meet the priorities and interests of another party to negotiations. Game theory can help to achieve these objectives, since it is a mathematical discipline that deals with the interactions of parties having their targets (Rufo *et al.,* 2014). It is a powerful tool for understanding the relationships that develop in the processes of cooperation and competition. The main objective during the negotiations in decision-making processes is to choose alternatives that would be acceptable to both parties, and it should be carried out within a reasonable period of time (Oderanti *et al.,* 2012; Chuah *et al.,* 2014; Kozina, 2014; Lin *et al.,* 2014; Marey *et al.,* 2014; Suh & Park, 2010; Rufo *et al.,* 2014). The friction of different interests, such as competition, or other challenging situations often arise from illegal practices which are expected from human relations. The nature of the subject of negotiations arise from a variety of disciplines, such as artificial intelligence, economics, social sciences and game theory (Marey *et al.,* 2014; Baarslag *et al.,* 2014; Chuah *et al.,* 2014). The models of strategic negotiation have a wide range of applications which can be used for resources and task allocation mechanisms, for conflict resolution measures, and for decentralised information services (Baarslag *et al.,* 2014; Rufo *et al.,* 2014).

The possibilities of the application of game theory for management tasks were examined by various authors (Aurangzeb & Lewis, 2014; Brown & Shoham, 2009; Rufo *et al.*, 2014; Marey *et al.*, 2014; Chuah *et al.*, 2014; Suh & Park, 2010; Lin *et al.*, 2014; Oderanti *et al*., 2012; Deng *et al*., 2014; Hao *et al*., 2014; Houser & McCabe, 2014; Yu *et al*., 2013; Pooyandeh & Marceau, 2014; Yuan & Ma, 2012; Wilken *et al*., 2013; Annabi *et al*., 2012). The article explores game theory and important aspects of negotiations.

## MATERIAL AND METHODS

### The Algorithm of International Business Negotiation Process

Negotiations are based on the knowledge of another party to negotiations, consequently, the tactics of strategy may vary at each issue. So, it is appropriate to apply heuristic algorithms in order to reflect the negotiations better. The methodology of this algorithm was created on the base of game theory (Deng *et al.,* 2014; Hao *et al.,* 2014; Houser & McCabe, 2014; Shoham & Brown 2009; Suh & Park, 2010; Yu *et al.,* 2013; Pooyandeh & Marceau, 2014; Yuan & Ma, 2012; Marey *et al.,* 2014; Wilken *et al.,* 2013; Annabi *et al.,* 2012; Zavadskas *et al.,* 2012), on heuristic theory (Zhang *et al.,* 2014; Azar 2014; Wang *et al.,* 2011; Segundo *et al*., 2012; Lova *et al*., 2000; Mandow & Cruz, 2003; Wibowo & Deng, 2013), on graph theory (Arsene *et al.,* 2012; Pancerz & Lewicki, 2014; Yu & Xu, 2012; Xu *et al.,* 2013; Darvish *et al.,* 2009) and on multi-criteria decision analysis (Zavadskas *et al.,* 2014; Ginevičius *et al.,* 2014; Nassiri-Mofakham *et al.,* 2009; Wibowo & Deng, 2013; Lourenzutti & Krohling, 2014).

Each issue of negotiations will be considered only once, without returning to it. Heuristic algorithm will "run" through the negotiator's strategies-winnings, which gives the greatest benefit. For this purpose, Hurwitz rule will be used (Hurwitz, Wald, Werner and other). The sequence of negotiating questions will start with the most important ones so that further negotiating will not run in vain. For example, as if in the last question, you will know that the other party cannot meet the basic criterion, so it means that negotiating costs incurred up to that point were in vain.

This optimisation task is complex, as the previous individual winnings from the earlier questions do not provide the most useful total winnings from the total questions of negotiations. This means that it is necessary to look for the best value of the aggregate winnings of negotiations in order to solve the task of the global optimisation. For example: if three negotiating issues are solved in negotiations, then for every issue we have an alternative choice. Although the winnings from the first two items by each question have not been most useful, their selection led to the best alternatives from winnings on the third question, which gave the maximum possible benefit for the whole negotiation process in the final.

After defining the priority list of negotiating questions, it must be noted that each of them is related to a set of potential negotiating partners. A set of the negotiator's alternatives is finite and for each question has $t$ alternatives. Let us take note the alternatives of *i*-th question $b_{i,j}, j = 1, 2, 3, \dots, t_i$. Then a set of all alternatives of *i*-th question will be marked as $w_i = \{ b_{i,1}, b_{i,2}, \dots, b_{i,t_1}\}$, and $w_1 \times w_2 \times w_3 \dots w_n$ is the set of all possible scenarios of negotiations, where for each question one possible alternative is selected, $n$ is the number of negotiating questions.

