OPTIMIZATION MODEL OF TRUCK CARGO SPACE BASED ON THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

Sustainable development assumes that it is possible to satisfy current needs in the way which is not eliminating possibility of satisfying the same needs in future. It is the ability to maintain the balance of a certain process or state in any system. In business activities it is the ability to maintain balance between three areas: economical, ecological and social. What is more, in the age of rapid economic changes companies are forced to continuously search for ways of cost rationalization. For manufacturing and distribution companies reduction of logistics and, in particular, transport costs is the most important. It must be remembered that transport processes in a company function within a big organism, i.e. the national or regional transport system. Thus, inefficiency of only one element of a certain system can have a negative impact on the other one.

Several methods (among others DRP, JIT, TQM, ECR, CPFR, TOC, Business Process Reengineering (BRP), Business process management (BMP), Trillium Model, Change management, Capability Maturity Model Integration (CMMI), Benchmarking, Six Sigma, Process Improvement and Management (PI&M), Rational Unified Process (RUP), Zachman Framework) were developed to support efficient organization of transport, warehousing and inventory management processes. The majority of methods, however, do not consider the correlation between above mentioned logistics processes. Additionally, all methods recommend focusing on internal company processes, and strictly within a particular range (e.g. transport or warehousing). A short-term economic account and customer requirements are becoming a leitmotiv of any business activity. Nevertheless, there are no methods, algorithms or tools that solve the above described trade-off relations problem comprehensively. Moreover, the methods do not take into consideration the relationships between transport organisation effectiveness and effective regional transport activity, neither.

In this article the authors aim at holistic presentation of optimization model of truck cargo space based on the concept of sustainable development. Proposed solution consist of three steps:

- Identification of trade-offs relations between transportation and inventory management.
- Transport process organisation taking into consideration trade-offs relations with inventory management.
- Common organization of transport process within a group of companies.

Keywords: Transport processes, co-modality, efficient planning, small & medium enterprises, distribution systems, e-platforms.

1. INTRODUCTION

In the age of rapid economic changes companies are forced to continuously search for ways of cost rationalization. For manufacturing and distribution companies reduction of logistics costs and, in particular, transport ones is the most important. In order to achieve it, an analysis and change of the way of transport process fulfilment as well as being open to new logistics management concepts are vital. Obviously, when implementing the changes, the fact that transport organization is not the source of profit for the above mentioned manufacturing and distribution companies should be also taken into account. The activity is supposed to support the core business, i.e. manufacturing and sales of goods. Therefore, the companies make, after transport service providers, the second group of transport process actors 12.

Transport process is a complex of organizational, trading and executive actions. Their goal is to move goods and/or people from one or a few points of origin (shipment) to one or a few points of destination (delivery) with the use of certain transport means 8. The difference between transport process and carrying process also needs to be pointed out. The carrying process is a part of the whole transport process. Detailed relations are presented in figure 1. Therefore, transport can be considered a bridge between the buyer and the seller 6.

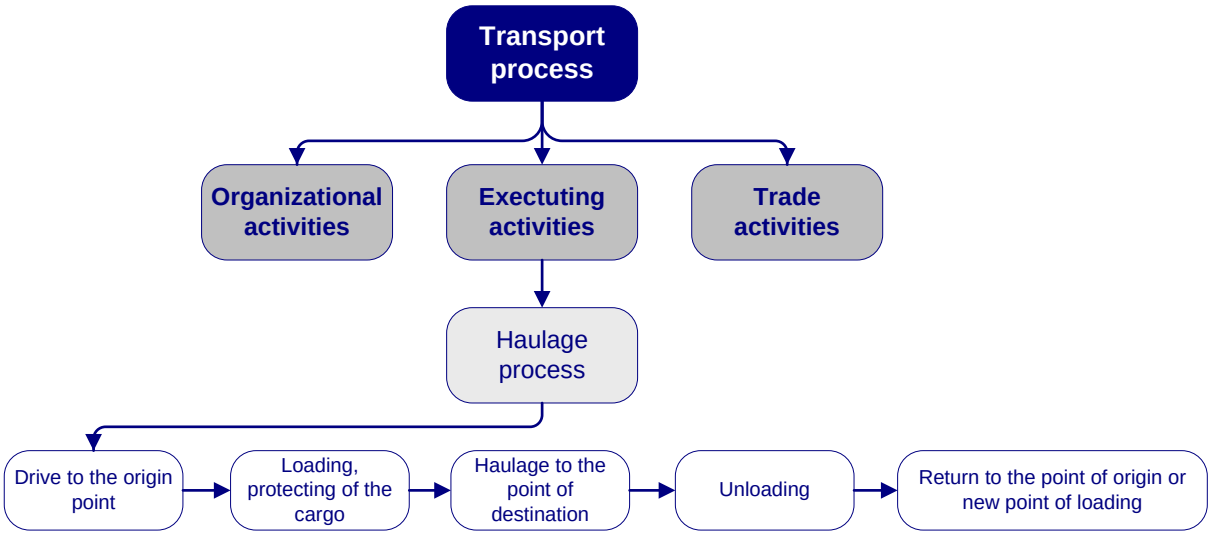

Figure 1 Example of transport process division

Source: Own study based on 8

It must be remembered that transport processes in a company function within a big organism, i.e. the national or regional transport system. Thus, inefficiency of one element of a certain system can have a negative impact on the other one. The correlation is presented in figure 2.

