AHP-Based Decision-Making Model for Supply Chain Coordination by a Modified Revenue-Sharing Contract Type

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Abstract: The efficiency of supply chains can be enhanced in several ways. One of them is the optimization of coordination mechanisms. Supply chain coordination is the course of activities by which a chain member tries to increase its profits through the quantity sold and the price. Coordination by contract types is one of the most widely studied topics in supply chain management. Depending on the market situation, companies can chose among several solutions of contracting. In this paper a contract that applies revenue-sharing rates is analyzed. This type of contract offers a relatively flexible determination of rates of profits of chain members and is suitable for a fair division of profits as well. However, the bargaining power of members differs in practice, meaning that they tend to move towards an unbalanced direction: the traditional decentralized setting in which simple wholesale prices and individual profit interests dominate. In our research a model was extended to allow a fairer profit division among the members while keeping the distorted difference of the decentralized setting, but only on a much lower level. This mixed model serves as a happy medium between the two contract types. The model is generalized for sequential supply chains and a case study-based decision-making model applying the Analytic Hierarchy Process (AHP) is introduced that can help in supporting decision-makers in choosing the most suitable rate of revenue sharing in a given situation.

Key-Words: Supply chain coordination, Revenue-sharing contract, Centralized setting, Decentralized setting, Analytic Hierarchy Process

1 Introduction

Not only short term agreements, which are based mainly on market and therefore negotiation power, but also general and specific contract types play an important role in supply chain coordination of companies that recognize the importance of cooperation with their suppliers or customer companies. In industrial branches like the automotive industry the extended network of suppliers allows relatively healthy competition because of the existence of competition among potential suppliers, so that original equipment manufacturers can focus on earning higher profits and not on long-lasting searches for suppliers.

In supply chain management one of the main issues is the pricing of sold goods; important influencing factors in this process are the price and quality of procured components. The members of the analyzed part of the supply chain have different interests and market goals, therefore various coordination solutions can be observed. There are some basic types of supply network morphology that result in different coordination mechanisms (Fig.1): vertical coordination between two members (Type I); vertical coordination among more than one member (sequential supply chain – Type II); more than one supplier of a member, delivering different components (Type III) [1]; one member is the supplier of members of different levels of the supply chain (Type IV); mixed version: one or more than one supplier on the different levels of the chain (supply network – Type V) [2]. There is a special situation that influences the coordination mechanism: two or more suppliers compete with each other to deliver the same components (Type VI) [3]. In this case there are three situations: all the suppliers will be contracted with because of the relatively high demand that can be satisfied by many suppliers, or only one competing supplier will be contracted with [4], or some of them will deliver but the delivered quantity depends on the market and negotiation power of the competing potential suppliers. In all three situations price interests determine the market situation. However, in all cases a shift in the direction of vertical integration always helps form more balanced cooperation.

In this paper the profit of members of a sequential supply chain (Type II) is calculated on the basis of production costs and constants that characterize the market. The recommended method differs from the existing ones in its basic conception: it incorporates a conventional contract type (wholesale pricing in decentralized setting) and an up-to-date one (revenue-sharing type in a centralized setting) in order to link the advantages of the latter (higher total profit of the members) and at the same time to keep the possibility of the sometimes unavoidable short-term thinking of the former one.

