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SOKSZÍNŰ VÁLASZOK

GAZDÁLKODÁS- ÉS SZERVEZÉSTUDOMÁNYI FOLYÓIRAT

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NEW APPLICATION OF GAME THEORY IN SUPPLY CHAIN MANAGEMENT

A JÁTÉKELMÉLET ÚJSZERŰ ALKALMAZÁSA AZ ELLÁTÁSI LÁNC MENEDZSMENTBEN

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SUMMARY

Game theory has become an essential tool in the analysis of supply chains with multiple players who often have different interests. In this study, we use the game theory to examine the possibility of decision optimization and achieving equilibrium in the operation of the supply chain. Our goal is to determine the optimal agreement between the wholesaler and the retailer(s) to minimize the total cost in the supply chain in a given situation.

The research method used in the study enriches the literature on the topic by linking the minimization of costs not to abstract evaluation metrics but to the stock order item size often calculated in real business as well. This facilitates the interpretation of the strategies and decision motivations used by the members of the supply chain.

ÖSSZEFOGLALÓ

A játékelmélet alapvető eszközzé vált a több, gyakran eltérő érdekű szereplővel rendelkező ellátási láncok elemzésében. Ebben a tanulmányban a játékelméletet használjuk arra, hogy megvizsgáljuk a döntések optimalizálásának és az egyensúly elérésének lehetőségét az ellátási lánc működése során. Célunk a nagykereskedő és a kiskereskedő(k) közötti optimális megállapodás meghatározása, hogy adott helyzetben minimalizáljuk a teljes költséget az ellátási láncban.

A tanulmányban alkalmazott kutatási módszer gazdagítja a téma szakirodalmát azzal, hogy a költségek minimalizálását nem absztrakt mérőszámokhoz, hanem a valós üzleti életben is gyakran kalkulált készletrendelési tételmérethez köti. Ez megkönnyíti az ellátási lánc tagjai által alkalmazott stratégiák és döntési motivációk értelmezését.

INTRODUCTION

From the past century many outstanding economists made it the focus of their research to learn more about what could be the reasonable behavior in cases when multiple players of the economy affect the result of an economic decision. A significant stage of these research was the application of game theory in the analysis of these situations.

According to Dimand and Dimand (1997) game theory was developed in the 18th century, but most of the literature regards John von Neumann and Oskar Morgenstein as the founders of the game theory. In their book published in 1944 (*Theory of Games and Economic Behavior*) they had presented the terms and definitions we use today, and what served as a baseline for developing new categories since then. By now literature was improved and expanded a lot, including Nash developing the term of equilibrium (1950), Kuhn defining games with incomplete information (1953), Aumann examining the cooperative games (1959), and the works of Shubik (1962) and Vickrey (1961). The rooster doesn't end here. Between 1966 and 1968 János Harsányi successfully eliminated a supposition that made the application of the game theory harder, that the players perfectly know the strategies and utility functions of each other (Harsanyi, 1968a, 1968b, 1968c). In the 70s game theory gained ground in evolutionary research too (Maynard Smith, 1974), then Selten (1975) improved the Nash Equilibrium Theory. However, this list is but a fragment of the great amount of research bringing more and more successes in the area of game theory.

In this study we too use the help of the game theory to analyze how the results of the decisions can be optimized in the supply chain, because the effective coordination of the supply chain requires an agreement satisfactory for all the participants. And this means the applicability of the game theory in this area too. (Szép & Forgó, 1974).

