CHARACTERISTICS OF THE GREEN SUPPLY CHAIN COORDINATION: THEORETICAL CONTRIBUTION TO USE THE WHOLESALE PRICING CONTRACT IN THE GREEN SUPPLY CHAIN

Tamas Faludi
Institute of Management, Science Faculty of Economics, University of Miskolc, Miskolc, Hungary
szvft@uni-miskolc.hu

Abstract: *Because of the eco-consciousness and the environmental protection companies become 'green', therefore many green supply chains are realized in the business sphere. Companies of green supply chain take care on the environmental protection. These companies try to decrease the pollution, so they implement some eco-conscious processes. The green supply chains contain these companies. The biggest problem is the coordination of these chains. Nowadays, supply chains have many members, so the cooperation is getting more and more difficult. It could be a potential good solution, if the chain members use the different contract types to coordinate the chain. Contract tries to handle the inequality between the chain members and gives a framework to the cooperation of chain members. This paper introduces the wholesale pricing contract, which can be used in the case of green supply chain and its different settings effectively. The wholesale pricing contract is one of the traditional contract types but it produces different performance in the case of centralized and decentralized setting. Centralized setting has a chain leader – this member operates and coordinates the whole chain and defines common goals for the members. In decentralized setting the members define their own goals and they act in accordance with their own interest. A simulation with numerical example is also included to represent the difference between the two settings.*

Keywords: Supply Chain Coordination, Contract Types, Green Supply Chain Management, Wholesale Pricing.

JEL classification: D21, L11, L14, M10.

1. Eco-consciousness and the supply chains in the 21st century

The eco-consciousness is an expanding subject both in the civil and the business sphere. Nowadays, this is a very important issue, because humanity has to stop or at least decrease the pollution of the Earth.

Companies can implement eco-conscious processes for example into the manufacturing or the distributing system. But it does not matter how much the cost of the implementation of these processes. Some companies would not like to – or simply just cannot – carry extra costs. However, more and more companies have the willingness to invest in favour of the environmental protection. These investments make the companies to be green. Not only the companies can be green, but also the supply chains – if a supply chain or network contains only green companies, it is called green supply chain.

In the 21st century, the numbers of green supply chains are increasing and the growing trend within the chain is realized as well. Many other partners (suppliers, logistics companies, etc.) join to the chains, so the coordination is getting more difficult.

Therefore this paper is based on the coordination of green supply chain with the help of one of the most popular contract type – the wholesale pricing contract. A numerical example represents the efficiency of this type.

2. Characteristics of green supply chains

The first concept of green supply chain and the question of eco-consciousness were appeared in the ’60s and the ’70s. In later years the conception of eco-consciousness was the mixture of the early conception of supply chain management and the environmental management. Both disciplines converged to each other and when the inverse logistics was appeared on the scene, they have been merged (Miskolcziné, 2017).

Due to the merger and development of the supply chain management and the environmental management, in the beginning of the 2000s, it was called environmentally conscious supply chain management (ESCM) by Zsidisin and Siferd (2001). The goals of the ESCM were to create some measures to defend the environment. According to Beamon’s (2005) theory, this approach was not enough – all of the products and processes of the companies must have environmental feature as far as possible; it does not matter if the effects of these are indirect or direct.

In the year of 2008, Carter and Rogers had a publication about the sustainable supply chain management (SSCM). It was the second step of the evolution of green supply chains. According to Carter and Rogers, the sustainable supply chain management also prefers the profitability; therefore, the profitability has to be combined with the social and the environmental criteria. Harms (2011) defined the helping areas to the implementation of Carter and Rogers’ theory (Figure 1).