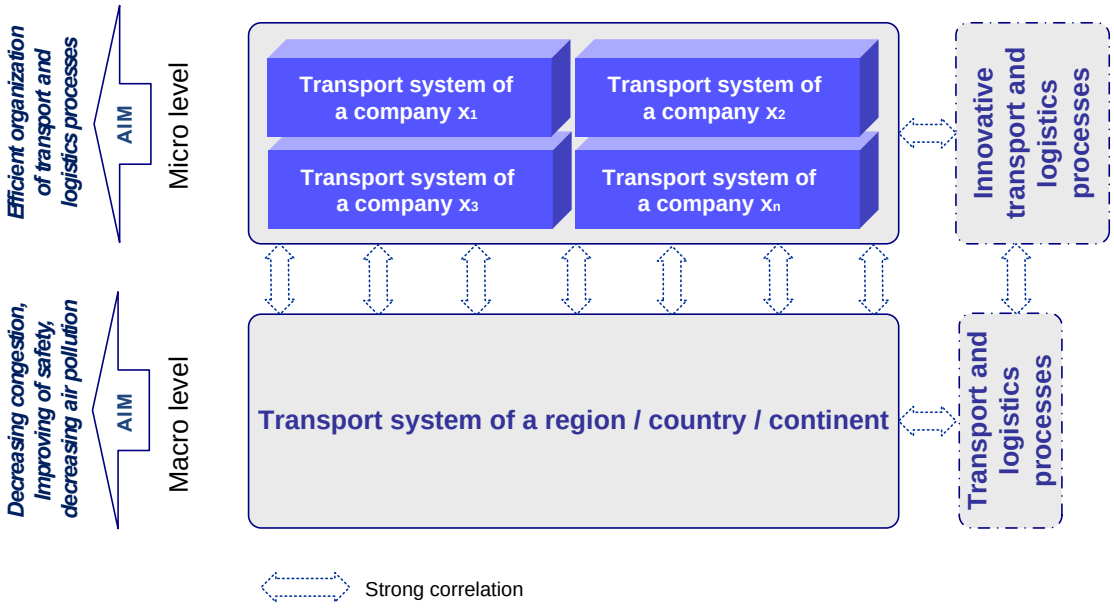

Figure 2 Correlation between the regional transport system and transport processes of enterprises

Source: Hajdul M., Koordynacja procesów transportowych w oparciu o koncepcję zrównoważonego rozwoju, IV Międzynarodowa Konferencja Politechniki Warszawskiej – Systemy Logistyczne – Teoria i Praktyka, Rawa Mazowiecka 2009.

The significance of transport process organisation can also be supported by transport cost analyses in various distribution network models carried out by employees of the Institute of Logistics and Warehousing. The analyses prove that in many cases transport costs account for more than 50% of total logistics costs [**Error! Reference source not found.**, p. 179; **Error! Reference source not found.**, p. 55]. As a result, more and more companies start to pay particular attention to them and make attempts to optimize them.

Most companies have already noticed that the effective transport process organisation has a great influence on their current performance, which determines total company costs [12, p. 295]. This resulted in creating many methods of business process realization and reengineering. Within the paper the authors analysed, among other things, the following methods: DRP, JIT, TQM, ECR, CPFR, TOC, Business Process Reengineering (BRP), Business process management (BMP), Trillium Model, Change management, Capability Maturity Model Integration (CMMI), Benchmarking, Six Sigma, Process Improvement and Management (PI&M), Rational Unified Process (RUP), Zachman Framework.

The methods described by the authors show how logistics processes including transport, warehousing and inventory management can be improved by companies. The methods, however, do not consider the correlation between logistics processes. Customer requirements are always in the first place and the whole rationalization process should be designed to meet them. This conclusion seems to be obvious since this is a customer that brings profits to the company.

Unfortunately, neither key processes nor tools for manufacturing and distribution companies in the supply chain are described by the methods.

Additionally, all methods recommend focusing on internal company processes, and strictly within a particular range (e.g. transport or warehousing). A short-term economic account and customer requirements are becoming a leitmotiv of any business activity. Nevertheless, there are no methods, algorithms or tools that solve the above described trade-off relations problem comprehensively. Moreover, the methods do not take into consideration the relationships between transport organisation effectiveness and effective regional transport activity, neither.

Furthermore, according to the authors' observations, companies try to fulfil orders often and quickly, mainly with the use of road transport. Obviously, they try to keep transport costs at a reasonable level. However, in the authors' opinion, the approach causes that improving processes and customer satisfaction in the short-term by manufacturing and distribution companies can worsen their long-term activity. The details are presented in figure 3, in which a decent correlation between the company and the national transport processes can be seen. The figure 3 is a result of the author's work in the Institute of Logistics and Warehousing, which proved that frequent and quick deliveries require more transport means to be involved, which makes traffic congestion bigger and road safety worse. Growing traffic congestion decreases the average technical speed of vehicles which makes delivery time longer. Furthermore, the average time of a vehicle "on the route" has been increasing which results in a higher CO2 emission as regards environmental impact. Regarding the influence on the transport economy, it leads to worsening of the rate of drivers' working time and the rate of kilometers/tone. Longer delivery time can cause customer dissatisfaction and, in the worst case, loss of some orders. Additionally, increased demand for transport services

makes transport service providers increase their transport rates. So, in the long-term companies make their financial results worse. It is confirmed by the authors' observations that many companies have problems to find a transport service provider, particularly in distribution.

