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GREEN SUPPLY CHAIN AWARENESS IN THE HUNGARIAN AUTOMOTIVE INDUSTRY

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Abstract: The integration of the disciplines of both the green operation and the complex supply chain (including purchasing, production and logistics) came into focus in the 1990s. In the literature review the focus of the researchers of this cross-sectional field was the automotive industry. It seems obvious that these closely-knit systems with high OEM dominance will offer more concrete results: it is difficult to resist when a given OEM starts to involve its first-, second- and third tier suppliers into its environmental schemes and processes. The Hungarian automotive sector can be characterized as somewhat one-sided: it consists of by few large international OEM's (Audi, Mercedes-Benz, Opel, Suzuki, Raba), but by a large number of small-medium enterprises as 3rd (or even 4th!) tier suppliers. The aim of the paper was to find out whether companies acting as a member of more advanced chains show also better results in their "green" supply-chain-behavior. As a study description, in our empirical research, we have created a toolkit, and examined whether companies, which are using more sophisticated inter-organizational cooperation-tools, are more environmentally cautious, and if yes to what extent. As a result, discussion it can be stated that companies with a higher developed traditional Supply Chain have also a more developed green supply chain management system.

Key words: supply chain management (SCM), green supply chain management (GSCM), automotive industry

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Introduction

As the impact of human activities on the environment is causing severe issues around the globe, economic activities are increasingly considering environmental aspects. Researchers think that environmentally conscious/sustainable operation may give companies a competitive edge. Technical literature suggests that strategic goals cannot be achieved efficiently enough merely through inter-organizational measures (e.g. by introducing an environmental management system). Operating our systems together with additional "shared values" along the entire inter-organizational value chain, taking advantage of chain synergies is much more efficient and effective. The idea of environmentally conscious (green) supply chain management first began to take root in technical literature in the early 1970s. Our own research discipline – supply chain management – started to gain more and

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more attention in the 1980s. The integration of the two disciplines – (green) operation over the complex supply chain (including purchasing, production and logistics) came into focus in the 1990s. Economic organizations had to adapt and were even becoming more and more proactive, starting to look for potential synergies. Scientific research in the field (scientific theories, empirical research, modelling) started to be conducted around the turn of the century.

Literature Review

"Green Supply Chain Management" is the most accepted term in technical literature for the idea of supply chain management that considers environmental aspects. Researchers in the field of Green Supply Chain Management (GSCM) approach the subject from two perspectives. One group of researchers (e.g. Shuvang et al., 2003; Srivastava, 2008; Che, 2010; Sarkis et al., 2011) define the aim of GSCM (minimization of loss and waste, more environmental-friendly products or improvement of competitiveness). The other group of researchers (e.g. Hervani et al., 2005; and Kalenoja et al., 2011) determine the activities and fields within GSCM, thus defining the idea of GSCM (green product design, green purchasing, green manufacturing, and green logistics). The term environmental or environmentally conscious supply chain management (ESCM or ECSCM), which can be found in the works of Zsidisin and Siferd (2001) or Beamon (2005), for example, is basically the equivalent of GSCM regarding its content. The concept of sustainable SCM (SSCM) is broader than GSCM, and takes social aspects into consideration besides environmental ones (see e.g. Carter and Rogers, 2008; Dakov and Novkov, 2008; Harms, 2011). The main direction of green supply chain management research is determining the fields of application and examining the applied management methods and techniques. The fields of GSCM relate to the individual stages of the supply chain and are the "green" equivalents of the field of inter-organizational supply chain management. Each area has its own set of tools facilitating environmentally conscious operation. In addition to these, there are general principles that cannot be clearly associated with any given area but can be classified as management methods by their nature. In accordance with the previous results found in technical literature, we applied four areas and one general management principle in our research:

Green design, eco-design - The goal of the area is to reduce the extent of environmental strain generated throughout the entire lifecycle of the product, while keeping the original characteristics of the product intact (performance, cost). Its most important tools are neutralizing the materials harmful for the environment, recyclability and the implementation of efficient use of materials and energy in the new product (see e.g. Dakov and Novkov, 2008; Srivastava, 2008; Zhu et al., 2008; Wooi and Zailani, 2010; Eltayeb et al., 2011; Kim and Rhee, 2012; Kumar et al., 2012; Lin, 2013).