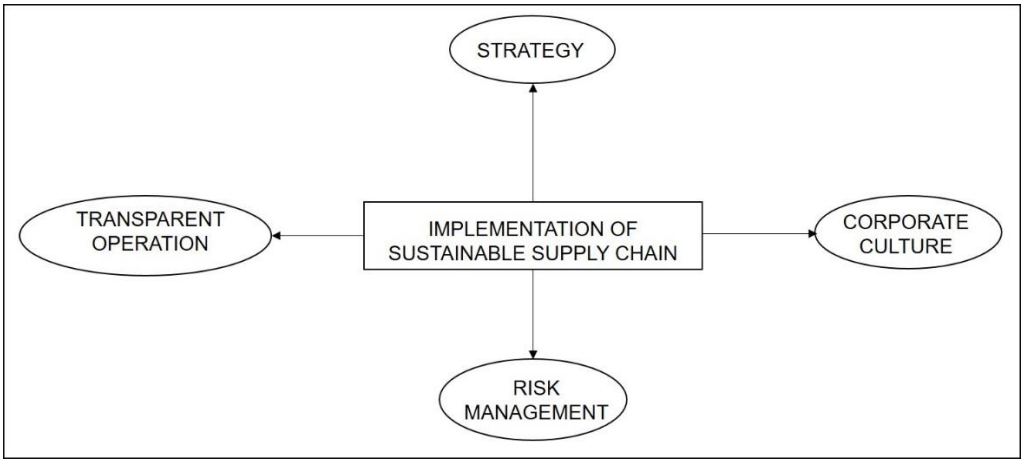

Figure 1: Conditions of the sustainable supply chain
Source: Own construction by Harms (2011)

The eco-consciousness management had a widespread name which is also used nowadays – it is called green supply chain management. Miskolcziné (2017) distinguishes two main approaches:

- one defines the methodologies, tools to reach the eco-conscious goals;
- second defines the processes and activities of the green supply chain management (Miskolcziné, 2017).

So, it means that first of all company has to define the eco-conscious goals. To reach these goals, the methodologies and tools has to be also determined. These methodologies and tools must be used in some basic business processes and activities. Consequently, this process is the condition of the green supply chain management (Figure 2).

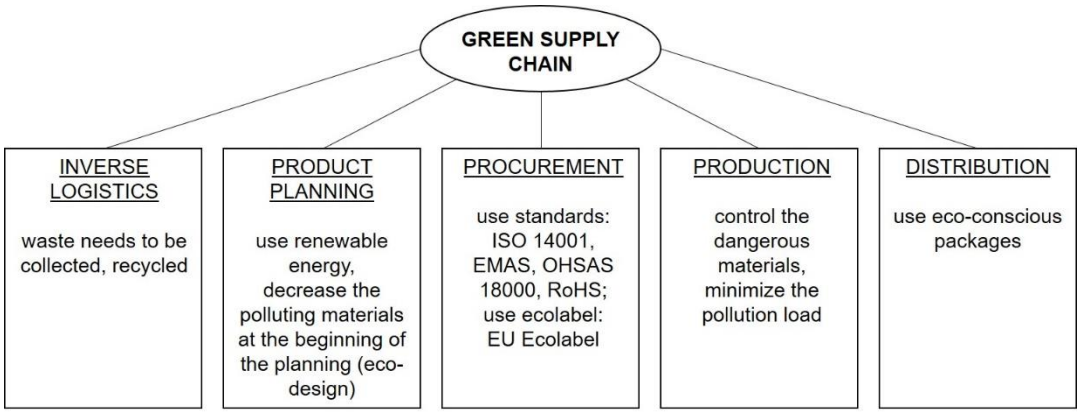

Figure 2: Conditions of the green supply chain
Source: own construction by Miskolcziné (2017) & Kovács et al. (2018) & Bándi (2014)

In the case of green supply chains, the processes of the logistics, the product planning, the procurement, the production and distribution need to be eco-friendly, too. There are many 'green' choices to use to these areas, for example the totally recycling processes, the ecolabels, and the eco-conscious packages.
The closing of chain is the first step to be green the chain (Figure 3). The goal of the closed-loop chain is to collect and recycle things which are defined worthless by the costumers or the partners – for example defective products, packages, or some components. After the recycling, the company can resell them (Guide & van Wassenhove, 2008).