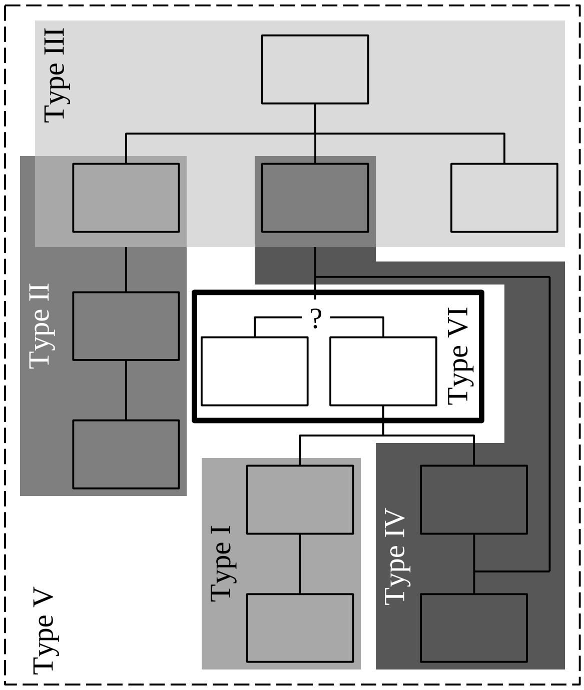

Fig.1 Basic types of relationships

2 Literature review

In the traditional approach, members of a supply chain tend to operate in a decentralized manner (similarly to the organization units of an enterprise). In contrary to this, in a centralized supply chain, higher profit can be earned due to the central decision-making [5]. Of course, this type of integration is difficult to realize. There are many areas that influence the operation and success of this type of contract [6]. Academic researchers have analyzed supply chain coordination mechanisms from a game theory point of view [7, 8]. Arani et al. [9] investigated mixed-type contracts on the basis of the Nash equilibrium. Most of the publications introduce simple analytic models [10] or simulations [11, 12]. Some researchers have begun to analyze the supply chain as a dynamic system, e.g. [13]. Sluis and De Giovanni carried out an empirical study for the selection of coordinating contracts [14]. It has to be noted that only a small rate of studies are based on empirical studies or real-life data.

There are also several analytical models introduced in existing works. They provide useful methods for decision-makers but the main problem is that these models are not systematically collected in academic books. One useful and wide-spread comparison of the models is the one that is demonstrated in Table 1 (type of coordination and form of results). Another problem in some existing papers is that they introduce mathematical models and neglect experiments or empirical data in the analyses. However, simulation results, which are applied by many of them, are useful.

Table 1 Some recent research in coordination with contract types

Type of coordination	Author(s) (year)	Results
Quantity discount	Zhao &Wei (2014) [15]	Comparative statistical analysis
Price discount	Heydari (2014) [16]	Numerical experiments
Real-option contract	Luo et al. (2015) [17]	Analytical results
Trade credit	Luo & Zhang (2012) [18]	Analytical results
Fixed ordering	Geunes et al. (2016) [19]	Analytical results
Quantity-flexibility	Li et al. (2015) [20]	Analytical results
Option contract	Cai et al. (2017) [21]	Analytical results
Revenue-sharing	Krishnan & Winter (2010) [22]; Zhang et al. (2015) [23]; Dye & Yang (2016) [24]	Analytical results

The revenue-sharing contract has been analyzed widely in recent years [5, 23, 24, 25]. In this setting the total profit of the considered part of the supply chain (cooperating members) is always higher than could be earned by the decentralized setting. When applying a revenue-sharing contract, the members divide the retailer’s revenue among them and therefore their profits are also divided in the same proportion. This means that the rates of profit depend on the members' market and negotiation power. However, it is possible for the members to divide the rates of profit equally among each other.

3 Model formulation

To build up the model some basic equations and notations are necessary. The notations applied in the model are summarized in Table 2.

Table 2 Notations applied in the model

R	Retailer
CST	Customers
i	Index of members
SU_i	*i*th supplier
n	Number of suppliers
q	Quantity sold by the chain members
$P(q)$	Inverse demand function
x, y	Constants of the demand function
P	Market price charged by the retailer
$R(q)$	Retailer's revenue
w_i	Wholesale price of the *i*th supplier
c_R	Unit production cost of the retailer
c_i	Unit production cost of the *i*th supplier
c	Sum of unit production costs
α_R	Retailer's rate of revenue
α_i	*i*th supplier's rate of retailer's revenue
Π_R	Retailer's profit
Π_i	*i*th supplier's profit
Π	Total profit of the supply chain

The supply chain is modeled as a sequential chain of member companies. It has to be noted that coordination is not guaranteed if there is more than one retailer in the supply chain [26], and the calculations differ from those introduced here if more than one supplier or customer is connected to one member. The structure of the model is shown in Fig.2. If a supply chain is managed centrally (vertical integration), i.e. one decision maker decides about profit optimization, the profit maximum can be derived as indicated in Eqs. (1-3).

$$\Pi^* = qP + q\sum_{i=1}^{n} w_i - qc_R - q\sum_{i=1}^{n} c_s - q\sum_{i=1}^{n} w_i = q(P-c), \quad (1)$$

where Π^* is the profit of the whole supply chain in centralized setting.