Green purchasing - Its interpretation in technical literature is fairly unanimous, according to which the purpose of green purchasing is to provide the company with

raw materials that are favorable from an environmental point of view (see e.g. Eltayeb et al., 2011; Chen et al., 2012; Chan et al., 2012). Cooperation with the suppliers is also emphasized. It's most important activities include environmental certification of suppliers, requiring suppliers to perform activities and produce documents guaranteeing appropriate performance, and also the support and development of suppliers.

Green manufacturing - The purpose of green manufacturing is to improve the existing manufacturing procedures, in order to reduce emissions of harmful substances. Most scholars cite this as an independent GSCM field (e.g. Dakov and Novkov, 2008; Srivastava, 2008; Chen et al., 2012; Kim and Rhee, 2012; Kumar et al., 2012). Green manufacturing is most often aimed at reducing consumption of materials and energy, controlling harmful substances and integrating the various forms of recycling.

Green logistics - The two main areas of green logistics are green distribution, which aims to reduce the environmental impact of packaging and transportation, and inverse logistics, which is necessary for the creation of a closed-loop supply chain. These activities are included in almost all sources dealing with this subject (see e.g. Dakov and Novkov, 2008; Srivastava, 2008; Wooi and Zailani, 2010; Eltayeb et al., 2011; Kim and Rhee, 2012).

Investment recovery - This management principle means the sales of superfluous tools (stocks, production equipment, waste), and the improvement of asset utilization. Besides the financial benefits, these methods also have a positive impact on the environment, which is cited for example in the works of Zhu et al. (2008) and Chen et al. (2012).

According to a survey on the Hungarian automotive industry, the trends of Hungarian supplier networks tend to follow the global trends, which means multi-layered (3-4 layers) networks "dominated" by international primary supplier companies. Hungarian companies tend to figure as second-, third- or even lower supplier levels. Hungarian researchers of the field have unveiled significant discrepancies among the members in the automotive supply chain, which is summarized in Figure 1. Among the discovered discrepancies, close cooperation, the management of the supplier network and innovative ability are important from the point of view of the subject at hand, as they are related to the development levels of SCM and GSCM.

Research Methodology

The most important question of the research was whether the development of the traditional supply chain management at the studied companies was in correlation with the development of green supply chain management. According to our hypothesis, the more developed a company's traditional supply chain management system is, the more developed its green supply chain management will be. We stipulated, therefore, that the closer the cooperation is among the partners within

the given supply chain, the more likely the members of the chain are to use GSCM methods as well.

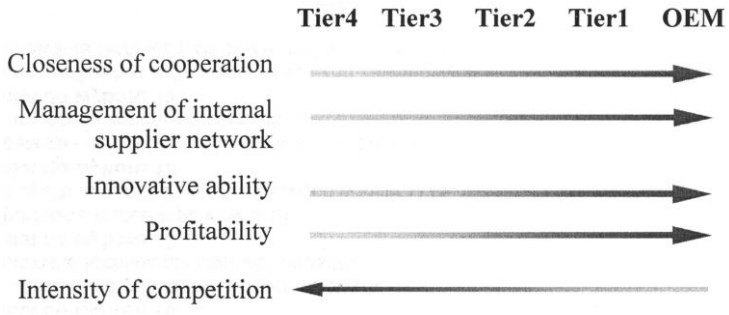

Figure 1. Discrepancies among the supplier levels in the automotive industry supply chain

The hypothesis was tested using a questionnaire-based survey. A part of the questions concerned the traditional supply chain management activities of companies, while the rest of the questions involved the application of the various fields and methods of green supply chain management.

From the toolkit of traditional supply chain management, we studied the effects of cooperation among the members of the supply chain and supplier-customer relationships. The top SCM fields studied are: a) information sharing among the members of the supply chain (5 sub questions), b) forms of cooperation – mutual decision-making, planning, work groups (5 sub questions), c) investment into the partnership (3 sub questions) and d) commitment to partnership (5 sub questions).

