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Constructive and Blocking Power in Marine Logistics

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Abstract Transport industry in economy had been studied for many years, however, only recently researchers have begun to widely apply concepts of cooperative game theory to optimize costs and profits which are incurred in hauling. Today a wide range of cost/profit allocation methods have become a trend in transport segment, particularly in logistics operations. The most of these methods based on cooperative game theory consider the effect of collaboration (cooperation) which means the integration of companies as a key way to share transportation costs or profits. This study aims to contribute to this area of research by exploring different allocation methods such as the Shapley value, the nucleolus and some other excess based solution concepts of transferable utility game (TU game). In this work we overview existing studies on the subject and consider methodology of cooperative game theory. Further, we calculate numerical example of three shipping companies based on real data. In order to compare profit sharing results we compute the set of allocations and examine the constructive and blocking power of coalitions. The importance and originality of the work are that it explores the new field of application of game theory in logistics which can provide additional insights in this research area.

Keywords: cooperative game theory, logistics, horizontal cooperation, cost allocation, Shapley value, nucleolus, SM-nucleolus, anti-prenucleolus, blocking power.

1. Introduction

In recent years, it has been widely viewed that collaboration can be the most appropriate solution for cost reduction in transportation. This effect means that companies interact with each other, reallocating their expenditures in such a way that increases profit of each organization and, therefore, leads to cost savings. Cooperation in transportation divides into two types: the integration of companies dealing with similar logistics operations - *horizontal cooperation* and companies with consistent stages of the production process - *vertical cooperation*. In this paper we consider different methods of cost and profit allocation in logistics. Nowadays these methods in logistics operations are based on the principle of collaboration and make extensive use of concepts of cooperative game theory. So far, however, a wide range of existing methods are only gaining popularity in logistics and usually these methods are applied mostly for horizontal integration in the works of Drechsel, 2010, Frisk et al., 2010, Gansterer and Hartl, 2018, Guajardo et al., 2016 , Littlechild and Thompson, 1977, Sun et al., 2015 and others. This happens because in vertical cooperation there are operational difficulties in allocation costs or profit due to the diversity of players in these structures.

The paper is structured as follows. Section 2 contains the review of the application of cooperative game theory in logistics. Sections 3 is devoted to notions and definitions of cooperative game theory. In Section 4 we switch to the game for three logistics companies in the field of marine container transportation. In order to analyze the influence of blocking power on the payoffs of players we use three types of allocation methods: (pre)nucleolus, SM-nucleolus and anti-(pre)nucleolus.

2. Collaboration in logistics

Various studies have assessed the efficacy of cooperation to cost allocation, see, for example, Young, 1985. One of the recent, practice-oriented, articles was conducted in 2010 and is still continuing its investigation. Frisk, M., Göthe-Lundgren, M., Jörnsten, K., Rönnqvist, M. examined cooperation of eight companies which operate in the field of woodworking in Sweden (Frisk et al., 2010). In the article horizontal integration implies the process of exchanging forestry goods (wood bartering) and backhauling. In this case collaboration based on wood bartering means that products are carried from one company to another and in return company вЂ“ sender receives the same volume of identical products. The aim of this study is to investigate the optimal way of cost distribution based on a fairness concept. It assumes that profit is allocated through collaboration in the most equal way as possible. In the article authors point out a new concept of cost allocation which offers the most equal cost and profit distribution to all coalitions. It is named Equal Profit Method (EPM). In the paper this method is computed in two phases. In the first stage, authors count the optimal volume of transportation which leads to cost savings. In the second stage, they minimize the difference between maximum costs of every coalition with others. In addition to this, in the paper there were conducted also the Shapley value (Shapley, 1953), nucleolus (Schmeidler, 1969) and other methods. The result of this study is that potential overall savings from cost allocation were 14,2 %. EPM method in the work is accepted as the best way to allocate costs because it makes it possible to reach an agreement about cooperation in easier way.