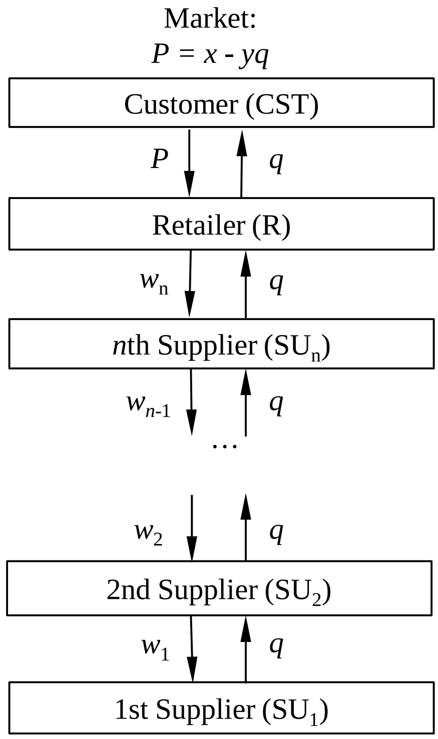

Fig.2 Structure of the analyzed supply chain model

Maximum profit belongs to the q^* of which value is determined by partial derivation (Eq. (2)).

$$\frac{\partial \Pi^*}{\partial q^*} = x - 2yq - c = 0 \rightarrow q^* = \frac{x-c}{2y} \quad (2)$$

After substituting q^* in Eq. (1):

$$\Pi^* = \frac{(x-c)^2}{4y} \quad (3)$$

If the supply chain members manage their profits individually, the basis of profit maximization is the wholesale price w (decentralized setting). It can be shown that the sold quantity depends on the number of suppliers (n) of the supply chain given by Eq. (4).

$$q^* = \frac{(x-c)^2}{2^{n+1}y} \quad (4)$$

In this setting the profits of the suppliers and the retailer can be calculated as in Eq. (5).

$$\Pi_i = \left\{ \frac{(x-c)^2}{2^{n+1+i}y} \middle| i = 1; \dots; n+1 \right\} \quad (5)$$

where n is the number of suppliers. Considering the retailer, there are (n+1) members in the supply chain.

On the basis of Eq. (5) the profits of the members can be calculated for sequential supply chains with n suppliers and one retailer if the wholesale prices and the unit costs of the analyzed product are available.

The profits of the members of the supply chain in cases of 2–5-level chains if members operate in a decentralized way are summarized in Table 3. The point of this collection is that in the introduced model the new solution falls between the idealistic revenue-sharing contract (when profits are divided equally among the members of the supply chain) and the conventional decentralized setting. It can be seen that the profit formulas are part of a geometric series.

Table 3 Supply chain members' profits (decentralized setting)

Two-level supply chain (n=1)
$\Pi_R = \frac{(x-c)^2}{16y}$; $\Pi_{SU1} = \frac{(x-c)^2}{8y}$
Three-level supply chain (n=2)
$\Pi_R = \frac{(x-c)^2}{64y}$; $\Pi_{SU2} = \frac{(x-c)^2}{32y}$; $\Pi_{SU1} = \frac{(x-c)^2}{16y}$
Four-level supply chain (n=3)
$\Pi_R = \frac{(x-c)^2}{256y}$; $\Pi_{SU3} = \frac{(x-c)^2}{128y}$; $\Pi_{SU2} = \frac{(x-c)^2}{64y}$; $\Pi_{SU1} = \frac{(x-c)^2}{32y}$
Five-level supply chain (n=4)
$\Pi_R = \frac{(x-c)^2}{1024y}$; $\Pi_{SU4} = \frac{(x-c)^2}{512y}$; $\Pi_{SU3} = \frac{(x-c)^2}{256y}$; $\Pi_{SU2} = \frac{(x-c)^2}{128y}$; $\Pi_{SU1} = \frac{(x-c)^2}{64y}$

4 Modified revenue-sharing model

4.1. Division of profit

A new approach is introduced in this paper on the basis of the revenue-sharing type of coordination contract, which partly keeps one disadvantage of a decentralized setting (lower than the theoretically possible maximum profit) while ensuring some level of independence for the companies, and shifts to a centralized setting that ensures higher profit than in the decentralized setting. Although this setting is not perfect in terms of the profit maximization criteria, the division of profits can be fairer than in the pure revenue-sharing model from all members' points of view.

With the application of a revenue-sharing contract the total revenue of the retailer is divided among all the supply chain members. The α_i rates of the division depend on the bargaining power of the members. In this setting it is supposed that the individual marginal revenues of the members are equal to that of the centralized setting of the supply chain. With the revenue-sharing contract, maximum values of the chain members are determined on the basis of demand quantity (q).