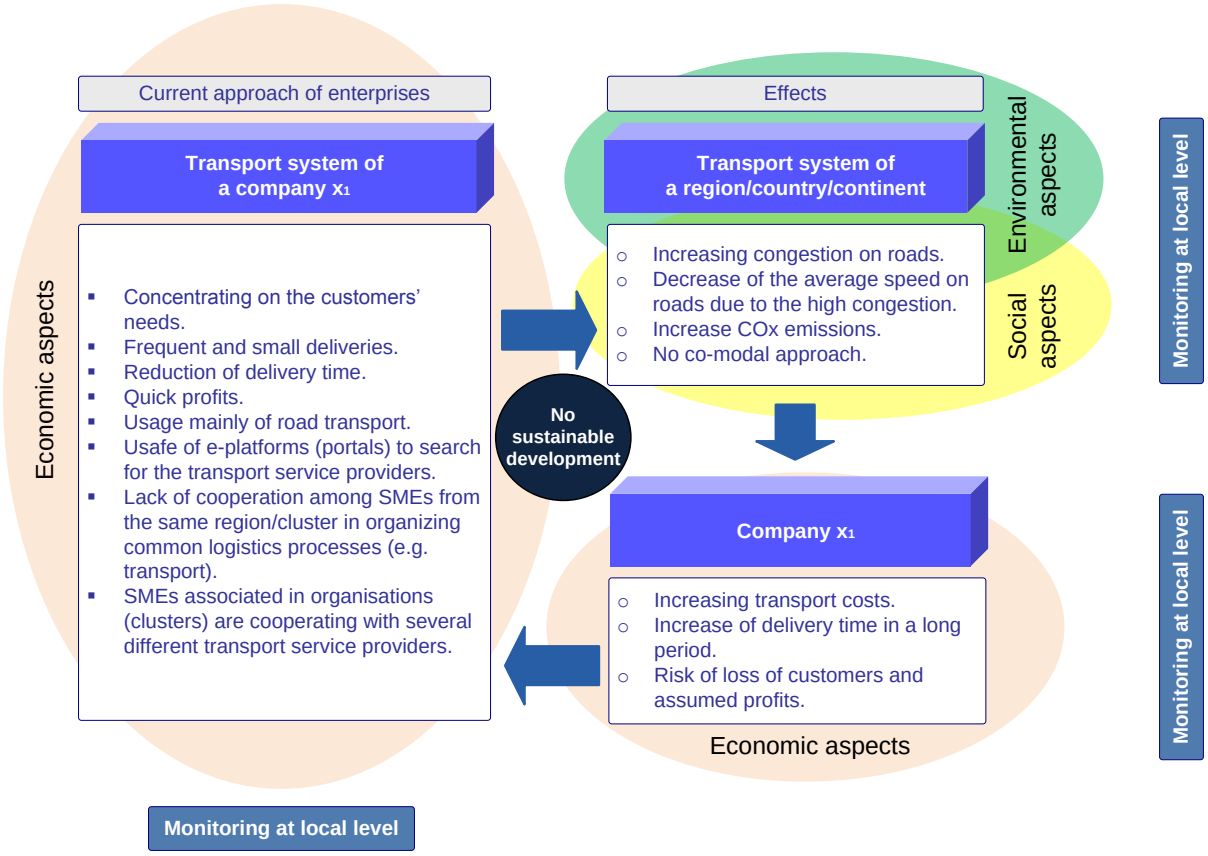

Figure 3 Results of contemporary companies' approach to the carrying transport process

Source: Own study

Thus, in the authors' opinion, during transport process rationalization by small and medium enterprises it is necessary to take into account the strong correlation between the company transport system and the regional or national one.

Additionally, it seems to be necessary to establish a solution which will eliminate the weaknesses of contemporary methods i.e. not taking into account the trade-off relations between selected logistics processes or their local optimization. Introducing changes to logistics processes should be carried out basing on the sustainable development concept. The concept assumes that sustainable development enables to meet current needs in a way that prevents certain unit from not meeting the same or other needs in the future [1, p. 27; 4, p. 5; 13, p. 10]. In case of business activity the development assumes balancing of three areas: economic, ecologic and social one 4, p. 5].

The further part of the paper presents results of Kassetts, an European research project, which shows advantages of implementing some elements of the proposed concept by a group of companies in Italy.

2. CONTEMPORARY MODEL OF TRANSPORT PROCESS ORGANISATION IN BUSINESS ACTIVITY

In traditional models of transport process organisation manufacturers or distributors concentrate on fulfilling everyday orders from customers and ordering goods from their suppliers. It is presented in the figure 4. Delivery and distribution of finished goods can be carried out with the use of own transport means or a specialized transport/forwarding company 12, p. 298-301; 7. In case of own fleet companies plan and optimize delivery routes from suppliers and distribution routes to customers on their own. Delivery fulfilment and distribution are in many cases handled together with the use of one vehicle, although these are two different parts of the supply chain 11. Such actions aim at transport cost rationalization and the effective usage of available transport means. Thus, many times the distribution of finished goods within a region is done first and only then are goods picked from the supplier. Next, the goods are transported to the company warehouse/plant. The actions aim at a maximum utilization of a truck loading capacity, which results in minimization of transport costs.
If a company does not have its own fleet of trucks, it uses transport/forwarding services. It is profitable since the company only places transport orders and it is the forwarder or transport service provider that is responsible for organizing the process in an optimal way 14.