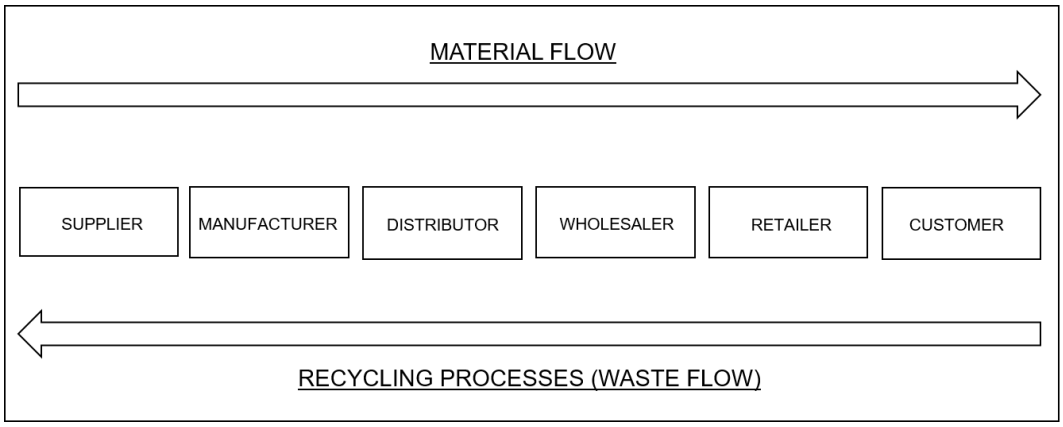

Figure 3: The closed-loop supply chain
Source: Own construction by Gaur et al. (2017)

The closed-loop supply chain needs the chain members to integrate the recycling processes into their corporate operations. At the end of the chain, the customer also has the responsibility for the closed-loop chain. One possible solution, if customer reuses the products.
The distributors can recycle the used packages. With this process, they help to close the chain.
The retailers' and the wholesalers' recycling process can be combined with the 'milk-run'. Milk-run is an optimization process, used by the supply chain management. The goal is to

reduce the shipping charges by using a delivery schedule. The order of the stations is determined. If they unload the package at the station, they can load and deliver the wastes (for example some recyclable bottles) as well. With this process the company can reduce the unit cost of the transportation – the vehicle will be never empty, and the wastes will be recycled.
The wastes of the manufacturers can be remanufactured. For example, plastic wastes can be prepared in granule form again, if the company grinds the plastic wastes, and the company reuses it or sell to a partner to further manufacturing processes. Unfortunately, this could not be a choice for every company. If the company is not able to reuse or resell the wastes, it can use the landfill to handle their wastes.
Thus, if companies use some recycling process, the pollution can be reduced and the profit can be realized at the same time.

3. Supply chain coordination by contracts – literature review

Coordination of the supply chains is getting a very important research topic regarding to both of the green and the traditional supply chains. The new trend is the expanding of supply chains. The cause of this phenomenon is the increasing number of the cooperating partners within the chains.
Supply chain management suggests two groups to coordinate the chain – hard factory and soft factors can be used. The hard factors, especially the contracts are included by much recent researches.
As a hard factor, contracts can coordinate the supply chain, because contracts try to handle the inequality between the chain members, it derives from the different levels of dominance which is appeared in the chain. If a chain member is more dominant than the others, it can provide better conditions in favour of itself – but it can be the source of many conflicts. Contracts try to cease the differences and decrease the number of the conflicts. Contracts provide a framework for cooperation; they show how partners share risks and benefits under uncertain supply or demand (Coltman, et al., 2009).
Several authors analyse the coordination-power of different types, make numerical examples to determine the advantages and disadvantages of using. There are traditional contracts – for example the wholesale pricing contract, but some authors try to mix for example some traditional contracts to create some hybrid or extremely complex types, because these solutions can be relevant to the coordination issue (Katok & Pavlov, 2013; Zhang et al., 2013).
This paper would like to introduce one of the typically contracts which can be used in the case of green supply chains as well. An important question is the settings of supply chains, because it can influence the performance.
Centralized setting is preferred by the literature, because in this case, there is a decision maker, who controls, manages the whole supply chain and maximizes the total profit of the whole supply chain (Giannoccaro, 2018).
In case of decentralized setting, the chain members do not strive for the effective cooperation, because they act in accordance with their own interest. It means that the total profit can be less. Thus, the cooperation, the information-sharing mechanisms and so the effectiveness won't be satisfactory.
According to the researcher's opinions, the centralized setting is preferred in a classic supply chain. The question is the following: is it a correct statement in the case of a green supply chain or not?