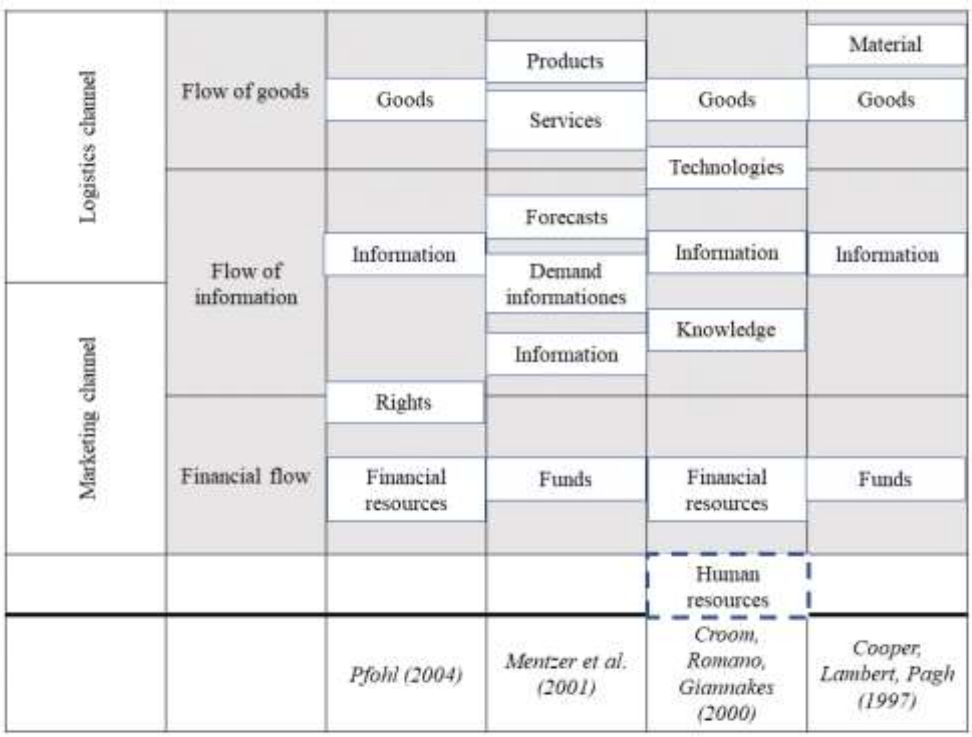
In our study we examined the possible balance situations in the relationship between a distributor and the retailers. Our goal is to determine an optimal agreement between the wholesaler and the retailers that could decrease the total cost to the lowest level.

The method of examination adds to the literature by linking the minimization of costs not to abstract evaluation metrics but to the stock order item size often calculated in real business as well. This facilitates the interpretation of the strategies and decision motivations used by the members of the supply chain.

THEORETICAL BACKGROUND

The many aspects of the research regarding the supply chain–although relying on a number of authors–are presented by Pfohl and Gomm (2009) in a well-organized chart which shows that supply chain management basically focuses on 3 areas: the–partnership–management of goods, information and financial resources (Figure 1).

Figure 1: Main Research Areas of the Supply Chain



Source: Pfohl & Gomm, 2009

Among the areas listed in Figure 1 there are many in which the applicability of the game theory models already has been proved.

The application of game theory in the supply chain was adopted around the turn of the millennium. Soon after these studies came out that were dedicated to the literature review of the articles published on the subject. Including the research of Cachon and Netessine (2004) who defined four categories for the main techniques of the published applications of game theory, and they thought these categories might be adopted during future research: (1) non-cooperative static and dynamic games; (2) cooperative games; (3) principal-agent model; (4) Bayesian games. In later research they examined the application opportunities of game theory in the supply chain in order to outline the game theory concepts that would be applicable in the future. The non-cooperative and the cooperative game theories alike are discussed in both static and dynamic environment (Cachon & Netessine, 2014).

Leng and Parlar performed similar research (2005) and based on more than a hundred articles they identified those supply chain management areas where game theory models are especially applicable.

There is ongoing research still in this area. Several authors discuss how to optimize the transfer prices, the profit and other coordination conditions in the supply chain.

In Table 1 we listed and categorized the literature of the last ten or more years we collected on the subject. The categories are based on the areas of research, game theory was applied in. Based on Table 1 we can tell that the researchers took most interest in pricing mechanism/transfer price and product quality.