The general formula of profit of the *i*th member is given in Eq. (6).

$$\Pi_i = \alpha_i R(q) + w_i q - (w_{i-1} + c_i)q = \alpha_i \Pi^* \quad (6)$$

where $\alpha_1 + \ldots + \alpha_i + \ldots + \alpha_n + \alpha_R = 1$.

With the revenue-sharing contract the members of the supply chain divide the profit depending on their negotiation powers, therefore the more dominant a member is the higher rate of profit it can earn. However, in a fair situation they can divide the profit equally. In a perfectly integrated chain this is easy to perform but in real life companies tend to consider their individual decentralized-setting profit as a basis level, even if they are aware of the fact that the profits of the members in a decentralized setting are below those of the centralized setting.

Keeping this behavior in mind, a consensus solution seems to be fair. Considering a two-member supply chain, for instance, where one supplier and one retailer are the members, the centralized profits are equal if α=0.5. The equal amount of profits is $\Pi^*/2$. In the decentralized setting the supplier's profit at α=0.5 is also $\Pi^*/2$ and the retailer's profit is $\Pi^*/4$ (Fig.3: Π_R, Π_{SU}).

To generalize the reallocation of profits the next logic can be suitable. The basis settings are the decentralized wholesale price-based profits and the revenue-sharing contract with equal profits. The latter represents a fair allocation. The consensus solution can be defined as the reallocation of profits in the following manner: let α be settled as the value that facilitates that the extra profits of all members in the centralized setting compared to their original decentralized profits be equal. Let $d(n+1)$ be the extra profit mentioned above, therefore d is the value of equal amount of each members' extra profit. The value of d is calculated generally (n members) by Eqs. (7-8).

$$(n+1)d = \Pi^* - \sum_i \Pi_i(\text{DSC}) \quad (7)$$

$$d = \frac{(x-c)^2}{y} \cdot \frac{2^{2n} - \sum_{i=0}^{n} 2^i}{(n+1)2^{2(n+1)}} \quad (8)$$

where Π^* is defined by Eq. (3) and Π_i is defined by Eq. (5).

Applying Eqs. (6) and (8), the new profit of a member can be calculated by the following formula, which contains the d equal amount of each members' extra profit.

$$\Pi_i' = \Pi_i + d = \alpha_i \Pi^* \quad (9)$$

This setting is illustrated in Fig.3 for a two-level supply chain: the differences between the equally divided profit and the profit earned by the use of wholesale prices in the decentralized model are not equal for the two members.

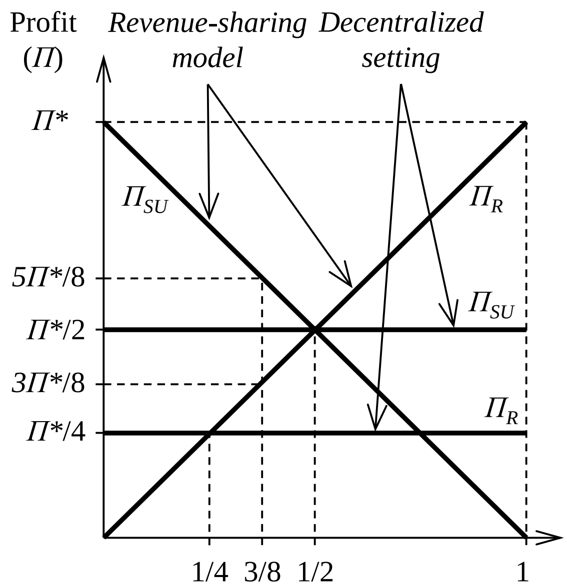

Fig.3 Illustration of the modified revenue-sharing model for two supply chain members (α: the retailer's revenue sharing rate)

If profits are divided equally according to the revenue-sharing setting, the supplier (*SU*) does not earn more profit than in decentralized setting and the retailer (*R*) earns double as much profit in the revenue-sharing setting than in the decentralized one. To avoid this unbalanced situation the differences can be set as equal, thereby the retailer earns 3/8 and the supplier earns 5/8 of the centralized supply chain profit (Π*) [27].