Respondents were asked to check one of the three options below:

I don't use the SCM method at all
I only use the SCM method with key partners
I use the SCM method with multiple partners

In studying GSCM activity, we surveyed the areas listed in the Literature review. The areas included in the questionnaire are the following: a) Green design (3 methods), b.) Green purchasing (10 methods), c) Green manufacturing (4 methods), d) Green logistics (5 methods) and e) Investment recovery (3 methods). Here are the answer choices and their related scores:

I don't use it and I don't plan to	*0*
I don't use it but I plan to	*1*
Under launch/implementation	*2*
I have used it for less than 1 year	*3*
I have used it for more than 1 year	*4*

We used a development indicator to evaluate the development level of GSCM areas, which was determined as the arithmetic average of the scores corresponding to the responses related to the methods applied in a given area. The development

indicator is thus measured on a scale between zero and four. The higher the indicator, the more developed the given GSCM area will deemed to be at the respondent company. We grouped the companies into categories based on the answers given to each of the SCM questions, then used variance analysis to compare the GSCM-intensity of groups created based on SCM activity. The analysis was prepared using LSD and Games-Hoewll post-hoc tests.

The subjects of the primary research were automotive manufacturers operating in Hungary and their suppliers. The research questionnaire was sent to 350 companies belonging to the above-mentioned target group between July 2014 and November 2015. We received 75 questionnaires back, out of which 72 were properly filled and appropriate for statistical processing. This accounts for a 21% response rate out of 350 companies contacted. 66.7% of the companies contacted are Hungarian, while 33.3% are of foreign majority ownership. Regarding staff numbers, the sample companies include small, medium and large enterprises: 22 companies (30.6%) employ 50 persons or fewer, 25 companies (34.7%) have a staff of between 51-250 employees, and 25 companies (34.7%) are large enterprises with over 250 employees.

Results Discussion

According to the results of the variance analysis, 45 out of the 90 SCM "Method – GSCM" area *pairs*, i.e. in 50% of the cases, there is significant discrepancy in "GSCM intensity" among the groups we have created on SCM methods. Table 1 shows the *pairs* where this difference was demonstrable with a 95% confidence level.

According to the table, significant discrepancy between the intensity of GSCM methods in groups created based on SCM is most often detected in the area of *green purchasing* out of the different GSCM areas: it affects 14 out 18 SCM methods. The post hoc tests show that the more intensive use of SCM methods correspond to a higher intensity rate for green purchasing, which means that generally well-developed supplier-customer relationships can be effectively utilized in green purchasing.

The area of *green design* also shows significant differences between the groups for several (11) SCM methods, which typically affects the areas of cooperation and investment in partnerships. More developed SCM was associated with a higher level of development in greed product design. Close supplier-customer relationships may facilitate joint development and cooperation in designing products with environmental-friendly features as well as in negotiations regarding needs.

Another area that showed significant differences for multiple (10) SCM methods was *green logistics*, where post hoc tests matched the results of the two areas presented above. Cooperation can support the resolution of logistics tasks (such as transportation, packaging and inverse logistics), especially through information sharing and cooperation.

Table 1. Correlation between traditional and green SCM

SCM method group	SCM method used	Green design	Green purchasing	Green manufacturing	Green logistics	Investment recovery	Frequency of incidence
Information sharing	Partners inform each other of changing needs		✓	✓	✓	✓	4
	Partners hold regular personal consultation	✓	✓	✓	✓		4
	Partners give each other feedback of performance		✓		✓		2
	Partners share with each other all information that may be of help to the other party						0
	Partners share information with each other even when it is sensitive from a business point of view						0
Cooperation	There is consensus among management that the supplier needs to be involved in the design process	✓	✓	✓	✓	✓	5
	Mutual design and finding joint solutions to relevant operative issues	✓	✓	✓	✓		4
	The supplier has a big say in product design	✓	✓	✓	✓		4
	Establishing joint work group(s) with partner company	✓	✓	✓	✓		4
	Partners consolidate their decisions in the interest of cost efficiency	✓	✓		✓		3
Investment into partnership	The company has made significant financial investment in order to improve cooperation	✓	✓	✓	✓		4
	The company has made HR-investment in order to improve cooperation	✓	✓	✓			3
	The company has shared their protected know-how or technology with their partner in order to facilitate cooperation	✓	✓				2