Below we present some literature findings regarding the areas of examination we identified. Most of the texts cannot be connected to only one category because most of the authors deal with more than one research subjects.

Table 1: Application of Game Theory in the Various Reasearch Areas of the Supply Chain

<table>
<tr><th>PRICING MECHANISM/
TRANSFER PRICE</th><th>PRODUCT QUALITY</th></tr>
<tr><td rowspan="3">Rosenthal, 2008
Zhao, et al., 2010
De Giovanni, 2011
Xie et al., 2011b
Wee & Wang, 2013
Giri et al., 2015
Nagurney & Li, 2015
Taleizadeh et al., 2017
Raj et al., 2018</td><td>Xie et al., 2011a
Xie et al., 2011b
Liu et al., 2015
Giri et al., 2015
Nagurney & Li, 2015
Taleizadeh et al., 2017</td></tr>
<tr><th>OUTSOURCING</th></tr>
<tr><td>Nagurney & Li, 2015</td></tr>
<tr><th>PROFIT/PROFIT MAXIMIZATION</th><th>ORDER QUANTITY/STOCK</th></tr>
<tr><td>Chinchuluun et al., 2009
Wee & Wang, 2013
Raj et al., 2018
Juhász et al., 2019</td><td>Dobos, 2012
Wee & Wang, 2013
Zamarripa et al., 2013</td></tr>
<tr><th>CREDITWORTHINESS</th><th>RISK PREFERENCES</th></tr>
<tr><td>Li et al., 2018
Lin & Xiao, 2018
Yu & Zhu, 2018</td><td>Henet & Arda, 2008
Zhao, et al., 2010
Nagurney & Li, 2015</td></tr>
<tr><th>COST REDUCTION</th><th>ADVERTISEMENT</th></tr>
<tr><td>Dobos & Pintér, 2010a
Dobos & Pintér, 2010b</td><td>De Giovanni, 2011
Wee & Wang, 2013
Liu et al., 2015</td></tr>
<tr><th>CSR</th><th>DECISION ORDER</th></tr>
<tr><td>Shi, 2011
Raj et al., 2018</td><td>Yu & Ma, 2013</td></tr>
<tr><th>INDIVIDUAL NEGOTIATION
SKILLS</th><th>PAYMENT TERMS</th></tr>
<tr><td>Zhao, et al., 2010</td><td>Zhan et al., 2018
Juhász et al., 2019</td></tr>
<tr><th colspan="2">SALE/REFUND</th></tr>
<tr><td colspan="2">Taleizadeh et al., 2017</td></tr>
</table>

Source: Own edition

Pricing Mechanism/Transfer Price

Rosenthal (2008) examines the issue of determining transfer prices in a vertically integrated supply chain in which the various divisions are sharing the costs of technology and transactions. In their study Zhao and his co-authors (2010) applied the cooperative approach in using the so-called option contracts to deal with the coordination issues of the producer-retailer supply chains. Their findings give us a comprehensive insight to how option contracts may be used to synchronize the supply chains of the producer and the retailer. In our view comparable to the wholesale pricing mechanism an option contract in the producer-retailer supply chain may result in Pareto improvement.

Product Quality

Hsieh and Liu (2010) examined the supplier's and the producer's quality assurance investment and control strategies with different amount of information in four non-cooperative games. Furthermore, they analyze the effects of information regarding control on the equilibrium strategies and profit of both parties, and the reasonable degree of fines for faulty parts in a balanced situation. Xie et al. (2011a) examines a market through the non-cooperative game theory model of Nash where two supply chains compete with each other in the quality of a product offered on the same price. In another article Xie and his co-authors (2011b) examine the quality investments and pricing decisions of a custom supply chain in a case when the producer and the deliverer have an uncertain demand in the international trade, and consequently they are at a financial risk. Giri and his co-authors (2015) examined the quality and pricing decisions regarding a given product in a supply chain where there are only one trader and more than one producer. They performed this research through two strategies (Cournot and Stackelberg).