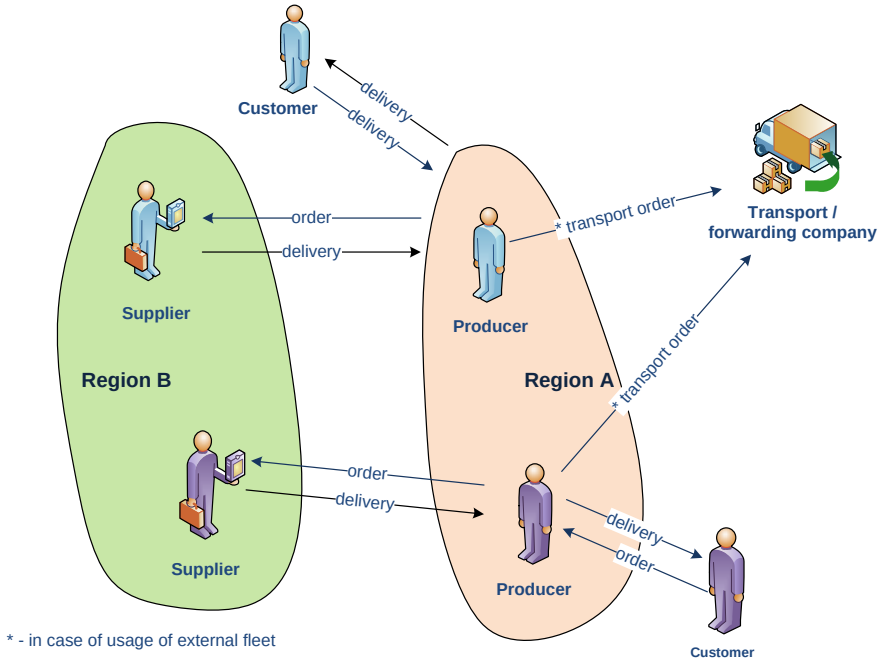

Figure 4 Traditional way of organizing transport process

Source: Hajdul M., Koordynacja procesów transportowych w oparciu o koncepcję zrównoważonego rozwoju, IV Międzynarodowa Konferencja Politechniki Warszawskiej – Systemy Logistyczne – Teoria i Praktyka, Rawa Mazowiecka 2009.

The above described solution has one disadvantage. The transport rate or the own transport cost depends directly on the size of load and our expectations regarding delivery time. The general rule is that transport companies have higher prices for larger delivery quantities. In both cases: own transport and the ordered one, the cost per weight unit declines with the growth of delivery weight 6. Unfortunately, the current trend, i.e. frequent and small deliveries results in high transport costs and they are still growing. Also growing number of delivery trucks which increases traffic congestion and, as a result, longer delivery times is another disadvantage. Furthermore, frequent and quick deliveries require more transport means to be involved, which makes traffic congestion higher and worsen safety of roads. Growing traffic congestion decreases the average technical speed of vehicles which makes delivery time longer. Longer delivery time can cause customer dissatisfaction and, in the worst case, loss of some orders. Additionally, increased demand for transport services makes transport service providers increase their transport rates. So, in the long-term companies make their financial results worse. It is confirmed by the authors' observations that many companies have problems to find a transport service provider, particularly in distribution.

3. ASSUMPTIONS OF THE TRANSPORT PROCESS RATIONALIZATION MODEL IN BUSINESS ACTIVITY

The authors state that in the rationalization of transport processes, it is necessary to consider strong correlation between transport system of the company and the one of a region or a country. What is more, monitoring of realized global processes and described correlation in a macro- and micro scale is extremely crucial. Companies that want to develop and perform effectively in the long-term and not only achieve profits in the short-term should search for alternative solutions of transport process organisation. The concept based on sustainable development strategy is an example of alternative transport process organisation strategy in business activity. Not only does the strategy enable companies to perform on the basis of the traditional approach but also offers cooperation of companies from one region in the field of logistics process organization with the support of modern IT solutions. The assumptions of the concept proposed by the authors are presented in the figure 5 and the details have been described in further chapters.

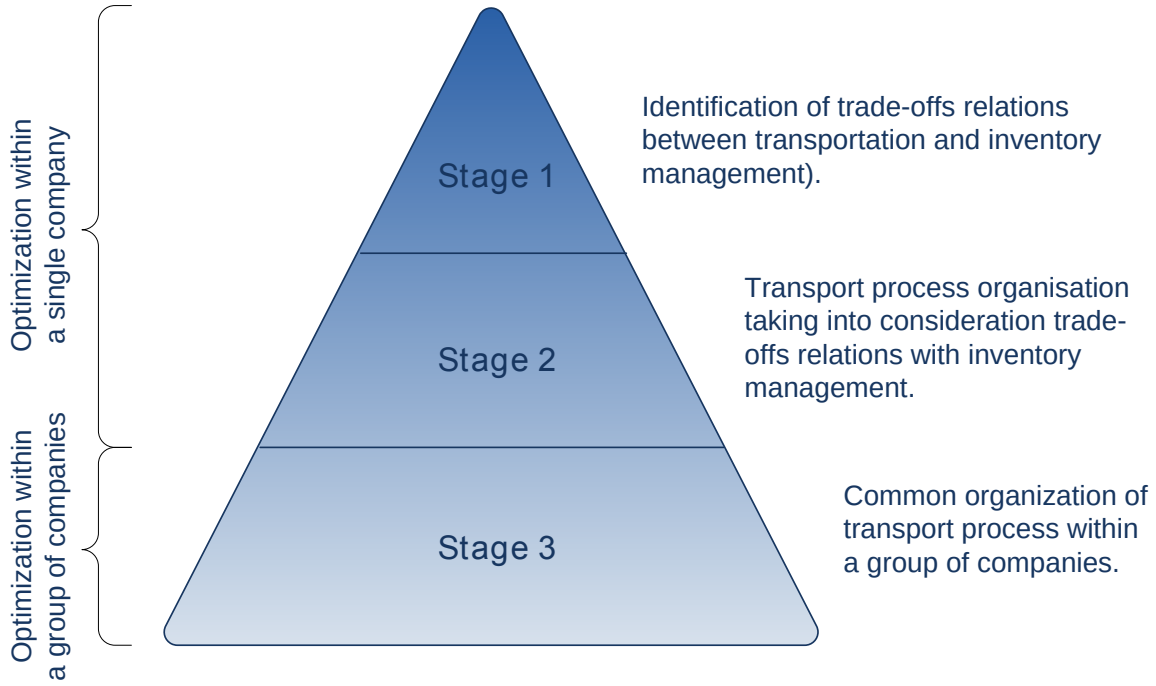

Figure 5 Model of rationalization of transport processes according to the concept of sustainable development