Guajardo, M., Jörnsten, K. and M. Rönnqvist six years later continued the previous work (Guajardo et al., 2016). They have complemented research by the solution of problems with those coalitions who want to leave the grand coalition. This study involves a new concept for cost allocation – blocking power (BP). In the paper BP is regarded through such allocation methods as the SM-nucleolus (Tarashnina, 2011) and the modiclus (Sudhölter, 1997). Constructive power (CP) is presented in the article as a concept based on best known cost allocation method in cooperative game theory – the nucleolus (Schmeidler, 1969). Authors consider BP which takes into account interests of companies which are situated in remote areas. Its basic idea is that such companies may destroy the balance of collaboration if they want to leave the grand coalition. Authors conclude that companies which are situated in more central areas largely benefit from nucleolus and they have constructive power. On the other side, players who are located in more peripheral areas gain greater profit from the SM-nucleolus and the modiclus allocations.

Further, we will consider these effects of constructive and blocking power in different profit allocation methods for three logistics corporations.

3. Cooperative game theory concepts

In this paper we deal with cooperative games with transferable utility, or simply TU-games. A cooperative TU-game is a pair (N, v), where $N = \{1, 2, \ldots, n\}$ is the set of players and $v : 2^N \to R^1$ is a *characteristic function* with $v(\emptyset) = 0$. Here $2^N = \{S \subseteq N\}$ is the set of coalitions in (N, v). Since the game (N, v) is completely determined by the characteristic function v, we shall sometimes represent a TU-game by its characteristic function v. Let G^N be the set of TU-games with a finite set of players N.

Due to the classical cooperative approach we look for the ways to distribute the amount $v(N)$ over the members of the grand coalition. Corresponding payoff vector (or a set of vectors) that distributes the amount $v(N)$ among the players is called a solution of the game. Here we consider solutions which that belong to the set $X^0(N, v)$ of preimputations of a game (N, v), i.e. $X^0(N, v) = \{x \in R^n : \; x(N) = v(N)\}$.

Let x be a preimputation in a game (N, v). The excess $e(x, v, S)$ of a coalition S at x is $e(x, v, S) = v(S) - x(S)$. Due to Maschler, 1992, the excess of a coalition evaluate a measure of dissatisfaction of a coalition at preimputation x, which should be minimized. For each $z \in R^n$ we define the vector $\theta(z) \in R^n$, which arises from z by arranging its components in a non-increasing order.

Definition 1. The prenucleolus of a game (N, v) is the set of vectors in $X^0(v)$ whose $\theta(e(x, v, S)_{S \subseteq N})$'s are lexicographically least, i.e.

$$\mathcal{N}(v) = \{x \in X^0(v) : \; \theta\big(e(x, v, S)_{S \subseteq N}\big) \preceq_{lex} \theta\big(e(y, v, S)_{S \subseteq N}\big) \text{ for all } y \in X^0(v)\}.$$

The prenucleolus of a game is a singleton (Schmeidler, 1969), so we denote this single point by $\nu(v)$. From Definition 1 it follows that the prenucleolus doesn't take into account the blocking power of coalition. This allocation method is based on constructive power. The meaning of the constructive power $v(S)$ is the worth of coalition S, or to be exact what S can reach by cooperation.

Two allocation methods that consider the blocking power in the paper are the SM–nucleolus and the anti-prenucleolus. By the blocking power of coalition S we understand the difference between $v(N)$ and $v(N \setminus S)$ — the amount $v^*(S)$ that the coalition S brings to N if the last is formed — its contribution to the grand coalition.

Given a cooperative TU-game (N, v), the dual game (N, v^*) of (N, v) is defined by

$$v^*(S) = v(N) - v(N \setminus S)$$

for all coalitions $S \subseteq N$. Then, the dual excess $e(x, v^*, S)$ of a coalition $S \subseteq N$ at x is $e(x, v^*, S) = v^*(S) - x(S)$ where x is a preimputation in a game (N, v).

Definition 2. The anti-prenucleolus of a game (N, v) is defined as

$$\psi(N, v) = \{x \in X^0(N, v) : \theta(e(x, v^*, S) \prec_{lex} \theta(e(y, v^*, S) \text{ for all } y \in X^0(N, v)\},$$

where $\theta(e(x, v^*, S)_{S \subseteq N})$ is a vector of excesses which components are arranged in non-increasing order.