Checking $b_0$ as the start of negotiations, we can represent the whole negotiation process with the help of a graph-tree (Figure 1), where the arc of the graph $H_{i,b_{i,j}}$ denotes the winnings which we got after choosing *j*-th alternative for resolving *i*-th question.

$$max_{k\in w_1\times w_2\times w_3\dots w_n}\left(\sum_{i=1}^{n} H_{i,b_{i,j}}\right), j = 1, \dots, |w_i| \quad (1)$$

where:

$H$ - negotiations winnings by Hurwitz rule;

$n$ - the number of negotiation issues (the top marks the start and the end of negotiations).

The top $b_0$ marks the start of negotiations, the top $b_{i,j}$ represents *i*-th question of *j*-th alternative. The arc of the graph $H_{i,b_{i,j}}$ denotes the winnings that we have after selecting *j*-th alternative for resolving *i*-th question $j \in w_1 \times w_2 \times w_3 \dots w_n$.

Hurwitz formula is an example which we will use in order to find the best winnings by the negotiator on the negotiating question under uncertainty:

$$H_{u,w} = max_u[\gamma\, min_z\, a_{uz} + (1-\gamma)\, max_z\, a_{uz}] \quad (2)$$

$$H_u = min_u[\gamma\, max_z\, a_{uz} + (1-\gamma)\, min_z\, a_{uz}] \quad (3)$$

where:

$a_{uz}$ - the negotiator's winnings which he may get if he has done a move u in case the opponent will make a move z;

$H$ - winnings of the negotiator's question by Hurwitz rule;

$\gamma$ - hope parameter.

A set of the negotiator's moves is finite and consists of s moves, which are numbered: $u = 1, 2, 3, \dots, s$.

We will accept the assumption that a set of possible moves of the opponent is complete, consisting of k moves. The number of the moves $z = 1, 2, 3, \dots, k$.
$\gamma$ - the coefficient which ranges from 0 to 1 in the formula, we see that if a $\gamma = 1$, then Hurwitz criteria coincide with Wald's pessimistic criterion. If $\gamma = 0$, we obtain an optimistic solution which allows us to get the maximum winnings. The size of coefficient $\gamma$ depends on the type of decision the negotiator will choose - optimistic or pessimistic. Perhaps the most acceptable coefficient is $\gamma = 0.5$ because it is the medium between pessimistic and optimistic solutions.

This game is possible to be written down with the help of winnings matrix and it is called gambling matrix. The form of zero-sum game is:

$$\Gamma = \{S_1, S_1; A\} \quad (4)$$

In solving the negotiating objectives, a set of the first negotiator's strategies (pure strategies) exists: $S_1 = \{S_{11}, S_{12}, \dots, S_{1s}\}$.

A set of the second negotiator's pure strategies is: $S_2 = \{S_{21}, S_{22}, \dots, S_{2k}\}$. $S_1\ ir\ S_2$ are finite and known. The winnings function is $A = \|a_{uz}\|_{sxk}$. A set of moves of negotiators is finite and consists of the moves which are: $u = 1, 2, 3, \dots, s$. We will accept the assumption that a set of possible moves of the opponent is complete, consisting of *k* moves. The moves are: $z = 1, 2, 3, \dots, k$.

Game matrix is used to find the most advantageous strategy for a negotiating question. Every finite gambling has a decision in the field of pure or mixed strategies, and the net value corresponds with the inequality: $\alpha \le v \le \beta$. If $\alpha = v = \beta$, this solution with clear strategies is a saddle point (only one optimal strategy for each player).

Number $\alpha$ is called the lowest slot value, $\beta$ - the biggest slot value, $v$ is called the value of the net playing or playing price.

The adaptation of game theory methods to specific tasks of negotiations needs to have indicators of efficiency, which can express the ratio of the optimal value, and to be independent from the type of matrix. We will use the method of simple adding weighting (SAW) exponential expression by applying different exponents in the cases of the best minimum criteria values and the maximum values, when normalized values are limited in the range [0, 1]:

$$a_{uz} = (\,min_u\, c_{uz}/\, c_{uz})^3, if\ \min_u c_{uz}\ positive \quad (5)$$

$$a_{uz} = (\,max_u\, c_{uz}/\, c_{uz})^2, if\ \max_u c_{uz}\ positive \quad (6)$$

We will use the latter formula for the normalization of the parameters of negotiation questions in order to facilitate the processing of negotiating results and to get comparative values.