Source: Own study

4. TRANSPORT PROCESS ORGANISATION CONSIDERING TRADE-OFF RELATIONS WITH INVENTORY MANAGEMENT

Manufacturing and distribution companies deal with many transport processes which are often closely connected with trade-off relations between other logistics processes. The term “trade-off” in logistics is connected with an idea of optimal resource and process management. It consists in searching for best system solutions. However, trade-off relations in logistics systems cause that improving one part of the system makes another area get worse. Thus, changes should be assessed for the whole logistics system since balancing positive results in one area and negative in the other one can result in either profits or losses for the whole system. In most cases trade–off relations are connected with cost conflicts which arise where various business activity areas meet [**Error! Reference source not found.**, s. 69; **Error! Reference source not found.**, s. 50; **Error! Reference source not found.**, s. 17]. So, the transport processes presented in the paper are closely related with inventory management, warehousing and customer service. In terms of total logistics costs rationalization, customer service level maintenance and, what is most important, making profits, these are the relations between transport process organization and inventory management that are crucial.

Establishing order quantity and frequency is a typical example of a trade-off relation between inventory and transport management. The trade-off is that decreasing order quantity causes reduction of procurement inventory and increase of transport costs (due to more frequent

deliveries of small quantities), number of orders (necessity of placing orders more frequently) and purchases (lower order quantities usually cause higher costs due to higher prices) [**Error! Reference source not found.**, **Error! Reference source not found.**]. Additionally, frequent deliveries also mean larger traffic congestion. The results of these actions are described at the beginning of the paper.
Today, material and information flows between the source and the user is coordinated and managed as one system. The goal is to achieve maximum customer service level with reduction of costs and frozen capital in the supply chain at the same time. Maintaining optimal inventory level is one of main aspects of logistics management. The attention should be paid to the term "optimal". Inventory optimization does not always mean inventory minimization. The following issues are crucial in this aspect:

- synchronization of transport and inventory management, which will help establishing optimal order quantity and delivery frequency;
- assuring on-time deliveries and high customer service level which leads to inventory level optimization and warehousing costs reduction;
- assuring goods and service quality by i.e. availability, higher delivery quality, punctuality, flexibility to changes, reliability and availability of transport means.

To sum up the above described problems and constraints of connecting two system areas i.e. transport and inventory management it must be pointed out that managers should think systemically and about total costs, and not only about costs of their field of activity. Furthermore, they should be value- and profit-oriented. It allows the processes to be really optimized.
In the research the authors extended the selected inventory replenishment models (continuous review, periodic review, min-max, scS) by the trade-off relations with transport. There is an example of algorithm based on scS taking additional transport rationalization criteria into consideration presented below. In connection with that, the model assumes that order quantity is established basing on the analysis of items delivered by many suppliers located in specified regions. Such a grouping will enable to deliver with bigger trucks and will increase the utilisation of loading capacity. Thus, transport costs will be minimized and inventory level will be rationalized at the same time.