The anti-prenucleolus takes into account only the blocking power of each coalition. Clearly, the anti-prenucleolus can be defined as the prenucleolus of dual game[1].

In order to define the SM-nucleolus, we consider the weighted sum-excess of a coalition $S \subseteq N$ at each $x \in X^0(N,v)$ as follows

$$\overline{e}(x,v,S) = \frac{1}{2}e(x,v,S) + \frac{1}{2}e(x,v^*,S).$$

Definition 3. The SM-nucleolus of a game (N,v) is defined as

$$\mu(N,v) = \{x \in X^0(N,v) : \theta(\overline{e}(x,v,S) \prec_{lex} \theta(\overline{e}(y,v,S) \text{ for all } y \in X^0(N,v)\},$$

where $\theta(\overline{e}(x,v,S)_{S\subseteq N})$ is a vector of sum-excesses which components are arranged in non-increasing order.

Here the weights for the constructive and the blocking powers are equal to $\frac{1}{2}$. However, these weights can be arbitrary, what has been showed in (Smirnova and Tarashnina, 2012; Smirnova and Tarashnina, 2016).

Notice that the SM-nucleolus coincides with the prenucleolus of the game $\left(N, \dfrac{v+v^*}{2}\right)$ and in case of game with three players — with the Shapley value (Tarashnina, 2011).

Since all considered solution concepts are connected with the prenucleolus one, we provide here the characterization of the latter in terms of balanced collections which is useful for computation of the solution.

The collection $\mathcal{B} \subseteq 2^N$, $\emptyset \notin \mathcal{B}$, is called balanced if there are positive numbers $\lambda_S > 0$, $S \in \mathcal{B}$, such that $\sum\limits_{S\in\mathcal{B}:S\ni i} \lambda_S = 1$ for all $i \in N$.

For arbitrary $(N,v) \in G^N$, $x \in X^0(N,v)$ and some number $\gamma \in R^1$ let us denote

$$\mathcal{B}_\gamma(x) = \{S \subsetneq N \mid e(x,v,S) \geq \gamma\}.$$

Then the following theorem holds (Kohlberg, 1972).

Theorem 1 (Kohlberg theorem.). *Let (N,v) be a game. A preimputation $x \in X^0(N,v)$ is the prenucleolus of game (N,v) if and only if the collections $\mathcal{B}_\gamma(x)$ are empty or balanced for all $\gamma \in R^1$.*

4. Cooperation of 3 shipping companies: structure P3

To conduct research on a given topic we analyzed the project of cooperation between three logistics companies in the sphere of sea container transportation which is called P3. This network includes such companies as Maersk Line, MSC (Mediterranean Shipping Company) and CMA CGM. These companies carry out operations by sea and transport containers all over the world. Head offices of shipping corporations are located in Copenhagen (Denmark), Geneva (Switzerland) and Marseille (France) respectively. The objectives of the cooperation are improving the quality of customer service because it becomes possible to provide services more often due to the increase in ship calls of P3 in different ports, also the aim is to implement more stable

[1] In the paper we use the definition of the anti-prenucleolus as it was given in Potters and Sudhölter, 1999, however, in some works it is called dual prenucleolus.

transportation and to form more flexible container delivery schedule. Furthermore, the lines plan to establish an independent operational center that will monitor and regulate maritime transportation and operate the vessels.

The cooperation of these companies is that each organization provides its vessels to carry containers in three sea directions: Asia-Europe, Europe-the eastern coast of the United States (Trans-Atlantic direction) and Asia-east and west coasts of the United States (Pacific direction).

It is worth noting that all companies within the P3 are building their activities independently. Therefore, each company establishes its tariffs for the transportation and operates according to the rules which are accepted by the principal (the head office of the organization). According to this plan, the type of this cooperation in logistics is horizontal because companies are engaged in the same type of activity and have the same stages of the technological chain. Target date indicated in plan P3 was second quarter of 2014.