It is necessary to determine weights of indicators characterising the negotiation questions after getting the original data on the indicators relevance of negotiating questions. These weights will show how many times one or another negotiating point usefulness rate is higher (lower) than another indicator's usefulness. Each of these values can be determined in such a way:

- the most important indicator of the negotiating question is selected - $a_{ger}$ ;
- for the best value of the analysed indicator 1 scour of value significance is given: ($a_{ger} = 1$);
- it is determined what percentage ($q_v$) of the remaining indicators' values ($b_v$) is lower than the best values ($a_{ger} = 1$);
- for the values of indicators the relative values ($a_v = 1 - q_v/100$) are given;
- the relative values of all indicators ($q_v$) are converted in such a way that their total amount would be equal to 1: $\sum_{v=1}^{m} q_v = 1; v = 1, 2, \dots, m$.

The negotiation process can be represented by the graph (Figure 1). The top $b_0$ marks the start of the negotiations, the top $b_{i,j}$ represents *i*-th questions of the *j*-th alternative,

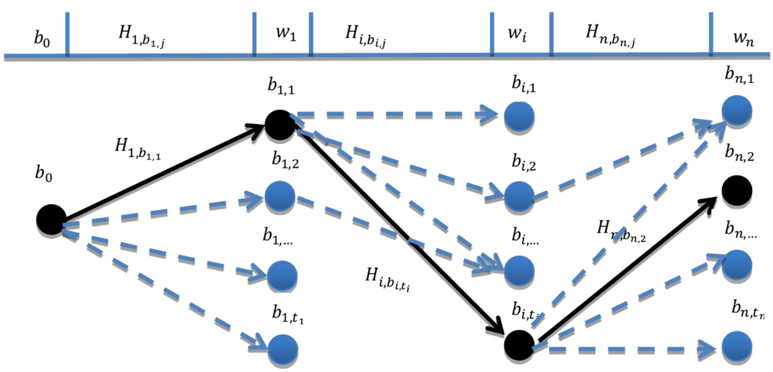


**Figure 1. The graph of negotiation**
Source: own elaboration.

and the arc of the graph $H_{i,b_{i,j}}$ denotes the winnings which we got after choosing *j*-th alternative resolving *i*-th question. Below there is a global optimisation task with a fixed number of negotiation questions which were envisaged before the negotiation.

We will use the developed negotiation algorithm for the strategy formulation purpose in international business negotiations, specifically in electronic business negotiations, for international business negotiations in order to support the negotiation context, for the modelling and simulation of cross-cultural business negotiations. This model of negotiation strategy will be applied in the next chapter in order to adapt them for solving complex negotiating questions and problems. We will determine whether the developed algorithm is effective as a stand-alone business negotiation engine, and whether it is appropriate for supporting international negotiations.

## LITERATURE REVIEW

### Restrictions on the Application of Game Theory

Negotiation is based not only on rationality, but also on other factors, such as emotions, moral understanding, avoidance of uncertainty, time orientation awareness (long or short), and others. Game theory has been very successful in developing a deeper understanding of how decisions of rational players are carried out in the circumstances of interaction with another party. One of the major critics of game theory is that players who behave irrationally might benefit more, thus the rationality itself directly hampers game theory (Hao *et al.,* 2014; De Bruin, 2009; Kelly, 2003).

Game theory is based on the assumption of rationality, but there is a need for further experimental evidence to support the assumption that individuals choose to perform important strategies and complex decisions under an element of uncertainty driven by rationality (Pooyandeh & Marceau, 2014; De Bruin, 2009; Kelly, 2003).

Rationality can be defined as a categorical behaviour which originates entirely from the reason (Kelly, 2003). Since individuals have the ability to find the reason, rationality dictates behaviour with which everybody can agree and all individuals are guided by their ability to find the reason and therefore to agree on uniform behaviour (Houser & McCabe, 2014; De Bruin, 2009). Rational players follow universal rules which are guided by rationality. If a player does not select a specific strategy, then it is referred to as irrationality. However, sometimes it is rational to behave irrationally, consequently, it is important to define the concept of rationality. The importance of this concept is far more than semantics because the success of game theory and the negotiations analysed depend on it. This may mean different things in different contexts for different people, however, this remains the basis of game theory and negotiations.