Profit/Profit Maximization

According to Chinchuluun and his co-authors (2009) the profit generated in the whole supply chain would be maximal if all the decisions are made by one decision maker in possession of all the available information. This needs a central control to take place. Because it is not possible, no one has the opportunity for optimization. Thus, every participant has their own information base and motivations. In this so-called decentralized control structure, the participants should know how to behave to maximize their profit. According to the authors there are two strategies for increasing the total profit of the decentralized supply chain and improving the efficiency of the participants:

- Double Marginalization: Contracts made by the participants by modifying their payments.
- Channel Coordination: The goal of a coordination contract is to inspire both participants to introduce a system-optimal solution that results in a higher total profit in the whole supply chain.

Order Quantity/Stock

Dobos (2012) extends the model suggested by Banerjee (1986) on the case when demand depends on the purchase price. He compares the ordered quantity determined by mutual agreement with the order in case of competition. In their article Zamarripa and his co-authors (2013) present the integrated model of various optimization methods for the improvement of decision making regarding the supply chain planning, in order to meet the challenges of the current and future market trends (decreasing the stock, challenges of the market competition, production and capacity changes, increased flexibility for processes and logistics, etc.). Wee and Wang (2013) discussed an issue about a product with short life cycle in a decentralized producer-retailer supply chain in to achieve an optimal price and order quantity, and to maximize the profit of the supply chain.

Creditworthiness

Yu and Zhu (2018) used game theory to examine the cooperation between a trader with limited capital, a producer, and a bank. In their research they proved that the trader orders less product if the financial costs are higher. Furthermore, with more assets the trader gets lower loan interests and increases the quantity of the orders gradually. Li and his co-authors (2018) examined the creditworthiness problem in the context of a supplier-buyer supply chain. For this they provided a game theory framework which records the interaction between the decision regarding the supplier's creditworthiness and the order decision of the buyer in several periods. The authors regard their work as the first data-centered model and solution approach that helps for acquisition and supply managers to make optimally dynamic creditworthiness decisions in the game theory environment in the context of production, order and determining the stock. Lin and Xiao (2018) used the Stackelberg model to examine the traditional supply chain and a loan guarantee financing in the relationship between a retailer and a low capital producer company. By comparing the strategies, they achieved a result showing that the situation of the producer facing a limit of the capital may be efficiently improved by the cooperation between the members of the supply chain, namely a loan guarantee offered to the producer by the trader.

Advertisement

De Giovanni (2011) optimizes the pricing, advertisement, and quality improvement decisions in a dynamic environment, considering the cooperative and non-cooperative cases between a producer and a retailer. Zhang and his co-authors (2013) analyzed the effects of reference price on the optimal decisions of all the members of a supply chain in a dynamic advertisement model. By using two different game theory models they determined the optimal decisions of the producer and the retailer. Liu et al. (2015) examined the effects of agreed and administrated transfer prices on the profit with the help of a differentiated game model, through the operation of both the operational and the marketing divisions of an enterprise. The operational division is responsible for the improvement of the quality of a given product, and it sells this product to the end costumers through the marketing division which controls the retail prices and the advertisements.

CSR

Raj and his colleagues (2018) used the Stackelberg game theory approach in their decentralized supply chain model where the deliverer is the leader company. In this context they analyze through five types of contracts (wholesale price, linear two-part tariff (LTT), environmentally friendly cost sharing, profit sharing, and environmentally friendly cost and profit-sharing contracts) and demonstrate how the various contract types influence the level of optimal greening and CSR, and the retail price and the profit. In his doctoral thesis Shi (2011) also connects the supply chain, the corporate social responsibility, and the game theory.