4. Numerical example with the wholesale pricing

My analysis is based on the literature reviews, case studies, and some numerical examples and it contains fictive data. The aim of this numerical example is to represent the differences between the two settings of green supply chain. So, this is theoretical contribution with a simulation of a simple green supply chain with two members – the supplier and the manufacturer.

The analysis compares the total profit, the individual profit, the market price, the unit price and the quantity sold in the case of each setting both of centralized and decentralized settings. By the help of these values some conclusions could be drawn in relation of the performance of different settings.

The comparison is based on a simple green supply chain model with two members (Fig. 4).

Figure 4: The simple green supply chain model
Source: own construction

Table 1 summarizes the notations applied in the model.

Table 1: Notations

SYMBOL	DESCRIPTION
i	Constant
u	Constant
P_{market}	market price
P_{unit}	unit price
Q	quantity sold
C_{sup}	cost of supplier
C_{man}	cost of manufacturer
$\sum C$	total cost of the members
$\sum \Pi$	total profit
Π_{SUP}	individual profit (supplier)
Π_{MAN}	individual profit (manufacturer)

Source: own construction

The economic parameters of the calculation are shown by the Table 2.

Table 2: Economic parameters of the calculation

Parameter	Value
i	160
u	2,25
P_{market}	160 – 2,25Q
C_{sup}	55
C_{man}	40

Source: Own construction

The market price (P_{market}) is calculated by the simplified market demand function which contains the market constants (i, u) and the quantity sold (Q). The model's assumption is the members are aware of the information about the market demand.
There are differences between the calculations of factors about each supply chain settings. The Equation (1), (2), and (3) show the total profit, the quantity sold, the unit price, if the partners use wholesale pricing contract in case of centralized supply chain. Model's assumption the members share the total profit equally.
Equation (3) derives from the equal sharing mechanism of the total profit.

$$\mathrm{CEN};\ \sum\Pi = (\mathrm{i} - \mathrm{uQ} - \sum\mathrm{C})\mathrm{Q} = (\mathrm{P_{market}} - \sum\mathrm{C})\mathrm{Q} \tag{1}$$

(2)

$$\frac{\partial \mathrm{CEN};\ \sum\Pi}{\partial \mathrm{CEN};\ \mathrm{Q}} = 0 \quad \rightarrow \mathrm{CEN};\ \mathrm{Q} = \frac{\mathrm{i} - \sum\mathrm{C}}{2\mathrm{u}}$$

$$\mathrm{CEN};\ \Pi_{\mathrm{SUP}} = \mathrm{CEN};\ \Pi_{\mathrm{MAN}} \ \rightarrow\ \mathrm{CEN};\ \mathrm{P_{unit}} = \frac{\mathrm{P_{market}} - \mathrm{C_{man}} + \mathrm{C_{sup}}}{2} \tag{3}$$

Equation (2) is expressed from the Equation (1), because of the profit-maximization criteria – it is based on the market demand. It means if the partial derivative form of the total profit (Equation (1)) is equal to zero, the quantity can be expressed, and the Equation (2) is true.
With the help of the Equation (4) and (5) the individual profits can be determined.