Another important element of game theory, which is open to criticism, is un-certainty. The choice of strategy is not necessarily rational. Choosing a strategy is often determined by experience or culture, but not rationality. Rationality is significantly related to norms, the understanding of rationality itself arises from the development of an individual, culture, traditions (Marey *et al.,* 2014; Frederick, 2010). Uncertainty is particularly harmful for the equilibrium of Nash mixed strategy because if one player hopes that the other party will behave in one way, so he will not have a reason to do otherwise. It is believed that if the players have the same information, then they must necessarily have similar beliefs, but rational players not always provide identical proposals or reach similar agreements, even though the same information was available.

Rationality means maximally effective decisions and behaviour which is based on the available information. If the negotiators have a different perception of rationality, then the support of negotiations cannot be effective, unless it is desired to know culture, traditions, experience and information on another party to negotiations.

Inconsistency, which is promoted by irrationality, is the third criticism of game theory. Rationality relates to the environmental control, systematic understanding and methodical sequence of actions (Basel & Bruhl, 2011). Logical thinking and behaviour are also based on rationality. Rational beliefs are those which are based on consistency, and rational arguments are those that are based on logical rules. In the games of game theory it is proposed to keep the cases of inconsistency as occasional (Kelly, 2003). For this purpose, errors are applicable in games.

These restrictions point out that the basic weakness of game theory is rationality, as the theory itself deals only with rational games. It is not clear how to deal with them in conditions when the basis of game theory, namely – the concept of rationality and irrationality, is not clear. In reality, people are not always rational (for example, decision-making may be influenced by emotions of the individual), and rationality itself can be interpreted in different ways, as the rules of an individual's rationality can be influenced by prior experience, culture of the region (Wilken *et al.,* 2013), moral awareness, and other factors.

### Potential of Adaptation of Heuristic Algorithms for Business Negotiations

In examining the development of negotiation strategies based on the assessment of bargaining power, it can be observed that the application of strategic principles may vary for each issue of negotiations and their selection is taking place in the learning process, so for the specifics of the negotiations it would be appropriate to use heuristic algorithms which hereinafter we will examine. The aim to solve complex optimisation problems (Minimax) encouraged the emergence of heuristic optimisation algorithms (Katkus, 2006; Segundo *et al.,* 2012). For solving these tasks many heuristic algorithms have been created, which calculate how to get the optimum possible result over a given period; heuristic algorithms are used in optimisation tasks and they help to achieve high quality within the desired calculation time (Berth *et al.,* 2000; Mandow & Cruz, 2003; Tamošiūnas, 2011; Wibowo & Deng, 2013; Azar, 2014). Negotiation strategies are based on gradual assessment of bargaining power of the other negotiating party. Thus, on each issue we can use nonetheless different tactics. So heuristic algorithms can help to represent the negotiation process between several negotiating parties. Developing fast acting heuristic algorithms is based on the processes that are taking place in the environment surrounding us (Segundo *et al.,* 2012; Katkus, 2006). Heuristic search methods became very important scientifically when the areas emerged where the standard combinatorial algorithms became unsuitable for the large data sample (Berth *et al.,* 2000; Mandow & Cruz, 2003; Tamošiūnas, 2011; Wibowo & Deng, 2013; Azar, 2014). Recently, optimisation management tasks apply heuristic optimisation techniques, relying on a variety of solution search paradigms which are often developed by analogy with nature, applying artificial intelligence techniques and so on (Bergroth, 2006; Felinksas, 2007). Realisation of various search paradigms for an optimal solution and several paradigm combination for solving separate classes of tasks is an urgent practical problem which recently gets much attention in the scientific literature (Berth *et al.,* 2000; Mandow & Cruz, 2003; Felinksas, 2007; Wibowo & Deng, 2013; Azar, 2014). Such algorithms are used in graph theory. Graph theory was applied for a narrow purpose - to analyse the routes. The development of graph theory has gained a name of the universal approach and spread to various areas of activities and has been used in a wide variety of tasks (both by subject and according to their nature) (Bivainis, 2011). The first graph theory task was investigated in 1736. It was the task concerning Konigsberg (Kongsberg) bridges. L. Euler not only successfully solved that task, but also formulated the necessary and sufficient conditions after the fulfilment of which a graph has a specific route, which is now called the Euler cycle (chain) (Plukas *et al.,* 2004). However, in the period of approximately 100 years, the solution of this task was only one result of graph theory. Later, in the mid -19th century, an electrical engineer Kirchgof developed theory of trees and applied it to examine the electrical chains.