Cost Reduction

In their work Dobos and Pintér (2010a) apply game theory terms in the case of a supply chain. They take the elements of the bullwhip effect in a supplier-producer supply chain in an Arrow-Karlin model with linear inventory and convex producing costs. In their research they presume a hierarchic system of decision making in which first the producer then the supplier optimizes their situation, and after this they compare a centralized (cooperative) model in which the companies minimize However, if both the retailer and the producer are risk-neutral, they share the extra profit in equal proportions their combined costs. In another study Dobos and Pintér (2010b) conducted this examination in the case of a Holt-Mogigliani-MouthSimon type supply chain.

Risk Preferences

In their article Hennet and Arda (2008) evaluate the efficiency of various contracts between the industrial partners of a supply chain. Their assessment is based on the relationship between a producer as a subject of uncertain demand and a supplier with random lead time. The model combines the queueing theory with the evaluation criteria and the game theory to determine the decision goals. Besides examining the pricing mechanism Zhao and his co-authors (2010) looked for answers for other questions like the risk preferences of the members of the supply chain. According to the results of their research the individual risk preference plays a significant role in the result of the coordination. The more risk-averse the retailer and the producer the less extra profit they can get. However, if both the retailer and the producer are risk-neutral, they share the extra profit in equal proportions. Additionally, to the risk preferences the individual negotiation skills also have a significant effect on the result. The higher the given participant's negotiating power relative to the partner's, the higher compensation fee they can gain.

Decision Order

Yu and Ma (2013) examined the effects of decision order in a multi-participant (two deliverer and a producer) supply chain with demand uncertainty. They used three strategies to analyze the decisions of the deliverers: (1) they decide about quality investments at the same time then they determine the product's price simultaneously; (2) they decide about the quality investments and the product's price at the same time; or (3) one of them plays a leading role.

Sale/Refund

For the analysis of the centralized and decentralized supply chains Taleizadeh and his co-authors (2017) used five different game theory models. Regarding an increase in demand, they expanded their examination to the areas of pricing, reference price, product quality and return policy, and sale.

Outsourcing

In their article Nagurney and Li (2015) discussed the game theory model of the supply chain in case of product diversification, possible production and sale outsourcing, and quality and price competition. Their purpose with elaborating the model was to determine an in-house optimal level of quality, and in-house and outsourced optimal production and delivery amounts that maximizes the total cost for a company.

Payment Terms

According to Zhan and his colleagues (2018) the importance of sustainability is increasing for the enterprises to get competitive advantage. In their research they proved that the payment terms essentially influence the efficiency and sustainability of the supply chain. Juhász and his co-authors (2019) examined the decisions regarding the financial management of supply chains, and their effects on competitiveness. According to their results the cooperation between the members of the supply chain may decrease the additional need of capital while supporting profitability and growth. They said this cooperation could be achieved by payment terms regulation, or by the introduction of a fee that is paid by the members to the dominant player in the supply chain.

RESEARCH PARAMETERS AND RESULTS

The stock size is connected directly to the sales process. Maintaining a large stock is costly, and the too low stock may lead to a shortage, consequently to more limited sales options. So, to maintain the proper stock size complex stockpiling models (static, dynamic, stochastic models) are helping to make the right decisions (Kozák & Fenyvesi).

A distributor operates with lower unit costs because the larger infrastructure of logistics makes the costs of maintaining and moving one unit of stock lower. The retailer's storage capacity is more limited, and the sales area should be suitable for placing more than one product categories requested by the customers (Table 2).

Table 2: Parameters for Determining the Economic Order Quantity

	Distributor	Retailer
Annual sell	1000	1000
Storage costs / pieces	1	6
Transaction costs / order	4	8

Source: Own edition

To compile the analysis model used for the research we assumed that

- The order lead time is known and constant
- The demand is known and constant, stock shortage is not allowed
- The unit costs of stockpiling are known and constant
- Receipt is happening once (spot-like), and its date can be planned
- 1% of the estimated demand is counted as a safety stock by the distributor, this rate is 2% at the retailer.

