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Cargo Consolidation in a Supply Chain in the Aspect of Sustainable Development of Transport

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ABSTRACT: Cargo consolidation is an important step towards sustainable development of transport. It allows to reduce: emission of greenhouse gases, energy consumption, fuel consumption. Combining cargos in one vehicle allows to reduce the number of runs necessary to deliver goods to the clients. It allows to reduce the amount of pollution, fuel consumption and costs of transport. Cargo consolidation also reduces emission of harmful substances to natural environment and allows enterprises to save time and money. As a result of the data obtained and the analysis carried out, solutions were proposed to reduce transport costs for both customer A and customer B. It has been proven that cargo consolidation is now a very important element of the entire supply chain to the destination in terms of sustainable transport development.

1 INTRODUCTION

In recent years, more and more interest in phenomenon of balancing and its implications for the processes of planning and functioning of transport system can be observed around the world. The concept of sustainable development of transport is a planning concept, which is a long-term, integrated plan of actions. It aims at achievement of strategic goals of general strategy of EU sustainable development.

The main goal of the Strategy of Sustainable Development of Transport is to improve safety of traffic users and efficiency of transport sector through creation of coherent, sustainable, innovative and user-friendly transport system on an European and global scale. Dynamic development of transport in last decades, mainly road transport, is also a significant source of arduousness and problems. Transport has negative effects both on natural environment and society [22]. They are connected, above all, with the results of road accidents and collisions, congestion, the use of fossil fuels (mainly petroleum), climate warming, air pollution, emission of traffic noise [15].

Therefore, enterprises looking for savings and outsourcing transport services more and more often choose logistic centres, which are based on ecological responsibility and implement solutions that reduce harmful impact on natural environment.

2 REVIEW OF LITERATURE

The issues of development and shaping transport system in the national agreements have become particularly important due to ongoing process of globalization. They are particularly important from the point of view of economic and environmental aspects [25, 26, 27]. Creation of uniform common market within EU led to the development of transport and contributed to increasing its economic importance

[24]. Under the influence of globalization of economy, range and frequency of transport has considerably increased. Subsequent logistic chains, networks of terminals and intermodal links are being created every year [11, 12].

Nowadays, logistics must face many challenges, especially due to crises such as Covid-19 pandemic, war in Ukraine, natural disasters [7]. Consolidation of parcels is perceived as one of the most important techniques in logistics, which is regarded by many forwarders as necessary due to benefits on many planes [9]. It played a very important role during crises and pandemics because in such situations, there are certain procedures and measures, which should be taken within the scope of safety of conducted processes. Cargo consolidation was an option supporting services during pandemic and helped many countries to overcome crisis [8].

In literature, there are many works, especially in the field of logistics and transport, in which cargo consolidation in a logistic centre is one of key elements of optimization of processes in the supply chains in road, sea or air transport [17, 18, 23]. The authors of the works analyse the impact of consolidation on the costs of transport, delivery date, quality of services or greenness of logistic processes [19, 21]. In literature, there are various methods and algorithms of cargo consolidation and analyses of costs and benefits from its application for the enterprises and organizations, as well as for the whole society through reduction of the impact of transport on natural environment [20].

Germany is an attractive region in economic and geographical terms to provide logistic services on an European scale because they have well-developed transport infrastructure providing quick and easy transport:
- to most of key shopping and industrial centres;
- to customers of services on the European market, which supports the development of logistic services in the region.

Logistic Centre in Nurnberg is one of the most thriving logistic centres thanks to good location in Bavaria, the most populated region of Germany, in the vicinity of large urban agglomerations: Nurnberg, Munich, Stuttgart, Frankfurt. It is located in a place where River Pegnitz and Rednitz meet, near communication routes connecting Northern Europe with Austria, Italy, Slovenia, Croatia and Southern Europe. Infrastructure of the Centre:
- surface area of the centre – 337 ha;
- infrastructure of the centre – facilities of surface area of about 758 000 m2;
- in the centre, there are 260 enterprises and more than 5500 employees;
- surface area of areas for development – 60 ha;
- 80 ha as a reserve for potential expansion of the centre;
- has direct link with:
  - highways A73, A3, A6 and A9;
  - Deutsche Bahn (railway line);
  - airport located about 12 km away from it.

This centre is the largest such facility in southern Germany [5]. Every year, about 15 million tons of cargos are handled here.