Travelling salesman problem is the task of the classic graph theory arising in a number of management cases of organising various trips (Tamošiūnas, 2011). The task of Travelling salesman was formulated as follows: having some amount of cities and prices of travelling from one city to another, it is necessary to find the cheapest route so that after visiting each city once, the route will end in the original city. Graph theory can reformulate the task – finding the minimum weight of the Hamilton cycle in a graph with weights (Bergroth, 2006; Felinksas, 2007; Tamošiūnas, 2011). The route (path) bypassing all tops of a graph only once is called the Hamilton route (Plukas *et al.,* 2004). If the start and the end tops of the route are matched, this path is called Hamilton cycle; otherwise - Hamilton circuit. The graph having Hamilton route is called Hamilton graph (Plukas *et al.,* 2004).

The application of heuristic algorithms in the negotiation process is appropriate because of its nature – the knowledge of negotiating power is taking part in the negotiation process, thereby reducing the uncertainty situations that are trying to solve previously considered rules for calculating optimal strategies. When examining the scientific literature, there is a noticeable lack of attention on the application of heuristic algorithms in business negotiations.

In the next part of the article we will try to combine the game theory approach with heuristic algorithms in order to create an algorithm to reflect the specifics of the negotiations better. The developed mathematical model can be successfully used to support strategic decisions of international negotiations.

## DISCUSSION AND THEORY DEVELOPMENT

### Application of the Model to Support e-Business Negotiations

The intensive use of fast Internet technology and intellectual development in recent years has stirred up the interest of scientists in searching the optimal negotiation strategies, conflict prevention, solving various issues related to negotiations, the introduction of electronic innovations. Decision support systems are widely used in order to facilitate the decisions which must be based on some information or decision reasoning in the management of various processes. Decision Support Systems Engineering is the most common branch of Engineering Sciences that investigates how to create artificial systems of any nature or kind. Electronic negotiation systems can be an effective means in solving complex problems and managing large amounts of information. These negotiations systems can be specialised and targeted to facilitate the specific processes or to be universal for all processes. A decision support system can rely on a variety of sources which must allow the users to transform enormous quantities of raw data for analysis, problem-solving, decision-making which is required for information reports. The negotiation process becomes more complicated when there is a whole set of problems considered, thus the proposed model of optimal negotiating strategies will be used for decision-making and searching for optimal strategies. Recently, e-business has changed the traditional business methods as innovative measures make business processes more efficient in cyberspace. In e-business people can easily publish information, negotiate with opponents, and look for the necessary tools. The tools of negotiations are very important in e-business, but it is quite closed and static and it does not reflect the reality of the business dynamics adequately. In a rapidly changing environment, e-business tools of negotiations can be unsuccessful for a variety of environmental changes and their unpredictability. The tools of e-business should be more flexible and more adaptable to the changing environment in future.

In order to verify the ability of the developed algorithm to formulate the negotiation strategy model to support business negotiations, a simulation of a few negotiating business subjects will be done.

We will explore 3 questions of negotiations with 3 potential partners. Each potential party to negotiations will give 4 alternative proposals. The experts of the negotiating team are employed for the assessment of the relevance of the indicators of each negotiation question.

Table 1 presents the normalised gaming matrix according to indicator weights. Also, there a compatibility of experts' opinions - coefficients of concordance are determined, which are satisfactory. In the next step a normalized decision matrix is presented, in which the weights of indicators are applied.

**Table 1. Normalized as that for procurement of gaming matrix**

| **Gaming matrix of 1 negotiating question of 1 alternative** | | | **Gaming matrix of 2 negotiating questions of 2 alternatives** | | | **Gaming matrix of 3 negotiating questions of 3 alternatives** | | |
|---|---|---|---|---|---|---|---|---|
| **W1H1** | A1 | A2 | **W1H2** | A1 | A2 | **W1H3** | A1 | A2 |
| R1 | 0.777 | 0.355 | R1 | 0.816 | 0.585 | R1 | 0.464 | 0.804 |
| R2 | 0.299 | 0.359 | R2 | 0.781 | 0.717 | R2 | 0.389 | 0.843 |
| **Gaming matrix of 1 negotiating questions of 2 alternatives** | | | **Gaming matrix of 2 negotiating questions of 2 alternatives** | | | **Gaming matrix of 3 negotiating questions of 2 alternatives** | | |
| **W2H1** | A1 | A2 | **W2H2** | A1 | A2 | **W2H3** | A1 | A2 |
| R1 | 0.794 | 0.383 | R1 | 0.873 | 0.854 | R1 | 0.638 | 0.738 |
| R2 | 0.455 | 0.433 | R2 | 0.836 | 0.730 | R2 | 0.558 | 0.718 |
| **Gaming matrix of 1 negotiating question of 3 alternatives** | | | **Gaming matrix of 2 negotiating questions of 3 alternatives** | | | **Gaming matrix of 3 negotiating questions of 3 alternatives** | | |
| **W3H1** | A1 | A2 | **W3H2** | A1 | A2 | **W3H3** | A1 | A2 |
| R1 | 0.832 | 0.611 | R1 | 0.905 | 0.927 | R1 | 0.517 | 0.748 |
| R2 | 0.667 | 0.578 | R2 | 0.888 | 0.928 | R2 | 0.529 | 0.755 |