Commitment to partnership	The company is planning to maintain the cooperation for the long-term	✓	✓				**2**
	The company's partner is planning to maintain the cooperation for the long-term	✓	✓				**2**
	Purchasing decisions are typically not made based on price		✓		✓		**2**
	The supplier receives shares in the jointly realized profit						**0**
	The company typically makes hedge contracts with suppliers to protect its own interests						**0**
Frequency of incidence		**11**	**14**	**8**	**10**	**2**	**45**

Fewer (8) SMC methods showed demonstrable differences between the groups for *green manufacturing*. This result is surprising, given the fact that manufacturing is an internal process, meaning that suppliers have a lesser impact on it than on other elements of the supply chain that are closer to them, such as purchasing or logistics. Certain cases of information sharing and cooperation may have a positive impact on the application of green methods, however. The study of *investment recovery* did not yield assessable results, which corresponds to our expectations given the lack of logical connection. We used post-hoc tests to uncover significant correlations between groups created based on SCM methods. The results point to three typical patterns, which are illustrated in Figure 2.

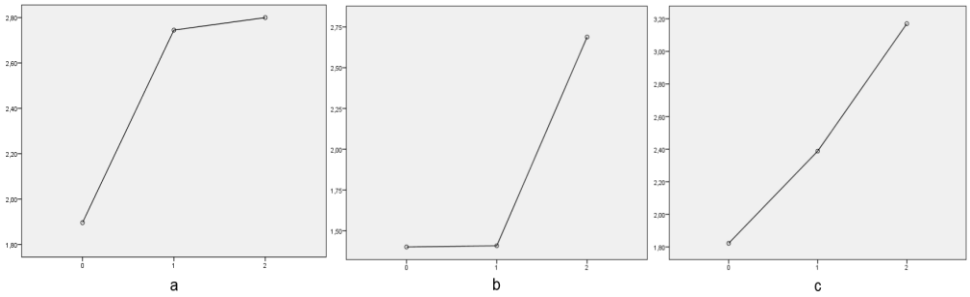

Figure 2. Typical examples of the GSCM development of groups created based on SCM methods (the horizontal axis shows the categories based on SCM methods, the vertical axis shows the GSCM intensity indicator)

In most of the cases (21 incidences), the GSCM development level of groups not applying the SCM method was significantly lower than the two groups using the SCM method. However, the results did not show demonstrable differences between groups using the SCM method with just a few or multiple partners. This pattern

was also typical for most of the methods within the category of Cooperation, regardless of the GSCM area studied. This is illustrated by Figure 2/a.
No significant difference in GSCM development was observed in 9 cases between the groups that did not apply the SCM method or only with a few partners, while those who applied the method with multiple partners performed considerably better in this regard. This pattern was typical of various forms of information sharing, regardless of the GSCM area studied. This is illustrated by Figure 2/b.
The GSCM development of groups applying traditional SCM methods more and more intensively showed gradually higher levels in three cases (see Figure 2/c). This pattern was observed with Joint work groups. The results clearly confirm our hypothesis that companies with a higher development level of traditional supply chain management activity also have a more well-developed green supply chain management system. The results thus verify the hypothesis.

Managerial Implications

Based on the above it can be stated that the following findings have high impact of the management of participating companies:
The *importance of cooperation* is exceptional among traditional SCM areas. All methods discussed in the questionnaire showed demonstrable differences in all of the GSCM areas. It can be concluded that companies using forms of cooperation more intensively in their partnerships have a higher development rate in GSCM areas. *Information sharing is of high importance*: prompt notification of the changed needs and regular personal consultations are crucial. Based on these results, successful GSCM is not conditioned upon partners sharing confidential or wide-ranging information.Companies that are willing to *invest in partnerships* can achieve better results in the areas of green product design, green purchasing and partly in green manufacturing.