In Germany, there are also different logistic centres such as: Fiege Mega Center in Ibbenbüren, DSV near Dusseldorf and METRO GROUP in Marl. Surface area of such facilities exceeds 150 thousand square meters. German DSV is building now a centre in a Danish city, Horsens. Its surface area will be about 750 thousand square meters and will handle about 5 % of European transport. If this investment succeeds, it will be the largest such facility in the world [6].

Nowadays, time and price are the most important factors so cargo consolidation in the logistic centre is the most accurate solution [16]. Dense network allows combination of parcels, both within national and international links [1]. Moreover, it is a safe form of transport of goods. Consolidation of parcels in the centre to one transport means, above all, one freight forwarding order, one number of a parcel, one customs clearance and one company dealing with transport [2, 3, 4]. Consolidation also contributes to greening of a supply chain on a global scale[10, 13].

3 CARGO CONSOLIDATION OF CLIENTS A AND B

The main research goal of the authors of this article was to define the role of a logistic centre and reduction of the costs of transport with the use of consolidation service illustrated with an example of clients A and B in the aspect of sustainable development of transport.

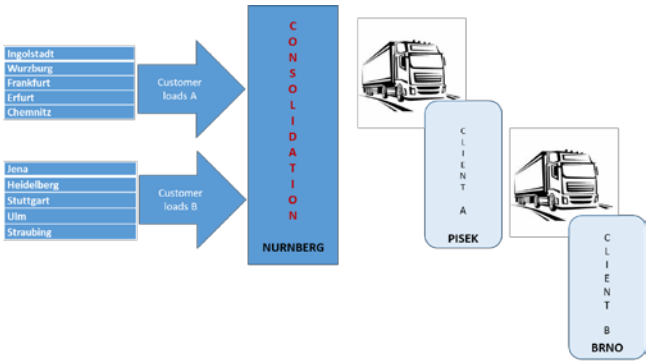

Figure 1. Location of the clients towards the logistic centre in Nurnberg

In the event of clients A and B located in Pisek and Brno, an analysis of consolidation service of all cargos in a logistic centre in Nurnberg, and their transport by one means of transport dedicated for both facilities were presented [14]. It is enabled due to the fact that Pisek is practically on the way to Brno, so the use of one means of transport is the best solution (Fig. 1). Each of facilities organizes now one 6-tonne means of transport per week (Table 1), (Table 2).

As a result of conducted research and analyses for client A (Pisek), transit will last one and a half day, whereas, in the event of a facility in Brno (client B), two days (Fig. 2), (Fig. 3).

Table 1. Transport schedule for client A located in Salzburg (Austria)

D Distance
W Working time
DT Driving time

City	Date Time	D	W	DT	Comment
Ingolstadt	18.04 08:00-09:00	0	1	0	loading
Wurzburg	18.04 12:15-13:15	202	4,25	3,25	
Frankfurt	18.04 16:00-17:00	119	7	5,25	pause 45 minutes
Erfurt	18.04 20:45-21:45	261	11,75	9	pause 11 hours
Chemnitz	19.04 11:30-12:30	149	3,5	2,5	start 9:00
Pisek	19.04 17:00	264	8	7	pause 45 minutes on the way
		995			

Table 2. Transport schedule for client B

City	Date Time	D	W	DT	Comment
Jena	18.04 08:00-09:00	0	1	0	loading
Heidelberg	18.04 15:30-16:35	372	8,5	5,5	pause 45min. on the way
Stuttgart	18.04 18:30-19:30	119	11,5	7,5	
Ulm	18.04 21:00-22:00	89	14	9	pause 11 hours
Straubing	19.04 13:00-14:00	252	5	4	start 9:00
Brno	20.04 09:30	470	13,5	11,5	Pause 11 hours 19.04 20:00
		1302			

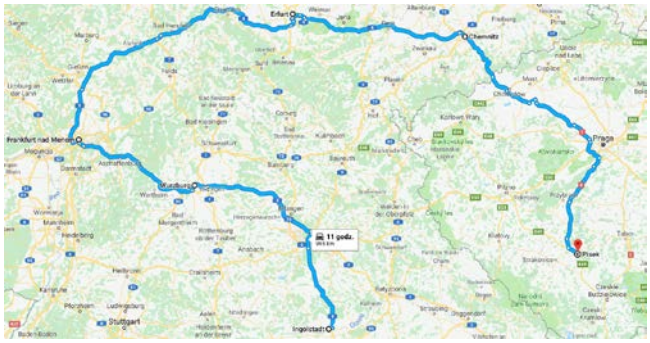

Figure 2. Organization of transport for client A (Google Maps PL)

Figure 3. Organization of transport for client B (Google Maps PL)

The first means of transport has to cover 995km and four additional points on the way, the second one 1302km and the same number of places to visit. The cost of transport is 896€ for client A and 1141,6€ for client B. Disposal of means of transport for Pisek is 86% (Table 3), in the event of Brno, it is 97% (Table 4).