Notes: R1, R2 are offer values of negotiation question; A1, A2 are offer alternatives of negotiation question; W shows alternative number of gaming matrix negotiation questions; H shows question number of gaming matrix negotiation.

Source: own calculations.

**Table 2. Results of gaming according to different optimisation rules**

| Negotiation winnings results using Hurwitz optimisation rule | | | | | Negotiation winnings results using Bernoulli-Laplace optimisation rule | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Hurwitz | H1 | H2 | H3 | | Bernoulli-Laplace | H1 | H2 | H3 | |
| W1 | 0.538 | 0.700 | 0.616 | | W1 | 0.447 | 0.725 | 0.625 | |
| W2 | 0.589 | 0.802 | 0.648 | | W2 | 0.516 | 0.823 | 0.663 | |
| W3 | 0.705 | 0.908 | 0.636 | Sum | W3 | 0.672 | 0.912 | 0.637 | Sum |
| MAX | 0.705 | 0.908 | 0.648 | 2.261 | MAX | 0.672 | 0.912 | 0.663 | 2.247 |
| **Negotiation winnings results using Wald optimisation rule** | | | | | **Negotiation winnings results using Bayes-Laplace optimisation rule** | | | | |
| Wald | H1 | H2 | H3 | | Bayes-Laplace | H1 | H2 | H3 | |
| W1 | 0.299 | 0.585 | 0.389 | | W1 | 0.447 | 0.725 | 0.625 | |
| W2 | 0.383 | 0.730 | 0.558 | | W2 | 0.516 | 0.823 | 0.663 | |
| W3 | 0.578 | 0.888 | 0.517 | Sum | W3 | 0.672 | 0.912 | 0.637 | Sum |
| MAX | 0.578 | 0.888 | 0.558 | 2.023 | MAX | 0.672 | 0.912 | 0.663 | 2.247 |
| **Negotiation winnings results using Savage and Niehaus optimisation rule** | | | | | **Negotiation winnings results using Hodges and Lehmann optimisation rule** | | | | |
| Savage and Niehaus | H1 | H2 | H3 | | Hodges and Lehmann | H1 | H2 | H3 | |
| W1 | 0.777 | 0.816 | 0.843 | | W1 | 0.373 | 0.655 | 0.507 | |
| W2 | 0.794 | 0.873 | 0.738 | | W2 | 0.450 | 0.777 | 0.610 | |
| W3 | 0.832 | 0.928 | 0.755 | Sum | W3 | 0.625 | 0.900 | 0.577 | Sum |
| MAX | 0.832 | 0.928 | 0.843 | 2.602 | MAX | 0.625 | 0.900 | 0.610 | 2.135 |

Notes: H1, H2, H3 are negotiations questions; W1, W2, W3 are negotiation winnings.
Source: own calculations.

**Table 3. Negotiation winnings scoreboard by optimisation rules**

| | The normalised expression data | | | |
|---|---|---|---|---|
| Rules of optimisation | Winnings of negotiation questions | | | Totals of all questions winnings |
| | H1 | H2 | H3 | |
| Hurwitz | W3 | W3 | W2 | 2.261 |
| | 0.705 | 0.908 | 0.648 | |
| Wald | W3 | W3 | W2 | 2.023 |
| | 0.578 | 0.888 | 0.558 | |
| Savage and Niehaus | W3 | W3 | W1 | 2.602 |
| | 0.832 | 0.928 | 0.843 | |
| Bernoulli-Laplace | W3 | W3 | W2 | 2.247 |
| | 0.672 | 0.912 | 0.663 | |
| Bayes-Laplace | W3 | W3 | W2 | 2.247 |
| | 0.672 | 0.912 | 0.663 | |
| Hodges and Lehmann | W3 | W3 | W2 | 2.135 |
| | 0.625 | 0.900 | 0.610 | |

Notes: H1, H2, H3 are negotiations questions; W1, W2, W3 are negotiation winnings.
Source: own calculations.