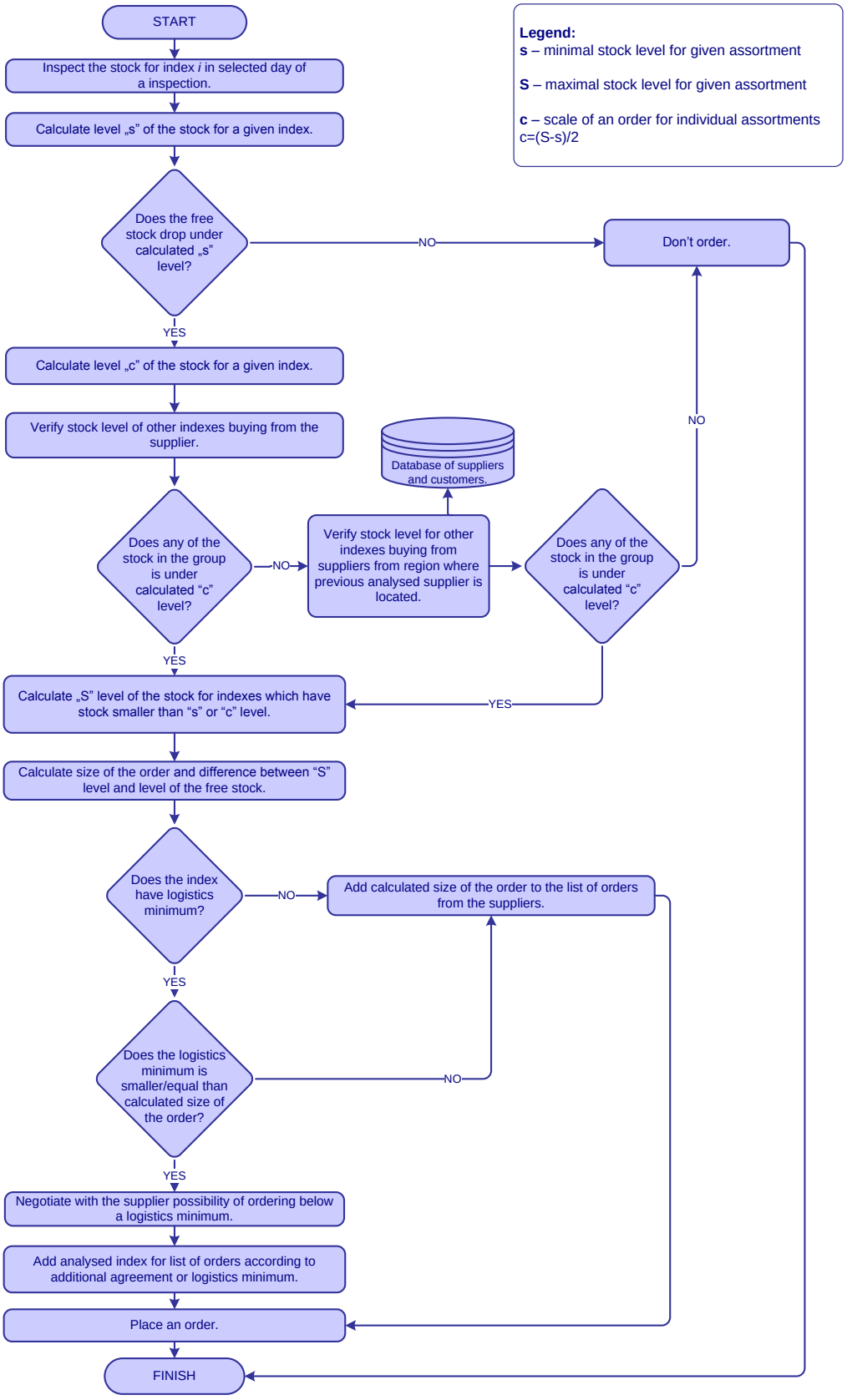

Figure 6 Order generation algorithm based on the Scs model

Source: Own study

5. POSSIBILITIES OF TRANSPORT PROCESS ORGANIZATION WITHIN A GROUP OF COMPANIES

If a company is convinced to have optimal transport processes in its current activity it may start the next rationalization stage and cooperate within a group of companies in organizing common deliveries. The concept assumes that companies from the same region exchange information on planned points of origins and points of destinations for deliveries of finished goods (figure 7). The information flow is supported by an electronic information exchange platform. The involved companies jointly hire a person who coordinates transport processes on their behalf. One of main tasks of the coordinator is connecting routes in a way that maximizes the size of the shipped or delivered cargo (to or from a certain destination). It helps to negotiate better prices with external transport service providers. Obviously, also a representative of one of manufacturing companies with their own transport fleet can be a logistics process coordinator. The goal of such companies is to reduce total transport costs by better utilisation of loading capacity.

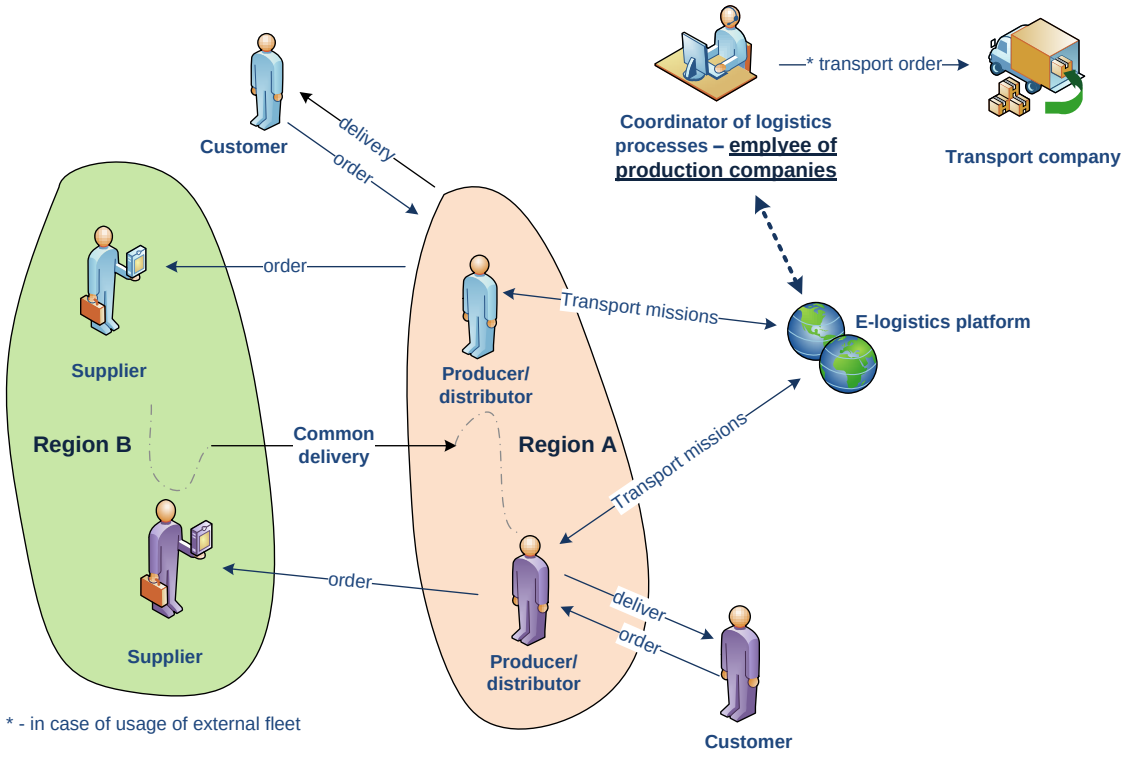

Figure 7 Common organization of transport processes within companies from the same region

Source: Hajdul M., Koordynacja procesów transportowych w oparciu o koncepcję zrównoważonego rozwoju, IV Międzynarodowa Konferencja Politechniki Warszawskiej – Systemy Logistyczne – Teoria i Praktyka, Rawa Mazowiecka 2009.