Conclusions

Our main research question sounded: what impact do the existing inter-organizational supply chains have on green supply chains “operating” along the same chains within the automotive industry. When studying this issue, it was essential to distinguish the various areas and methods within green supply chain management (which are mostly discussed separately also in the existing international technical literature, although are sometimes integrated with traditional areas). For practicing managers it can be a new impetus that the areas are related to the specific phases of the supply chain and are the “green” equivalents of inter-organizational supply chain management areas. Within each area, we identified the toolkit that facilitates environmentally conscious operation. Besides that, there were also general principles identified that cannot be clearly associated with any given area, but are by their nature to be classified among the management methods.
As an overall summary, it can be stated, that supply chain cooperation brings shared values to the participants and also additional value to GSCM. Moreover,

this process is expected to continue: artificial intelligence, smart factory and Industry 4.0 create opportunities. Future will prove, on what way smart supply chains will effect sustainability and environmental issues.

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ŚWIADOMOŚĆ DOTYCZĄCA ZIELONEGO ŁAŃCUCHA DOSTAW W WĘGIERSKIM PRZEMYŚLE MOTORYZACYJNYM

Streszczenie: Integracja dyscyplin, zarówno działalności ekologicznej, jak i złożonego łańcucha dostaw (w tym zakupów, produkcji i logistyki) w centrum uwagi znalazła się w latach dziewięćdziesiątych ubiegłego wieku. W przeglądzie literatury przedmiotem zainteresowania badaczy był przemysł motoryzacyjny. Wydaje się oczywiste, że te ściśle powiązane systemy o wysokiej pozycji dominującej wśród producentów oryginalnego wyposażenia(OEM), oferują bardziej konkretne wyniki: trudno jest oprzeć się sytuacji, kiedy dany producent zaczyna angażować swoich dostawców pierwszego, drugiego i trzeciego szczebla w swoje systemy i procesy środowiskowe. Węgierski sektor motoryzacyjny można scharakteryzować jako nieco jednostronny: składa się on z kilku dużych międzynarodowych producentów OEM (Audi, Mercedes-Benz, Opel, Suzuki, Raba), a także dużej liczby małych i średnich przedsiębiorstw jako dostawców trzeciego (lub nawet czwartego) poziomu. Celem artykułu było ustalenie, czy firmy działające jako członkowie bardziej zaawansowanych sieci wykazują również lepsze wyniki w swoich "zielonych" zachowaniach związanych z łańcuchem dostaw. W badaniach empirycznych stworzono zestaw narzędzi i zbadano, czy firmy, które używają bardziej wyrafinowanych narzędzi współpracy międzyorganizacyjnej, są bardziej ostrożne ekologicznie, a jeśli tak, to w jakim stopniu. Na podstawie przeprowadzonych badań, można stwierdzić, że firmy o bardziej rozwiniętym tradycyjnym łańcuchu dostaw mają również bardziej rozwinięty system zarządzania zielonym łańcuchem dostaw.
Słowa kluczowe: zarządzanie łańcuchem dostaw (SCM), zarządzanie zielonym łańcuchem dostaw (GSCM), przemysł motoryzacyjny

绿色供应链意识在匈牙利汽车工业

摘要:1990年，绿色经营和复杂供应链(包括采购，生产和物流)的学科整合成为焦点。在文献综述中，这个横截面领域研究人员的重点是汽车行业。很明显，这些具有高OEM优势的紧密结合的系统将会提供更具体的结果:当一家特定的OEM开始将其一，二，三级供应商纳入其环境计划和流程时，难以抗拒。匈牙利汽车行业的特点可以说是片面的:由少数大型国际原始设备制造商(奥迪，梅赛德斯奔驰，欧宝，铃木，拉巴)组成，但由大量中小型企业第四！)层供应商。本文的目的是要发现，作为更先进的链条成员的公司在"绿色"供应链行为中也表现出更好的结果。作为一个研究描述，在我们的实证研究中，我们创建了一个工具箱，并检查使用更复杂的组织间合作工具的公司是否更环保谨慎，如果是的话，程度如何。因此，可以说，传统供应链较高的企业也有一个比较发达的绿色供应链管理体系。
关键词:供应链管理(SCM)，绿色供应链管理(GSCM)，汽车行