In Table 3 and Figure 2 summary results of the negotiations winnings are presented by optimisation rules. It is shown which negotiator's offer was with the highest winning under different optimisation rules, as well as the total winnings of all the questions.

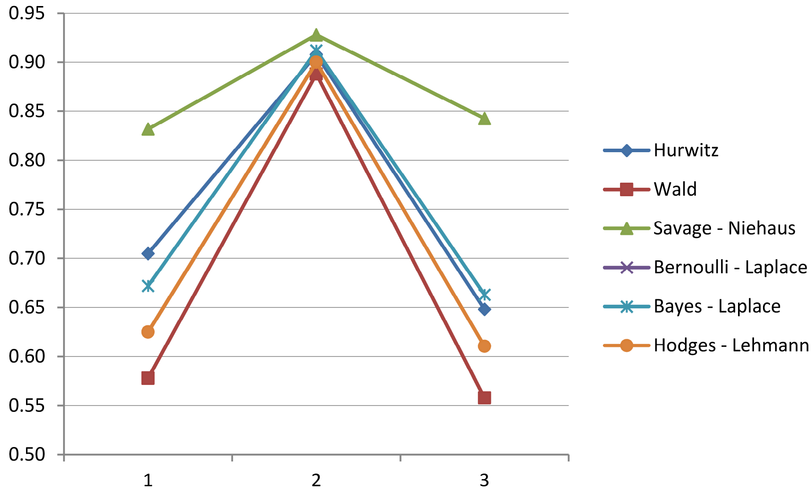


**Figure 2. Negotiation winnings distribution under different negotiation issues, applying different optimisation rules**

Note: vertical axis shows negotiation winnings, horizontal shows negotiation question number.

Source: own calculations.

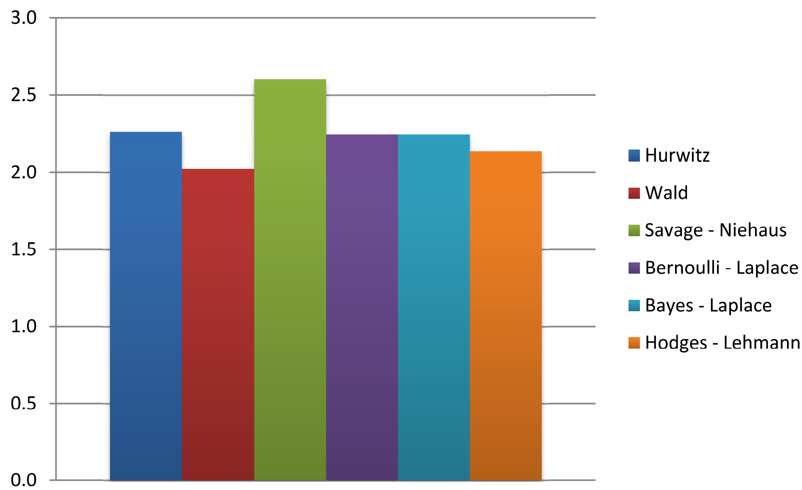


**Figure 3. The aggregated results of all negotiation questions, applying different optimisation rules**

Note: vertical axis shows negotiation winnings, horizontal shows negotiation question number.

Source: own calculations.

The results chart in Figure 3 shows that optimistic – the maximum winnings are provided by Savage and Niehaus optimisation rule, the smallest winnings are provided by

Wald rule. Hurwitz, Bernoulli-Laplace and Bayes-Laplace rules showed very similar results, and Hodges and Lehman rules have slightly larger winnings than the minimum winnings demonstrated by Wald rule. The obtained results confirmed the works of other researchers, stressing the importance of game theory for business negotiations support (Zavadskas *et al.,* 2012; Hao *et al.,* 2014; Houser & McCabe, 2014; Deng *et al.,* 2014; Shoham & Brown, 2009; Suh & Park, 2010; Yu *et al.,* 2013; Pooyandeh & Marceau, 2014; Yuan & Ma, 2012; Marey *et al.,* 2014; Wilken *et al.,* 2013; Annabi *et al.,* 2012).