The advantages of the above mentioned solution can be confirmed by transport costs analyses based on data from three manufacturing companies for a 400km-long route. In the traditional way there are two ways of performing the transport process. Firstly, ship pallets with the help of a transport service provider and settle accounts for the number of pallets. The second way is to hire a dedicated truck and settle accounts based on the length of the route. The details are presented in table 1.

Table 1 Analysis of transport cost for a hypothetical route

Traditional way of organizing transport processes						
Shipper	Number of pallets [PCS]	Cooperation with logistics operator – transport costs depend on number of pallets		Cooperation with transport company – transport costs related to distance (km) and size of the truck		Number of used trucks [PCS]
		Total transport costs [EUR]	Transport costs of 1 pallet [EUR]	Total transport costs [EUR]	Transport costs of 1 pallet [EUR]	
Producer 1	18	229,5	10,8	190	10,5	3
Producer 2	5	122,5	24,5	89	17,75	
Producer 3	10	177,5	17,75	125	12,5	
Coordination of transport processes based on the concept of sustainable development						
P1+P2+P3	18+5+10=33	-	-	400 km*0,725= =290	8,78	1

Source: Own study

The table above shows precisely the profits from the solutions presented by the authors. What is also worth noticing, is that one truck is used instead of three ones which decreases road traffic congestion. Therefore, the solution eliminates disadvantages of the traditional method of transport process organization.

6. EXAMPLE OF TRANSPORT PROCESS COORDINATION ACCORDING TO SUSTAINABLE DEVELOPMENT STRATEGY

Selected elements of the presented transport process organization strategy are verified based on real examples within the Project KASSETTS (Knowledge-enabled Access of Central Europe SMEs to Efficient Transnational Transport Solutions) financed by the European Commission (Central Europe Programme). The KASSETTS Project aims at supporting rationalization of specific transport processes and logistics actions that lead to the improvement of SMEs competitiveness and environment protection by creating an European logistics coordinator network using specific IT tools. Additionally, in order to support the information flow between the subjects an electronic information exchange platform is being developed. The author (Marcin Hajdul) is co-responsible for developing planning algorithms and general concept of cooperation among enterprises within the project.

The current version of the tool enables the coordinator to pass on information from manufacturing to transport companies. Additionally, the solution also supports effective route planning.
The current functionalities are 15:

- Ordering – submitting daily transport and keeping their evidence and status.
- Planning – optimization of transport missions, effective route planning and utilization of logistics service providers.
- Reporting – transferring detailed information on used truck, costs and kilometers to the manufacturing company.

A screen of the main menu of the tool is presented in figure 8.

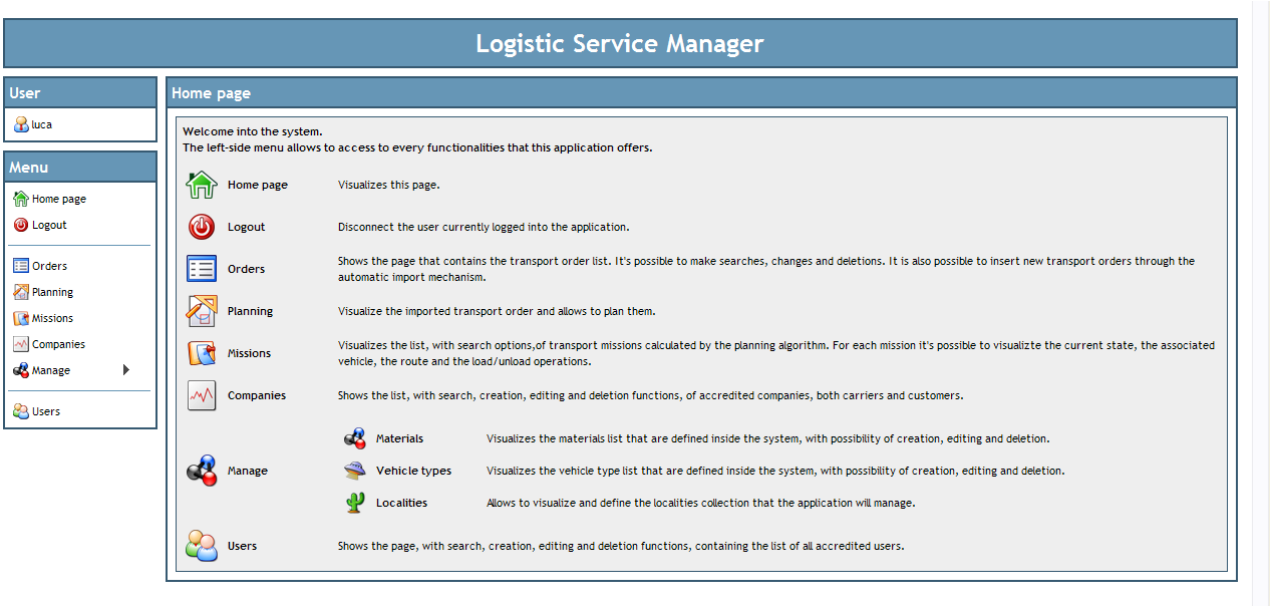

Figure 8 A screen of the electronic information exchange platform created within the KASSETTS project

Source: Own study.