The P3 project was approved by the US Federal Maritime Commission (FMS US), and by the European Commission in March and June 2014 respectively. However, the decision of the Ministry of Commerce in China (MOFCOM) which was based on the principles of antitrust law was negative because their norms for a merger of companies are different from FMS US and the European Commission. As a result, the companies stopped the implementation of the P3 project.

One year later, companies revised their plans for the organization of cooperation due to the refusal of MOFCOM and decided to create an alliance of 2M which would include only MSC and Maersk Line. Consequently, all goals and principles on which P3 cooperation was based remained in 2M. Companies were allowed to organize cooperation on the sea lines where P3 planned to operate. After that, MSC and Maersk Line signed a vessel sharing agreement for the next 10 years and the first 2M vessel was transported in January 2015. Nowadays their work is carried out on full according to the plan which was published by the alliance.

4.1. Game description

As mentioned previously, cooperation in the structures of P3 and 2M is considered by companies in terms of integration of their vessels. The number of vessels in projects is measured in respect to their loading capacity by the amount of TEUS containers. In sea container transportation TEUS means the size of a classic 20-foot container. Therefore, using the amount of TEUS we formed the characteristic function of this game. On the basis of the available data that can be found in the projects of P3 and 2M we decided to consider the TU-game (N, v) and compute allocation methods, using such unit of measurement of profit as TEUS.

Values of the number of TEUS containers that companies transport independently on the same routes were received in MSC company. In the game only the coalition 2M (Maersk Line & MSC) is known, therefore, characteristic function of the game has two parameters α and β.

$N = \{1, 2, 3\}$, 1 – Maersk Line, 2 – MSC, 3 – CMA CGM:

$v\{1\} = 1$, $v\{2\} = 0,8$, $v\{3\} = 0,5$, $v\{1,2\} = 2,1$, $v\{1,3\} = \alpha$, $v\{2,3\} = \beta$, $v\{N\} = 2,6$, where $1,5 \leq \alpha \leq 2,6$ and $1,3 \leq \beta \leq 2,6$.

Unit of measurement of the characteristic function – mln. TEUS.

4.2. (Pre)nucleolus

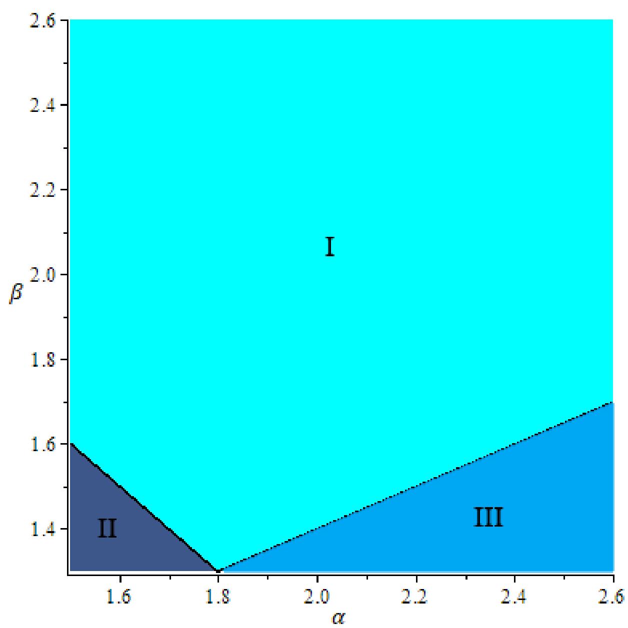
Let us consider $x = (x_1, x_2, x_3) \in X^0(N, v)$. According to the characteristic function of a game, excess of each coalition will take the following form:

Table 1. Table of excesses: the prenucleolus case

S	$e(x, v, S)$
$\{1\}$	$1 - x_1$
$\{2\}$	$0,8 - x_2$
$\{3\}$	$0,5 - x_3$
$\{1,2\}$	$x_3 - 0,5$
$\{1,3\}$	$x_2 + \alpha - 2,6$
$\{2,3\}$	$x_1 + \beta - 2,6$

In this particular case we have three situations with balanced sets which define the (pre)nucleolus and depend on values of parameters α and β. These cases are shown in the graph below.