Recently, for the optimisation of management tasks heuristic optimisation technique is applied, relying on a variety of solution search paradigms which are often developed by analogy with nature, applying artificial intelligence techniques, and so on. Heuristic algorithms in negotiations are purposeful due to the nature of negotiations - knowledge of negotiating power is going in the negotiation process itself, thereby reducing the uncertainty that hampers negotiating situations by using the rules for calculating the optimal strategy. To deal with these tasks a number of heuristic algorithms are developed, which calculate the optimum possible to get a result over time. Heuristic algorithms are used for optimisation problems, and they help to achieve high quality. Negotiation is based on the gradual knowledge of negotiating power of the other party to negotiations, so with every issue you can use other tactics. Therefore, heuristic algorithms can help to manage the negotiation process effectively. The selection of principles and rules must be carried out by specialists with high qualifications and experience, consultants, negotiators in the fields concerned, in order to determine which option is the best, taking into account the specifics of each task, goals and conditions.

## CONCLUSIONS

The research results showed that the created algorithm helped to identify the optimal way of the negotiation strategy. In order to determine the best option it is needed to assess specifics, goals and context of each individual task. The author is proposing the following cases of the algorithm use: in the case of multiple negotiations and making a lot of solutions it is advisable to apply Bayes (Bayes-Laplace) and Hurwitz principles. If negotiations are one-off, it is better to apply the Mini max and Savage-Niehaus principles. If in certain circumstances even minimal risk is unacceptable, solutions should be based on the principle of Wald. If the partial risk is possible, thus defining of the optimal strategy is subject to Savage-Niehaus rule. The examination of the application of negotiation strategies revealed that the application of strategic principles can fluctuate in every question of negotiations. To make a selection of negotiation principles and rules only negotiators with high qualifications and experience in this field can do this.

The investigation carried out demonstrated that the mathematical algorithm developed by the author for the strategy formulation of international business negotiations can be used in electronic business negotiations, both as a standalone tool, and partially requiring intervention by the negotiator. Moreover, this algorithm can be used to support negotiations through various databases. In this article we analysed the reduction of uncertainty in the formation of negotiation strategy through data-bases describing the context of the negotiations. The research results showed that the proposed negotiation algorithm can be also used for the analysis and support of negotiation strategies with various parameters.

It is estimated that game theory cannot fully define the decision-making process in some circumstances, but it is a great tool for making the right strategic decisions. Game theory does not give ethical or moral guidance, but explores what does encourage selfish interests of people. The basic weak point of game theory is its rationality, as the theory itself deals solely with rational games. And how to examine them when the basis of game theory is not entirely clear – is this the concept of rationality and reasons which encourages irrationality? In reality, people are not always rational (as decision-making can be influenced by emotions of the individual), and rationality itself can be interpreted in different ways because the rules of the individual rationality can be influenced by prior experience, culture of the region, moral awareness, and other factors.

In further investigation opportunities for the developed algorithm could be verified in the following aspects:

- *As a negotiations support tool.* The main purpose of this model use - support of the international business negotiation. As these days businesses lack propensity to take strategic decisions based on the evaluations of negotiations bargaining power, assessing the negotiating partners, competitors and their resources, this model, unlike currently existing tools, assesses the influence on these entities by a variety of factors. What encourages to use this model is the simplicity of managing this instrument and good results of support for negotiations.
- *As an information uncertainty reduction tool.* The main negative feature of negotiation support measures is uncertainty of information. This model has a possibility to assess the uncertainty by using both databases, as well as expert evaluations. Databases can include both economic indicators such as tender, creditworthiness of the entities, operating history, as well as non-economic indicators, such as cultural dimensions, which are important for international business negotiations. In making decisions it is important to understand participants in the negotiations correctly because in represented different cultures even the understanding of rationality can vary.
- *As an autonomous negotiation process engine.* Presenting businesses in cyberspace is increasingly gaining in popularity in distance trade, and thus in distance negotiations. After making appropriate restrictions, this negotiation model could function as an autonomous negotiation process engine that can itself provide solutions, options and alternatives. The negotiator should only assign the model data bases which should help to assess the participants in the negotiations and their proposals.
- *As a tool for the management of large amounts of information*. During the international business negotiations, unlike a single country-wide negotiation, the number of negotiations, competitors or partners, increases by a dozen, a few dozen or a few hundred times. Such processing of data flow physically, without computer assistance, is practically impossible. Therefore, this model would be appropriate to be used for simplicity and speed processing of large information flow.
- *As a tool for improving the conditions for communication.* Negotiations are often lost even before the start because of language barriers or different understanding of matters or values. Therefore, this model is designed to help identify and understand common points of reference of the international business negotiation subjects. For this task various cultural brokers would be deployed who assist to manage this model with partial intervention.

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