$$\mathrm{CEN};\ \Pi_{\mathrm{SUP}} = \left(\mathrm{P_{unit}} - \mathrm{C_{sup}}\right)\mathrm{Q} = \left(\mathrm{P_{unit}} - \mathrm{C_{sup}}\right)\frac{\mathrm{i} - \sum\mathrm{C}}{2\mathrm{u}} \tag{4}$$

$$\mathrm{CEN};\ \Pi_{\mathrm{MAN}} = (\mathrm{P_{market}} - \mathrm{P_{unit}} - \mathrm{C_{man}})\mathrm{Q} = (\mathrm{P_{market}} - \mathrm{P_{unit}} - \mathrm{C_{man}})\frac{\mathrm{i} - \sum\mathrm{C}}{2\mathrm{u}} \tag{5}$$

It must be also used the Equation (2) to calculate the individual profits, because it needs to know the sold quantity. As the Figure 3 shows, the supplier gets the unit price from the manufacturer as an income, but his profit is decreased by his costs.
In the case of the manufacturer, his income is the market price, the decreasing factors are the unit price – which is paid to the supplier for the ordered quantity – and his own costs.
The factors are influenced by the quantity sold.
The (6), (7), (8), (9) and (10) equations calculate the previously represented values, but in this case the supply chain is decentralized.

$$\mathrm{DEC};\sum\Pi = \frac{3(\mathrm{i} - \sum\mathrm{C})^2}{16\mathrm{u}} \tag{6}$$

$$\frac{\partial \mathrm{DEC};\ \Pi_{\mathrm{MAN}}}{\partial \mathrm{DEC};\mathrm{Q}} = 0 \ \rightarrow\ \mathrm{DEC};\mathrm{Q} = \frac{\mathrm{i} - \mathrm{P_{unit}} - \mathrm{C_{man}}}{2\mathrm{u}} \tag{7}$$

$$\frac{\partial \mathrm{DEC};\ \Pi_{\mathrm{SUP}}}{\partial \mathrm{DEC};\ \mathrm{P_{unit}}} = 0 \quad \rightarrow\ \mathrm{DEC};\ \mathrm{P_{unit}} = \frac{\mathrm{i} - \mathrm{C_{man}} + \mathrm{C_{sup}}}{2} \tag{8}$$

$$\mathrm{DEC};\ \Pi_{\mathrm{SUP}} = \left(\mathrm{P_{unit}} - \mathrm{C_{sup}}\right)\mathrm{Q} = \frac{(\mathrm{i} - \sum\mathrm{C})^2}{8\mathrm{u}} \tag{9}$$

$$\mathrm{DEC};\ \Pi_{\mathrm{MAN}} = (\mathrm{P_{market}} - \mathrm{P_{unit}} - \mathrm{C_{man}})\mathrm{Q} = \frac{(\mathrm{i} - \sum\mathrm{C})^2}{16\mathrm{u}} \tag{10}$$

Equation (7) is expressed by the partial derivative form of the manufacturer's individual profit (10). The manufacturer must maximize his profit by the quantity sold because of the profit-maximizing criteria. Also for this reason Equation (8), the unit price derives from the supplier's profit (Equation (9)). Supplier of the decentralized setting maximizes the profit by the unit price.
The Equation (9) and (10) can be determined, if the constants and the costs – all of which describes the market demand – are used to the calculation.
Table 3 summarizes the results of applying the formulas and data of Table 1.