While planning, the tool takes into consideration constraints of logistics infrastructure in the point of origin and destination. Additionally, own available trucks and trucks of external transport service providers are taken into account. The algorithms also consider the characteristics of loading units. The optimization criterion is the minimization of transport cost through increasing the utilization of loading capacity and one-time transport of large quantities of goods. Figure 9 shows a screen with a list of orders to be fulfilled.

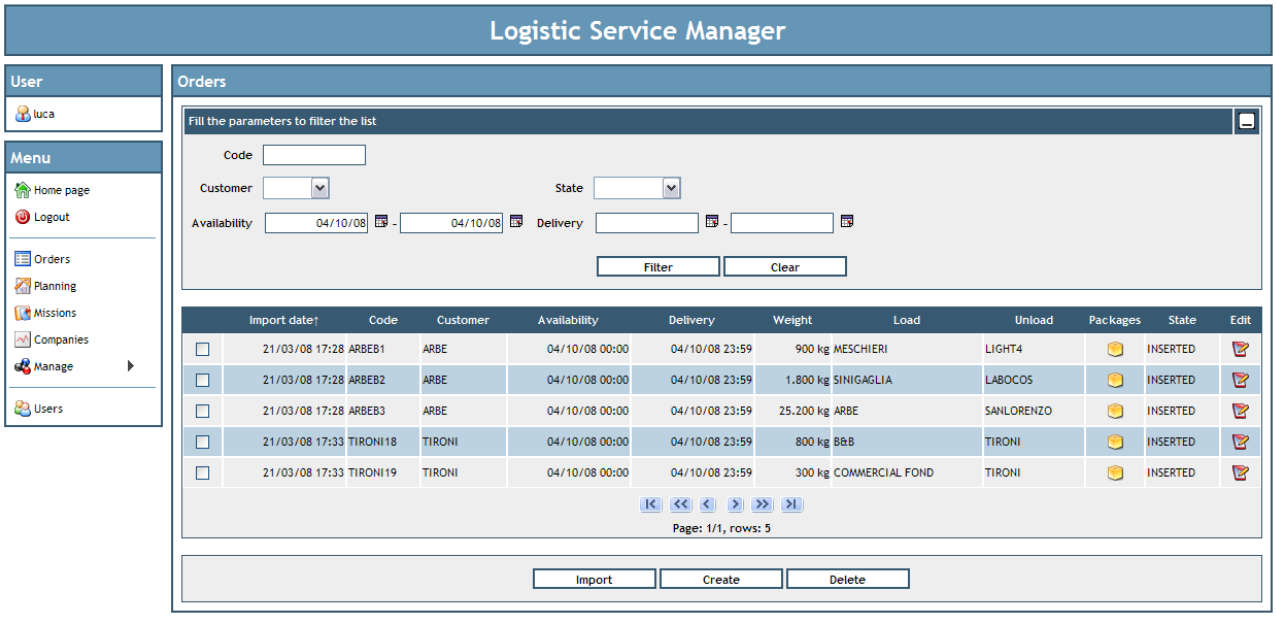

Figure 9 List of transport orders to be fulfilled

Source: www.kassetts.eu

Figure 10 shows examples of loading units used by one of companies involved in the project.

Figure 10 Examples of loading units used by the tool

Source: www.kassetts.eu

The new concept of transport process organisation and the above described tool were first tested by Italian companies in the Emilia Romagna region. The manufacturing companies located in the region come across problems resulting from delivery frequency and limited contact with transport service providers. The companies jointly hired a person who coordinates transport processes. The person gathers transport orders every day and optimizes them within the supply chain. Transport missions are planned twice a day.

Additionally, the coordinator periodically reports and issues pro-forma invoices which enables to control transport and service costs continuously.
The initial stage research shows that it is a simple way of cost savings – in transport costs (ca. 20%), kilometres (almost 30%), or decreasing the number of individual transports 37%, as well as shortening time of the order fulfilment 15. The selected group of companies appreciated the profits achieved in the testing stage as well as the potential of such solutions and decided to use ICT as a supporting tool for their logistics activity.
Similar promotional attempts will be made within the KASSETTS project in Poland, Germany, Czech Republic, Slovakia, Slovenia and Hungary.

7. CONCLUSIONS

It can be noticed on the example of Italian companies that many of them are more and more open to new solutions that bring profits to many units directly or indirectly involved in the supply chain. Firstly, profits are achieved by companies which reduce transport costs without reducing customer service level. Furthermore, the solution reduces the number of used trucks which contributes to reduction of truck traffic. Thus, the average road transport speed does not decrease and companies can still fulfil deliveries within 24 hours. It is noticeable that such an approach brings benefits companies from increased effectiveness both in the long- and short-term. Therefore, the approach complies with the sustainable development concept.
Another group that is indirectly involved in the supply chain are road users that have more and more problems with moving on the roads due to the growing traffic congestion. So, transport process organization improvement in companies resulting in reduction of delivery trucks is also profitable for the users of passenger cars.
The transport process organization strategy presented in the paper is also compatible with the current European Commission transport policy promoting transport process co-modality. The term describes separate or joint effective utilisation of various transport means in order to make the utilisation of the resource optimal and sustainable [9, 10]. „Optimal" should be understood in terms of both economic, financial, service level and environment protection aspects [10]. However, there is a need to raise awareness of all actors, involved directly and indirectly in the transport chains, about strong relations between micro and macro scale and the potential benefits from implementing suggested solution in terms of economy, environment and society.
To sum up, we should hope that real financial advantages and a perspective of a long-term development will convince some groups of small and medium enterprises to start rationalizing their transport processes according to the presented three-stage-solution.

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