Fig. 1.



I. For $\alpha \in [1,5; 1,8]$ and $\beta \in [3,1 - \alpha; 2,6]$, $\alpha \in [1,8; 2,6]$ and $\beta \in [\frac{0,8+\alpha}{2}; 2,6]$ the (pre)nucleolus of the game (N, v) is given by formula

$$\frac{1}{3}(4,7 + \alpha - 2\beta; 4,7 - 2\alpha + \beta; -1,6 + \alpha + \beta).$$

It follows from Kohlberg's theorem and the inequalities which define balanced sets

$$\max_{S\subset N} e(x,v,S) = \max\{e(x,v,\{1,2\}), e(x,v,\{1,3\}), e(x,v,\{2,3\})\} \geq$$

$$\geq e(x,v,\{i\}), i \in N.$$

II. For $\alpha \in [1,5;1,8]$ and $\beta \in [1,3;3,1-\alpha]$ the (pre)nucleolus of the game (N,v) is given by formula

$$\left(\frac{2,1+\alpha-\beta}{2};\frac{2,1-\alpha+\beta}{2};0,5\right).$$

The justification is the same as in the first case, the system of inequalities changes:

$$e(x,v,\{3\}) = e(x,v,\{1,2\}) \geq e(x,v,\{1,3\}) = e(x,v,\{2,3\}) \geq e(x,v,\{i\}),$$

$$i = 1,2.$$

III. For $\alpha \in [1,8;2,6]$ and $\beta \in [1,3;\frac{0,8+\alpha}{2}]$ the (pre)nucleolus of the game (N,v) is given by formula

$$\left(\frac{6-2\beta+\alpha}{4};\frac{3,4-\alpha}{2};\frac{-2,4+2\beta+\alpha}{4}\right).$$

The inequalities' system is

$$e(x,v\{2\}) = e(x,v,\{1,3\}) \geq e(x,v,\{1,2\}) = e(x,v,\{2,3\}) \geq e(x,v,\{i\}),$$

$$i \in \{1,3\}.$$

If we consider different values of α and β it becomes noticeable that in most cases the constructive power of coalition is taken into account, consequently, first and second players gain greater profit and largely benefit from (pre)nucleolus. The worst scenario for player 3 is considered in the case II where $\alpha \in [1,5;1,8]$ and $\beta \in [1,3;3,1-\alpha]$: according to (pre)nucleolus her share is a minimal one. Therefore, for this player (CMA CGM) in these situations there are no motivating factors for participation in the cooperation P3 because company does not achieve greater profit in alliance and, as a result, it can use its power in cooperation as a block.

4.3. The SM-nucleolus and the Shapley value

It was proved that for a game with 3 players the Shapley value coincides with the SM-nucleolus (Tarashnina, 2011). Therefore, in our game it is enough to calculate the Shapley value to get SM-nucleolus or vice versa.

Using the probabilistic interpretation of the Shapley value, we obtain Table 2.

Following that, the Shapley is equal to SM-nucleoulus and has the form:

$$\frac{1}{6}(8+\alpha-2\beta;7,4-2\alpha+\beta;0,2+\alpha+\beta).$$

If we look at different values of α and β, we will find that for the same values of these parameters the Shapley value and SM-nucleolus always give preference to the

Table 2. Table 2. Contributions of players

Order of arrival	Player 1	Player 2	Player 3
123	1	1,1	0,5
132	1	2,6-α	α-1
231	2,6-β	0,8	β-0,8
213	1,3	0,8	0,5
312	α-0,5	2,6-α	0,5
321	2,6-β	β-0,5	0,5
Total	$8+\alpha-2\beta$	$7,4-2\alpha+\beta$	$0,2+\alpha+\beta$

first player (Maersk Line), but if β exceeds α by 0,3, the share of the second player (MSC) becomes larger. The third player (CMA CGM) in this distribution receives the least amount of profit.