Table 3: Results

		WHOLESALE PRICING CONTRACT	
		Centralized setting	**Decentralized setting**
Q	100 pcs	14,44	7,22
$\mathbf{P_{market}}$	EUR	127,5	143,75
$\mathbf{P_{unit}}$	EUR	71,25	87,5
$\mathbf{\Pi_{SUP}}$	100 EUR	234,65	234,72
$\mathbf{\Pi_{MAN}}$	100 EUR	234,65	117,36
$\mathbf{\sum\Pi}$	100 EUR	469,44	352,08

Source: Own construction

As shown by the table, the centralized setting gives higher performance than the decentralized setting. The total profit of the whole supply chain is much higher, so the individual profit – in the case of the manufacturer – is also can be higher. Profit of the supplier is almost equally in both settings, there is no big difference between the values. Market and unit prices are also better; less than in the decentralized setting. Because of these prices members and costumers are interested in to buy larger quantity of product.
Results show the advantages of the centralized setting. In the long term, this setting can be profitable to the chain members, and of course to the whole chain.
The difference between the classic and green supply chain is the eco-consciousness. Increasing costs may be caused by the changes based on the eco-consciousness. So these costs can be influence the contracts, they can change the factors, and also the weights of the factors. For example, a green product can be more expensive, and it can influence the market price in the case of both contract types. The prices also can be determined by the quality of the green product and the degree of environmental impact. Therefore, the companies have to clarify the aspects of environmental protection, because green companies prioritise the reducing the environmental impact of their products or services even at the increasing costs.

5. Conclusions

There are no big differences between the behaviour of members whether in the traditional or in the green supply chains. The goal of both members in each case is to maximize the profit and reduce the costs at the same time. But the members of green supply chain have willingness to make investments and incur additional expenses to have eco-friendly processes. Many companies have saved capital to make the eco-consciousness investments. These companies are not price-sensitive ones. The quality of the product is more important than its price. However, in the traditional supply chain the price and the quality usually have the same importance, the same weights. Thanks to the centralized setting the cooperation helps to improve the quality of the green products. Therefore, centralized setting is recommended to the green supply chain as well.

In the case of decentralized setting the members' acting in their own interests, so there is only a minimal level of cooperation. It causes the problem – for example – if one member uses eco-consciousness manufacturing processes but other members do not. It is in the way of the existing of green supply chain. Another problem when the information is not available about the demand.
Therefore, the effective solution is the centralized setting whether the chain is green or not, but in the case of green supply chains the centralized setting is more important than in other cases. The numerical example shows the value-differences between the settings in proportion to the decentralized setting (Table 4).

Table 4: Differences between the settings of supply chain

$\underline{Q}$			$\underline{P_{market}}$			$\underline{P_{unit}}$			$\underline{\sum \Pi}$		
CEN	200% >	DEC	CEN	89% <	DEC	CEN	81% <	DEC	CEN	133% >	DEC

Source: own construction

As Table 4 shows in decentralized setting companies can sell 50% less quantity of products – or double the quantity of products can be sold in the centralized supply chain, because the profit maximizing variable is the quantity sold – based on the market demand – in the centralized setting. The prices are lower in centralized setting than decentralized setting, because the profit maximizing variable is the unit price in the decentralized setting – 11% and 19% less are the market and the unit price. Thus, the total profit can be higher in the case of centralized supply chain.
In the case of green supply chain, the quality and the quantity of products are more emphasized and the prices are not strong influencing factors. Based on the results decentralized setting is appropriate for the green companies and the green supply chain as well. But decentralized setting is not high-level cooperation system, therefore members lose many information and with this the quality and the eco-friendliness of green products can be reduced which leads into dissatisfaction.
Basically, the centralized setting is recommended to every type of supply chain, including the green companies and green supply chains. With the help of the high-level cooperation, the coordinated strategies companies in the chain can be green easily; therefore, the whole chain can be green more easily.
The wholesale pricing contract can coordinate the chain very well, if the chain operates as a centralized supply chain. The simulation introduces a simple green supply chain model. The calculations include the standard factors; by the help of these factors the performance of the chain can be determined and the different settings become comparable.

6. Final discussion

Nowadays a very important question in both of the green and the traditional supply chain management is how the efficiency of supply chain coordination can be improved. In case of the green supply chain this topic is getting be more relevant, because there are more and more green supply chains. Soft and hard factors can be applied to coordinate the chain. The second group, namely the contracts can be a good solution according to the literature. One relatively frequent contract type was analysed in two different settings of supply chain. The difference between the centralized and decentralized green supply chain were demonstrated with the help of a simulation. As the results show the centralized setting of green supply chain becomes more efficient. It is very important to develop a more efficient cooperation – with better communication and trust the right level of cooperation can be reached. If the managers are able to change their attitudes and they prefer the long-term

cooperation, the supply chains can shift from the decentralized setting to the centralized setting.