The cost of holding stock is determined by multiplying the unit cost of holding stock with the average stock.

$$\frac{K \text{ x } Q}{2}$$

- K: cost of holding inventory of one unit of product (1 or 6 units);
- Q: order quantity.

The order transaction cost can be calculated as follows:

$$\frac{S \text{ x } R}{Q}$$

- S: the transaction cost of one order placement (4 or 8 units);
- R: demand in the given period (1000 pieces);
- Q: order quantity.

The minimum of the total cost will be where the costs of holding stock and the order costs are equal. With these data this is 89 pieces in the case of the distributor, and 52 pieces in the case of the retailer. (These amounts–assuming the sale of

1000 units–were calculated by using the economic order quantity $(Q) = \sqrt{\frac{2SxR}{K}}$ formula.)

The result, namely the final state connected to the possible decisions is that how the costs can be decreased by the order quantity. These decisions include the utility–based on cost calculation–that shows the strategies that should be followed.

In our research we examined the effects of a quantity type "competition". The structures of the calculated payments were determined by clear (cooperative and non-cooperative) strategies, considering that the different logistic infrastructure of the wholesaler and the retailer give way to no symmetric business policy of cost decreasing opportunities shared in equal proportions.

The results of the various strategic settings or the cost combinations depending on stock policy can be found in Tables 3-6.

a) Table 3 models an economic situation in which both the distributor and the retailer considers only their own interests, consequently they order only so many products that minimizes their own costs. *If the distributor purchases 89 pieces, and the retailer purchases 52 pieces, both of them reaches the lowest cost, a sum of 399 units.* There is no cooperation, coordination, or any communication regarding the order quantity, so this means a competition strategy like corporation behavior by which the players try to minimize only their own stock order costs.

   In the next two cases–in points b) and c)–we examine what happens if additionally to the amounts calculated in point a) one of the players is sticking to their optimal quantity, and the other party cooperates by accepting it and ordering product in the same quantity (52 or 89 pieces).

Table 3: Costs of Various Stock Sizes if the Wholesaler and the Retailer Compete with Each Other

The wholesaler does not cooperate	The retailer does not cooperate: 32	42	52	62	72
109	. 346 91 *437*	316 91 *408*	310 91 *401*	315 91 *406*	327 91 *418*
99	346 90 *436*	316 90 *406*	310 90 *400*	315 90 *405*	327 90 *417*
89	346 89 *435*	316 89 *406*	310 89 *399*	315 89 *404*	327 89 *417*
79	346 90 *436*	316 90 *407*	310 90 *400*	315 90 *405*	327 90 *417*
69	346 92 *438*	316 92 *409*	310 92 *402*	315 92 *408*	327 92 *420*

Source: Own edition

b) In Table 4 we determined what happens if the distributor cooperates and orders the same amount as their partner, but the retailer considers only their own interests and remains at the previously determined 52 pieces purchase. *The retailer optimizes their cost management, but the distributor loses from their competitive advantage, and the total cost reaches 413 units.* If the wholesaler increases the order quantity to 72 pieces, the costs may be decreased significantly (401 units), but it does not go under the 399 units result calculated in the previous example. Table 4 shows a solution that contains the elements of both the competition and the cooperation. Both players recognize that with lowering their costs the competitiveness of the supply chain will increase, even so the distributor makes their decision by regarding the retailer's decision fixed at the 52 pieces order. This is the so called Cournot Equilibrium in which optimization happens with the same amounts and a given decision of one of the players.