4.2. Analysis of a 5-member supply chain

The calculations of the decentralized profits and the profits of the modified model are illustrated in Table 4. The α_i rates are also included in the model. It can be seen that the farther a member is from the market the higher its rate from profit earned. This results from the characteristic of the basic model: the order of rates is the same in the decentralized setting, the differences between them are lower but not equal, which means that the proposed model is between the conventional wholesale price-based decentralized setting and the perfectly fair revenue.

Table 4 Supply chain members' profits according to the decentralized setting and the introduced approach

	Π_i	π_i'	α
RE	$\frac{(a-x)^2}{1024y}$	$\frac{49}{1024}\Pi^*$	$\frac{49}{1024}$
SU_4	$\frac{(a-x)^2}{512y}$	$\frac{53}{1024}\Pi^*$	$\frac{53}{1024}$
SU_3	$\frac{(a-x)^2}{256y}$	$\frac{61}{1024}\Pi^*$	$\frac{61}{1024}$
SU_2	$\frac{(a-x)^2}{128y}$	$\frac{77}{1024}\Pi^*$	$\frac{77}{1024}$
SU_1	$\frac{(a-x)^2}{64y}$	$\frac{109}{1024}\Pi^*$	$\frac{109}{1024}$

One-fifth of the surplus profit (equal reallocation) is given by:

$$d = \frac{(a-x)^2}{y}\frac{225}{5120} \quad (10)$$

In the decentralized setting the profit of the first supplier (SU_1), which is located the farthest from the end market, is 16 times higher than the profit of the retailer. With the introduced calculation the first supplier's profit is only 2.22 times higher, which means that the reallocation is more balanced than in the decentralized setting.

4.3. The problem of transfer pricing

Between the members of the supply chain a transfer price can be applied instead of a market price. In the centralized setting of the supply chain, due to its nature, the members can be considered as organizational units of a single enterprise in terms of the contract. This approach facilitates the use and analysis of the theoretical contract types.

If the members are considered as organizational units, the pricing and the consideration of unit costs can be managed as a cost allocation problem. The cost allocation as a problem first occurred in the second half of the 19th century. In the production of single products the direct costs were easily managed but with the increase of production complexity the consideration of indirect costs became necessary [28]. Cost allocation can lead to an advantageous behavior of the decision makers: it reminds them of the existence of overhead cost and the use of service centers [29]. Therefore a certain sense of responsibility can be formed for costs. However, the cost allocation can reflect the power of the organizational units, and the manner of allocation could be the 'playground' of the strong interest groups. This logic reflects the problem of cooperation between supply chain members, too. The transfer pricing acts similarly to the cost allocation mechanism.

Even if a healthy cooperation is realized between the supply chain members and a transfer price can be determined in this manner, legal regulations have precedence over the relative simplicity of cooperation. The OECD Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrations is a base document in transfer pricing [30]. Beyond this, national law also regulates transfer pricing. In order to plan a contract between supply chain members, not only the existing theoretical models but the legal background has to be considered. This makes the pricing more difficult.

5 Case study

In this example the Analytic Hierarchy Process is applied. The method is useful in many decision problems but it is recommended to consider the included decision factors. The method is simple to use; [31] gives a detailed description about the application process and its limitations.

The company is an automotive supplier (SU) and delivers forged raw material for its customer (R). The company has no competitor in the region; therefore it is a dominant member of the analyzed 2-member supply chain. The company is to sign a 3-year contract with a customer. The decision-maker was faced with the following problem. Three alternatives have to be chosen from. In the first the company earns all the profit of the integrated supply chain but the expected duration of the cooperation is short (half a year). The second option is based on the above introduced hybrid model; the company earns 5/8 of the total profit and the expected duration of the cooperation is 2 years. The third version is the idealistic case in which the company and its customer share the profit equally and the cooperation can last 3 years. The situation is illustrated in Fig.4. The decision factors are:

- T_1: Short-term profit (can be earned in 1 year).
- T_2: Expected duration of cooperation.
- T_3: Profit to be earned in the cooperation period.
- T_4: Effort of finding a new customer.