The model has limitations. It does not quantify relevant values and weights in green supply chains, such as price and quality of products. Further research can be focused on how the different weights influence the company's decision makers – is it worth to be green or not – and also the performance of centralized or decentralized green supply chains, so it is recommended to use these additional variables in order to make the analyses more realistic. The simulation is based on two partners' relation; results can be improved, if the analysed green supply chain has more members.

References

Bándi, Gy., 2014. *Környezetjog*, Budapest: Szent István Társulat.

Beamon, B. M., 2005. Environmental and Sustainability Ethics in Supply Chain Management. *Science and Engineering Ethics,* 11 (2), pp. 221-234.

Carter, C. R., Rogers, D. S., 2008. A framework of sustainable supply chain management: Moving toward new theory. *International Journal of Physical Distribution & Logistics Management,* 38 (5), pp. 360-387, https://doi.org/10.1108/09600030810882816.

Coltman, T., Bru, K., Perm-Ajchariyawong, N., Devinney, T. M., Benito, G. R., 2009. Supply Chain Contract Evolution. *GR, European Management Journal*, 27 (6), pp. 388-401.

Gaur, J., Subramoniam, R., Govindan, K., Huisingh, D., 2017. Closed-loop supply chain management: From conceptual to an action-oriented framework on core acquisition. *Journal of Cleaner Production*, 167 (20), pp. 1415-1424.

Giannoccaro, I., 2018. Centralized vs. decentralized supply chains: The importance of decision maker's cognitive ability and resistance to change. *Industrial Marketing Management*, 73, pp. 59-69., https://doi.org/10.1016/j.indmarman.2018.01.034.

Guide, V. D. R., van Wassenhove, L. N., 2008. The evolution of closed-loop supply chain research. *Faculty & Research Working Paper*, INSEAD, Fontainebleu.

Harms, D., 2011. Environmental Sustainability and Supply Chain Management – A Framework of Cross-Functional Integration and Knowledge Transfer. *Journal of Environmental Sustainability*, 1 (1), pp. 1-23., https://doi.org/10.14448/jes.01.0009.

Katok, E., Pavlov, V., 2013. Fairness in Supply Chain contracts: A laboratory study. *Journal of Operations Management*, 31 (3), pp. 129-137., https://doi.org/10.1016/j.jom.2013.01.001

Kovács, L., Pónusz, M., Kozma, T., 2018. A zöld beszerzés stratégiai jelentősége. *Együttműködési láncok, Hatékonyság és IT, Logisztikai trendek és legjobb gyakorlatok IV*. évf. 1. szám, május, pp. 28-32.

Miskolcziné, G. M., 2017. *Zöld ellátási lánc menedzsment átfogó vizsgálata a hazai közúti gépjárműiparban*, Doktori (PhD) értekezés, Gödöllő: Szent István Egyetem,.

Zhang, Q., Dong, M., Luo, J., Sergerstedt, A., 2013. Supply chain coordination with trade credit and quantity discount incorporating default risk. *International Journal of Production Economics*, 153, pp. 352-360., https://doi.org/10.1016/j.ijpe.2014.03.019.

Zsidisin, G. A., Siferd, S. P., 2001. Environmental purchasing: A framework for theory development. *European Journal of Purchasing & Supply Management* 2001/7, pp. 61-73.

Bio-note

Faludi, is a *PhD student* at the *University of Miskolc, Faculty of Economics, Institute of Management Science* and member of the several research teams developed within the projects implemented by the Faculty. Faludi's research topic is focused on the supply chain coordination, especially the coordination with the help of different contract types.