Table 4: Costs of Various Stock Sizes if the Wholesaler Cooperates and the Retailer Competes

The wholesaler cooperates	The retailer does not cooperate: 32	42	52	62	72
72	346 92 *438*	316 92 *408*	*310* *92* *401*	315 92 *407*	327 92 *419*
62	346 96 *442*	316 96 *412*	310 96 *405*	315 96 *411*	327 96 *423*
52	346 103 *449*	316 103 *419*	310 103 *413*	315 103 *418*	327 103 *430*
42	346 116 *462*	316 116 *433*	310 116 *426*	315 116 *431*	327 116 *443*
32	346 141 *487*	316 141 *457*	310 141 *151*	315 141 *456*	327 141 *468*

Source: Own edition

c) Conversely the result (Table 5) is even worse than in the previous example, because if the retailer cooperates and purchases the same amount as the wholesaler (89 pieces) but with higher stockpiling and logistic unit costs than the wholesaler's, *the total cost goes to the highest level of all the examples: 446 units.* If the retailer decreases the order quantity to 69 pieces, then the costs may be decreased significantly (412 units) but it does not go below the lowest result so far (399 units). Similarly to the previous example both players recognize that with lowering their costs the competitiveness of the supply chain will increase, but here the retailer makes their decision by regarding the wholesaler's decision fixed at the 89 pieces order.

This is too a so called Cournot Equilibrium, but the cooperation is realized with higher cost level because the retailer adapts to the decision of the wholesaler, even if they have higher unit costs.

Table 5: Costs of Various Stock Sizes if the Wholesaler Competes and the Retailer Cooperates

The wholesaler does not cooperate	The retailer cooperates: 69		79		89		99		109	
109		323		338		357		378		400
	91	*414*	91	*429*	91	*448*	91	*469*	91	*492*
99		323		338		357		378		400
	90	*413*	90	*428*	90	*447*	90	*468*	90	*490*
89		323		338		357		378		400
	89	*412*	89	*428*	89	*446*	89	*467*	89	*490*
79		323		338		357		378		400
	90	*413*	90	*428*	90	*447*	90	*468*	90	*491*
69		323		338		357		378		400
	92	*415*	92	*431*	92	*449*	92	*470*	92	*493*

Source: Own edition

d) The results of cooperation were examined by the data of Table 6.

The economic operators optimize by their resources and transaction costs. Because the unit costs of holding stock are lower for the distributor, there is no use for the retailer to maintain and develop significant storage capacity. The purchase numbers optimized in competitive environment (Table 3) may be decreased further if the distributor is taking all the actions connected to the stock as a resource. The retailer decreases their costs if the wholesaler adapts to the retailer's purchase schedule, and the more efficient logistic infrastructure decreases the total cost (economies of scale). Optimal cooperation can be realized only this way. Achieving lean management, the retailer should adopt a "just in time" stock policy for this cooperation that results in the lowest total cost (203).

Table 6: Costs of Various Stock Sizes if the Wholesaler Cooperates and the Retailer Cooperates too

		The retailer cooperates, no stockpiling									
		32		42		**52**		62		72	
The wholesaler cooperates	**72**		250		190		154		129		111
		92	*342*	92	*282*	92	*245*	92	*221*	92	*203*
	62		250		190		154		129		111
		96	*346*	96	*286*	96	*249*	96	*225*	96	*207*
	52		250		190		154		129		111
		103	*353*	103	*293*	103	*257*	103	*232*	103	*214*
	42		250		190		154		129		111
		116	*366*	116	*307*	116	*270*	116	*245*	116	*227*
	32		250		190		154		129		111
		141	*391*	141	*331*	141	*295*	141	*270*	141	*252*

Source: Own edition

The retailer may decide to order products in the lowest stock size (32 units) from the examined options, but this way they must calculate with higher logistic costs because of the more frequent deliveries, and the total cost will be higher (342) than the best option. In both cases we assume that the retailer determines their stocking strategy and communicates it to their partner then the distributor forms their rational decision by taking it into consideration. However, this is in accordance with the supply level goal and there is no conflict between the partners. The behavior of the players can be examined by the Stackelberg model, in which the quantity optimization means that one of the players (in this case, the retailer) fixes their own rules and payment conditions, and the other party (the distributor) optimizes their own operative boundary conditions and profit expectations by these (Kozák & Fenyvesi, 2020).