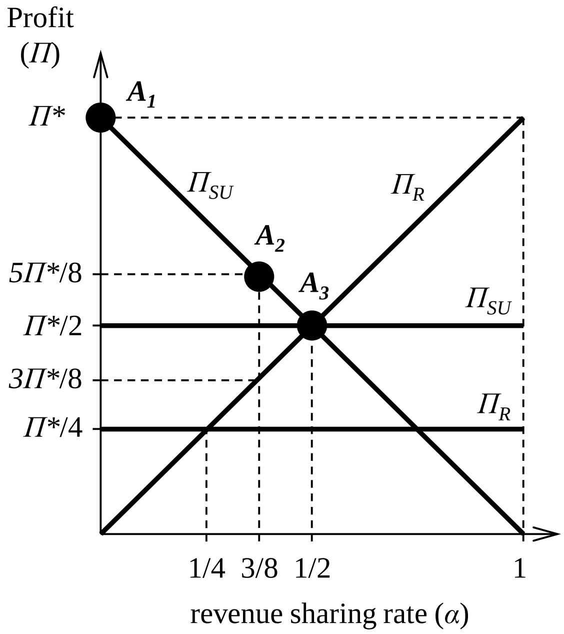

Fig.4 Illustration of the alternatives of the analyzed case

T_1 and T_2 are quantifiable decision factors and T_3 depends on these factors. The profit expectations connected to T_1 and T_3 are summarized in Table 5.

Table 5 Profits to be earned in the analyzed situation

Decision factors		Alternatives		
		A_1	A_2	A_3
T_1	One-year profit	Π^*	$\frac{5}{8}\Pi^*$	$\frac{1}{2}\Pi^*$
T_2	Expected duration of cooperation (year)	0.5	2	3
T_3	Profit that can be earned in the period of cooperation	$\frac{1}{2}\Pi^*$	$\frac{5}{4}\Pi^*$	$\frac{3}{2}\Pi^*$

The value of factor T_4 depends on the expected duration of cooperation, namely how many times a new customer needs to be found within the 3 years. The performance value of the first alternative is 6, that of the second alternative is 2 and in case of the third the contraction requires this effort from the company only once.

The decision problem is illustrated in Fig.5. There are highly dependent factors in the decision tree. This means that AHP can be applied only with the consideration of the connections, because decision factors in the AHP decision tree must be additive independent variables [32]. Considering T_1 and T_2 factors as dummy ones that help in the calculation of T_3 and T_4 factors, AHP method can be applied. Therefore only the latter two factors have to be weighted by the decision-maker.

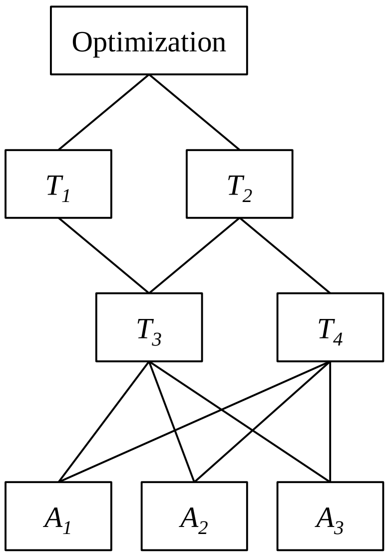

Fig.5 Decision tree of the analyzed case

The pairwise comparison matrices (**P**) of the alternatives on the basis of factor T_3 (Eq. (11)) and T_4 (Eq.(12)) and the weight vectors of the alternatives resulting from the matrices (Eqs. (13-14)) can be constructed:

$$\mathbf{P_{T3}} = \begin{bmatrix} 1 & 2/5 & 1/3 \\ 5/2 & 1 & 5/6 \\ 3 & 6/5 & 1 \end{bmatrix} \quad (11)$$

$$\mathbf{P_{T4}} = \begin{bmatrix} 1 & 1/3 & 1/6 \\ 3 & 1 & 1/2 \\ 6 & 2 & 1 \end{bmatrix} \quad (12)$$

$$\mathbf{w}_{\mathrm{T3}}^{\mathrm{T}} = [0.154 \quad 0.385 \quad 0.461] \quad (13)$$

$$\mathbf{w}_{\mathrm{T4}}^{\mathrm{T}} = [0.100 \quad 0.300 \quad 0.600]. \quad (14)$$

The effort of finding a new customer connects not only to the transaction costs but also determines the market reputation of the company (frequent changes mean an instable presence on the market). The employees and managers are also affected by extra work hours and efforts. However, the number of changes can be in proportion with these efforts. Applying the AHP method, the T_3 and T_4 factors have to be weighted by the decision maker (Eq. (15)):

$$\mathbf{w}_{\mathrm{T}}^{\mathrm{T}} = [0.95 \quad 0.05] \quad (13)$$

Once the decision problem is formulated, the ranking of the alternatives can be given by the aggregated sums of weights (S(A_i)). This is summarized in Table 6.