However, it should be emphasized that for such values of the parameters which are equal to minimum values ($\alpha = 1{,}5$ and $\beta = 1{,}3$) the third player has a minimal payoff. In this case CMA CGM by cooperation gets 0,5 mln. TEUS which is the same amount that the company can achieve without P3. Consequently, with such ratio of parameters we can observe the influence of SM-nucleolus. This distribution takes into account the blocking power of coalition and is intended to make values of all players equal as possible according to their contribution to the grand coalition.

4.4. Anti-prenucleolus

Further, we consider another excess-based solution which is called anti-prenucleolus or the nucleolus of a dual game (N, v^*). Characteristic function of the dual game v^* is defined in Table 3.

Table 3. Table 3. Table of excesses: the anti-prenucleolus case

S	$v(S)$	$v^*(S)$	$e(x, v^*, S)$
$\{1\}$	1	2,6-β	$-x_1 + (2,6-\beta)$
$\{2\}$	0,8	2,6-α	$-x_2 + (2,6-\alpha)$
$\{3\}$	0,5	0,5	$-x_3 + 0,5$
$\{1,2\}$	2,1	2,1	$x_3 - 0,5$
$\{1,3\}$	α	1,8	$x_2 - 0,8$
$\{2,3\}$	β	1,6	$x_1 - 1$
$N = \{1,2,3\}$	2,6	2,6	

Let us denote $e(x, v^*, S)$ by $e^*(x, S)$, $x \in X^0(N, v)$.
Using the same approach that was applied to the prenucleolus we obtain five cases of balanced sets defining anti-prenucleolus for different values of parameters α and β (see Fig. 2).

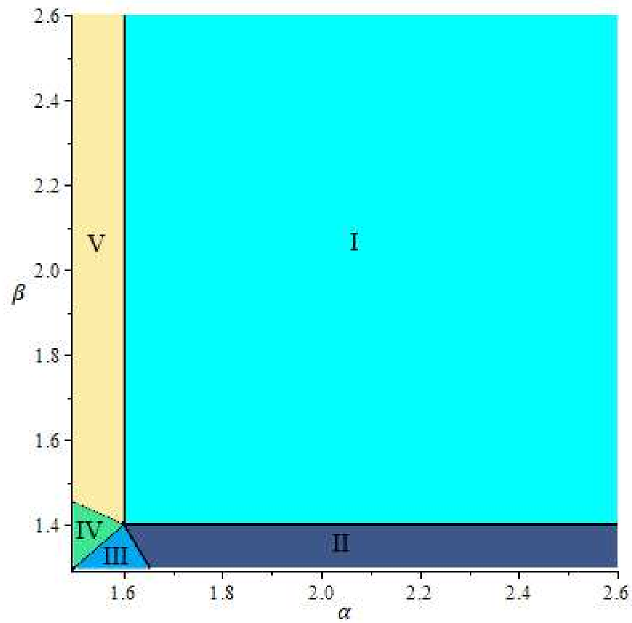
I. For $\alpha \in [1,6; 2,6]$ and $\beta \in [1,4; 2,6]$ the anti-prenucleolus is given by formula

$$(1,1; 0,9; 0,6).$$

By Kohlberg's theorem

$$\max_{S \subset N} e^*(x, S) = e^*(x, \{1,2\}) = e^*(x, \{1,3\}) = e^*(x, \{2,3\}) \geq e^*(x, \{i\}), i \in N.$$

Fig. 2.



II. For $\alpha \in [1,4; 2,3 - \frac{\beta}{2}]$ and $\beta \in [1,3; 1,4]$ the anti-prenucleolus is given by

$$\left(1,8 - \frac{\beta}{2}; 0,55 + \frac{\beta}{4}; 0,25 + \frac{\beta}{4}\right).$$

The corresponding system of inequalities holds

$$e^*(x,\{1\}) = e^*(x,\{2,3\}) \geq e^*(x,\{1,2\}) = e^*(x,\{1,3\}) \geq e^*(x,\{i\}), i \in \{2,3\}$$