SUMMARY AND CONCLUSIONS

The application of lean management has become a fundamental competitive criterion in the operation of industrial enterprises in the 21st century (Gáspár, Vajda & Martos, 2021). One fundamental strategic task of supply chains is how the balance can be maintained between the productivity focused and customer focused behaviours. That the customer can purchase the selected product is ensured by quick stock rotation in the former case and by high or cyclic stock level in the latter case. Our aim was to determine that logistic strategy which takes into consideration both expectations by help of game theory.

In Table 7 the costs depend on the willingness in cooperation can be found where the cooperative behaviours seem to be dominant strategies. Strategic cooperation which appears in the acceptance of lean procedures and the aligned management generates the lowest cost: 203 units.

Table 7: Game theory results based on cost-outputs

		Retailer			
		cooperates		**does not cooperate**	
Distributor	**cooperates**		**111**	-	310
		92	**203**	103	413
	does not cooperate	-	357		310
		89	446	89	399

Source: Own edition

The results can be explained by the points table, where the highest point (3) means the lowest cost level of the company, and the highest cost levels got 1 point. In Table 8 we summarized the profit outcome of cooperative and non-cooperative behaviours of distributors and retailers. Differences between the point values indicate the cost saving order with consideration of data showed in Table 8. We can see that the cooperation-cooperation strategy gives the same points (3+2) as competition-competition, which assumes the existance of two Nash's equilibria, however the two different forms of behaviours mean two very different business models. The bilateral cooperation can be seen as the best rated position, because in this case the Nash equilibrium can be defined as a situation where every players' strategy is the best respond to the strategies of the other players, meaning the best overall respond and the synergy effect manifest at the supply chain level. So, it does not make any sense for none of the parties to change the behaviour. Higher cost saving can be achieved when in the cooperation-cooperation relationship the distributor accepts a cooperative form where the customer focused, and flexibility behaviours have role in the strategy due to the cooperation beside the expectation of effectiveness.

Table 8: Game theory results based on cost level order

		Retailer			
		cooperates		**does not cooperate**	
Distributor	**cooperates**		**3**		2
		2		1	
	does not cooperate		1		2
		3		3	

Source: Own edition

In the normal form of the game, it means such a strategic twosome, which belongs to the results or disbursal, where the disbursal is not worse off for the distributor than for anyone of strategic twosome, and it is also not worse off for retailer than for any of strategic twosome. This can be seen as clear strategic, because all players choose a strategy for good and all, with other words, all players have made a decision and insist on it, which means they carry the distributor chain management based on lean concept. Asymmetric strategies do not give outstanding cost saving, only the cooperation of the two partners leads to improvement in effectiveness. In that case, when both of the two players pass upon the non-cooperative strategy, both of them quantify the size of the order which is rentable, and purchase the goods based on it.

The relationship in the supply chain gives the optimal disbursement, if

- retailer keeps minimal stock in its shops or warehouses, and it is based on a fundamental condition – the confidence in the distributor;
- distributor accepts the rules of the retailer, meaning the storage policy of the retailer, and he defines his own purchasing and storage policy according to it;
- retailer makes his order in such quantities, which helps for the distributor to optimize his own costs (disbursement function);
- rationalization happens on the level of distributor chain management, so the clear strategy guaranties competitiveness of the partners-network;
- partners have the information needed for their decisions, and they share them among themselves;
- planning of purchasing and goods ordering based on cooperation guaranties the continuous product supply and the high-level service.

In short, cooperation based on lean approach generates the highest cost saving, which gives opportunity to strengthen the price position among the supply chains and so to improve the competitiveness.

Only the bilateral cooperation can generate acceptable disbursement, what is to say, cost saving, even if the result is unequal, the profit sharing is not zero-sum.

One of the parties should approbate compromise, and due to this the "good-relationship", the strategic cooperation can be maintained and the competitiveness in the level of supply chain rises.

Our opinion is that the study should be continued with the analysing of price competition being in strong relationship with it, as the other important factor in the completion of supply chains.

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