Table 6 Assessment of the alternatives

Alternatives	T_3	T_4	S(A_i)
	0.95	0.05	
A_1	0.154	0.100	0.151
A_2	0.385	0.300	0.381
A_3	0.461	0.600	0.468

The AHP calculation ranks the alternatives as: $A_3 \succ A_2 \succ A_1$. The relative performance (S(A_i)) of the second alternative is 80% of the third one. The rate of the first one compared to the third is 32%. This means that the first alternative, which reflects a strong short-term approach, is the worst among the analyzed alternatives. As suggested in the supply chain coordination model that applies revenue sharing rates, the equal division of the whole supply chain profit is the most advantageous for not only the dominated but also the dominant party (here: the supplier). The second alternative is between the other two but its position is closer to the third and best alternative.

6 Conclusions

The introduced model is based on the fact that strategic decision makers tend to operate the supply chain in a decentralized setting. Among other factors, revenue-sharing contract types can facilitate a more balanced and fair operation and profit allocation among the supply chain members. In regard to profit, the introduced model is between the conventional decentralized setting and the fair (equal profit allocation) revenue-sharing contract. With this balanced position the profit differences among the supply chain members decrease, while perfect equity is avoided. This is of high importance mainly for multinational companies because their transfer prices are influenced by both exchange rates and strict legal regulations.

In this paper a new model was developed in which the extra profit that could be earned by a fair revenue sharing contract compared to the decentralized wholesale price setting is divided among the supply chain members. With this reallocation the total profits of the members become closer to each other. In a five-level sequential supply chain the decentralized setting results in a 16-fold difference in the profit of the first and the last member of the chain. With the application of the introduced model this difference is reduced to 2.22.

A case study was described for a two-member supply chain in which the supplier is the dominant member. In the situation three alternatives were compared and assessed by a decision-maker. It can be stated that the alternative that simulated the new coordination setting introduced in this paper proved to be more useful (252% on the basis of AHP calculation) than the extreme alternative A_1 (all the supply chain profit is earned by the supplier) and only to a small extent worse (19%) than the alternative A_3 (equal division of the whole supply chain). The limitation of the model is that the legal factors of transfer pricing are not considered in it.

Future directions of the research can be the extension of the model to non-sequential networks and the in-depth consideration of other soft or behavioral factors of decision-making, i.e. what are the drivers behind avoiding more balanced communication and cooperation among supply chain members.

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References:
[1] Lan, Y., Li, Y, Papier, F., Competition and coordination in a three-tier supply chain with differentiated channels, *European Journal of Operational Research*, Vol.269, No.3, 2018, pp. 870–882.
[2] Rafiei, H., Safaei, F., Rabbani, M., Integrated production-distribution planning problem in a competition-based four-echelon supply chain, *Computers & Industrial Engineering*, Vol.19, 2018, pp. 85–99.
[3] Ma, P., Zhang, C., Hong, X. Xu, H., Pricing decisions for substitutable products with green manufacturing in a competitive supply chain, *Journal of Cleaner Production*, Vol.183, 2018, pp. 618–640.
[4] Luo, M., Li, G., Wan, C.L.J., Qu, R., Ji, P., Supply chain coordination with dual procurement sources via real-option contract, *Computers & Industrial Engineering*, Vol.80, 2015, pp. 274–283.
[5] Chakraborty, T., Shauhan, S.S., Vidyarthi, N., Coordination and competition in a common retailer channel: Wholesale price versus revenue-sharing mechanisms, *International Journal of Production Economics*, No.166, 2015, pp. 103–118.
[6] Erhun, F., Keskinocak, P., Game theory in business applications, Working Paper, *SiteSeer*, 2003, pp. 39–42.
[7] Chaab, J., Rasti-Barzoki, M., Cooperative advertising and pricing in a manufacturer-retailer supply chain with a general demand function; A game-theoretic approach, *Computers & Industrial Engineering*, No.99, 2016, pp. 112–123.
[8] Brusset, X., Agrell, P.J., Dynamic supply chain coordination games with repeated bargaining, *Computers & Industrial Engineering*, No.80, 2015, pp. 12–22.
[9] Arani, H.V., Rabbani, M., Rafiei, H., A revenue-sharing option contract toward coordination of supply chains, *International Journal of Production Economics*, No.178, 2016, pp. 42–56.
[10] Huang, Y-S., Hung, J-S., Ho, J-W., A study on information sharing for supply chains with multiple suppliers, *Computers & Industrial Engineering*, No.104, 2017, pp. 114–123.
[11] Proch, M., Worthmann, K., Schluchtermann, J., A negotiation-based algorithm to coordinate supplier development in decentralized supply chains, *European Journal of Operational Research*, No.256, 2017, pp. 412–429.
[12] Bányai T., Supply chain optimization of outsourced blending technologies. *Journal of Applied Economic Sciences*, Vol.12, No.4, 2017, pp. 960–976.
[13] Palsule-Desai, O.D., Supply chain coordination using revenue-dependent revenue sharing contracts, *Omega*, No.41, 2013, pp. 780–796.
[14] Sluis, S., De Giovanni, P., The selection of contracts in supply chains: An empirical