III & IV. For $\alpha \in [1,5; 1,65]$ and $\beta \in [1,3; \alpha - 0,2]$, $\alpha \in [1,5; 1,6]$ and $\beta \in [\alpha - 0,2; 4,6 - 2\alpha]$ the anti-prenucleolus is given by

$$\left(1,8 - \frac{\beta}{2}; 1,7 - \frac{\alpha}{2}; -0,9 + \frac{\beta}{2} + \frac{\alpha}{2}\right).$$

The corresponding inequalities hold

$$\left[\begin{array}{c} e^*(x,\{1\}) = e^*(x,\{2,3\}) \geq e^*(x,\{1,3\}) = e^*(x,\{2\}) \geq e^*(x,S), \\ S \in \{\{3\},\{1,2\}\}, \\ e^*(x,\{2\}) = e^*(x,\{1,3\}) \geq e^*(x,\{1\}) = e^*(x,\{2,3\}) \geq e^*(x,S), \\ S \in \{\{3\},\{1,2\}\}. \end{array}\right.$$

V. For $\alpha \in [1,5; 1,6]$ and $\beta \in [2,2 - \frac{\alpha}{2}; 2,6]$ the anti-prenucleolus is given by

$$\left(0,7 + \frac{\alpha}{4}; 1,7 - \frac{\alpha}{2}; 0,2 + \frac{\alpha}{4}\right).$$

The corresponding system of inequalities holds

$$e^*(x,\{2\}) = e^*(x,\{1,3\}) \geq e^*(x,\{1,2\}) = e^*(x,\{2,3\}) \geq e^*(x,\{i\}),$$
$$i \in \{2,3\}.$$

Let us recall that the anti-prenucleolus takes into account the blocking power of coalition. As whole, it has the positive effect on payoff of player 3 (CMA CGM). For different values of α and β the third player gets the payment from 0,5 to 0,6. In the worst case that company can leave the grand coalition because the income it receives in cooperation P3 does not exceed the profit that it earns independently. Therefore, the blocking power of this player can further destabilize the state of the grand coalition.

5. Conclusion

The study examined the horizontal cooperation P3 which consists of three shipping companies: Maersk Line, MSC and CMA CGM. In the paper the volume of TEUS (20-foot containers) was considered as the profit of companies. The number of TEUS determines the occupancy of vessels which are used by all companies in the framework of cooperation. Using such methods as Shapley value, SM-nucleolus, (pre)nucleolus and anti-prenucleolus we calculate different allocations and analyze the influence of constructive and blocking power of coalition on them.

The following results were obtained: the distribution of the Shapley value and SM-nucleolus divides as much as possible the same amount among all players according to their contribution to the grand coalition; nucleolus takes into account the constructive power of coalition, therefore, gives preference to 1 and 2 players, in some cases of values of parameters α and β the third player may destabilize the agreement; anti-prenucleolus takes into account the blocking power of coalitions and shows different influence on payoffs of players. However for certain values of parameters it can give preference to weak player (CMA CGM).

The most optimal method is the Shapley value and SM-nucleolus because the risk that the third player (CMA CGM) will leave the grand coalition in this case is minimal. However, in the long-run period companies should use different variations of all distributions that were computed in this paper because the profit of weak player is also increases in most cases except of areas (which are presented in the figures 1 and 2) where the value of its stand-alone coalition coincides with the corresponding type of distribution. Therefore, if it is possible to modify the parameters for coalitions $\{1,3\}$ and $\{2,3\}$ it is necessary to take into account the results of all types of distributions to conduct the full analysis, vary and apply these methods for cooperation, depending on the situation which emerges in the industry.

The organization of cooperation provides the following consequences for companies: cooperation P3 based on the principles of economies of scale has a significant increase in the level of supply, consequently, the number of customer services has risen for each company. With full loading capacity of vessels and access to more ports we assume that costs of companies are reduced. This happens due to the lower use of fuel and smaller port tariffs because of fewer ship calls. The assumption of cost reduction can be also justified by the fact that vessels of each organization which work independently are often not fully loaded. In cooperation on the same vessel exist containers of several independent companies simultaneously, therefore, it reduces the frequency of ship calls and, moreover, positively affects the environment.

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