analysis, *Journal of Operations Management*, Vol.41, 2016, pp. 1–11.

[15] Zhao, J., Wei, J., The coordinating contracts for a fuzzy supply chain with effort and price dependent demand, *Applied Mathematical Modelling*, No.38, 2014, pp. 2476–2489.

[16] Heydari, J., Supply chain coordination using time-based temporary price discounts, *Computers & Industrial Engineering*, No.75, 2014, pp. 96–101.

[17] Luo, M., Li, G., Wan, C.L.J., Qu, R., Ji., P., Supply chain coordination with dual procurement sources via real-option contract, *Computers & Industrial Engineering*, No.80, 2015, pp. 274–283.

[18] Luo, J., Zhang, Q., Trade credit: A new mechanism to coordinate supply chain, *Operations Research Letters*, No.40, 2012, pp. 378–384.

[19] Geunes, J., Romeijn, H.E., van den Heuvel, W., Improving the efficiency of decentralized supply chains with fixed ordering costs, *European Journal of Operational Research*, No.252, 2016, pp. 815–828.

[20] Li, L., Lian Z., Choong, K.K., Liu, X., A quantity-flexibility contract with coordination, *International Journal of Production Economics*, No.179, 2016, pp. 273–284.

[21] Cai, J., Zhong, M., Shang, J., Huang, W., Coordinating VMI supply chain under yield uncertainty: Option contract, subsidy contract, and replenishment tactic, *International Journal of Production Economics*, No.185, 2017, pp. 196–210

[22] Krishnan, H., Winter, R.A., On The role of revenue-sharing contracts in supply chains, *Operations Research Letters*, 2010, pp. 1–4.

[23] Zhang, J., Liu, G., Zhang, Q., Bai, Z., Coordinating a supply chain for deteriorating items with a revenue sharing and cooperative investment contract, *Omega*, No.56, 2015, pp. 37–49.

[24] Dye, C-Y., Yang, C-T., A note on “Coordinating a supply chain for deteriorating items with a revenue sharing and cooperative investment contract”, *Omega*, No. 62, 2016, pp. 115–122.

[25] Krishnan, H., Winter, R.A., On the role of revenue-sharing contracts in supply chains, *Operations Research Letters*, No.39, 2011, pp. 28–31.

[26] Huang, Y-S., Hung, J-S., Ho, J-W., A study on information sharing for supply chains with multiple suppliers, *Computers & Industrial Engineering*, No.104, 2017, pp. 114–123.

[27] Molnar, V., Faludi, T., A supply chain coordination model with fair revenue-sharing rates, *Transformation of international economic relations: modern challenges, risks, opportunities and prospects – Collective monograph* (Ed. by Bezpartochnyi, M.), ISMA University: Riga, 2017, pp.119–129.

[28] Cooper, R., Kaplan, R.S., Measure Costs Right: Make the Right Decisions, *Harvard Business Review*, No.5, 1988. pp. 96–102.

[29] Musinszki, Z., Cost Allocation Problems and Solutions, *Controller Info*, No.4, 2015, pp. 2–10.

[30] OECD, OECD Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrations 2017, OECD Publishing, Paris, 2017.

[31] Saaty, T. L., Highlights and critical points in the theory and application of the Analytic Hierarchy Process, *European Journal of Operational Research*, Vol.74, 1994, pp. 426–447.

[32] Molnar, V., Horvath, D.D., Determination of Coefficients of Multi-Attribute Utility Function with Attribute Breakdown, Proceedings of the 12th International Conference on Strategic Management and its Support by Information Systems, 2017, pp. 312–319.