Table 3. Consolidation costs for client A

City	Number of pallets	LDM [m]	Mass [kg]	Handling	Transport
Ingolstadt	2	0,8	300	4 €	36,74 €
Wurzburg	4	0,8	500	8 €	50,06 €
Frankfurt	3	0,6	600	6 €	73,27 €
Erfurt	4	0,8	500	8 €	58,15 €
Chemnitz	14	2,8	3300	28 €	230,54 €
Total	27	5,8	5200	54 €	448,76 €
Disposal of the means of transport		80,56%	86,67%		502,76 €

Table 4. Consolidation costs for client B

City	Number of pallets	LDM [m]	Mass [kg]	Handling	Transport
Jena	3	1,2	500	6 €	55,97 €
Heidelberg	1	0,4	200	2 €	26,17 €
Stuttgart	2	0,4	400	4 €	50,15 €
Ulm	5	1	900	10€	86,80 €
Straubing	20	4	3800	40 €	218,55 €
Total	31	7	5800	62€	437,65 €
Disposal of the means of transport		97,22%	96,67%		499,65 €

Table 5. Date of delivery of cargos to Nurnberg (Client A)

City	Date Time	City	Date Time
Ingolstadt	18.04 08:00	Nurnberg	20.04 08:00
Wurzburg	18.04 12:15	Nurnberg	20.04 08:00
Frankfurt	18.04 16:00	Nurnberg	20.04 08:00
Erfurt	18.04 20:45	Nurnberg	20.04 08:00
Chemnitz	18.04 11:30	Nurnberg	20.04 08:00

Table 6. Date of delivery of cargos to Nurnberg (Client B)

City	Date Time	City	Date Time
Jena	18.04 08:00	Nurnberg	20.04 08:00
Heidelberg	18.04 15:30	Nurnberg	20.04 08:00
Stuttgart	18.04 18:30	Nurnberg	20.04 08:00
Ulm	18.04 21:00	Nurnberg	20.04 08:00
Straubing	18.04 13:00	Nurnberg	20.04 08:00

The cargo will be completed on 20/04 at 9 am for both client A and B (Table 5), (Table 6) 24-tonne means of transport will have to cover 496km. The cost of such transport will be 645€. Pisek usually uses 5,8 LDM, whereas Brno uses 7 LDM, therefore, so the ratio of costs of means of transport from Nurnberg will be 45% (290,25€) to 55% (354,75€).(Table8.). Delivery to Brno will take place at about 18 pm. (Table 7). Duration of the whole transport process will be two and a half days [14].

Table 7. Transport of consolidated cargo to Pisek and Brno

City	Date Time	City	Date Time
Nurnberg	20.04 09:00	Pisek	20.04 13:30
Piesk	20.04 14:30	Brno	20.04 18:00

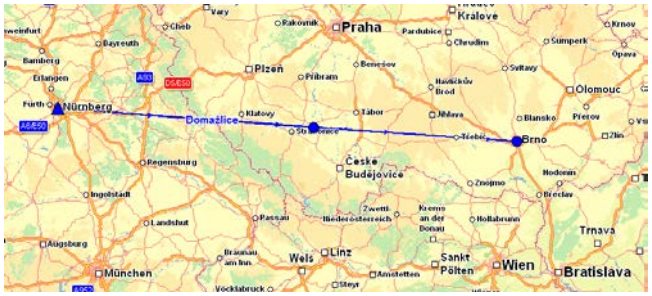

Figure 4. Route Nurnberg -Pisek-Brno (Optimizing XYZ)

Table 8. Savings of the clients A and B as a result of cargo consolidation

Route	Car type	Distance	Feet	costs [€]
Suppliers -> Pisk	6t	995	4	896,00
Suppliers -> Brno	6t	1302	4	1 141,60
Current Total client Cost A				896,00
Current Total client Cost B				1 141,60
Suppliers -> Nurnberg -Pisek	consolidation			502,76
Suppliers -> Nurnberg -Brno	consolidation			499,65
Nurnberg -> client A Pisek	24t	496		290,25
Nurnberg -> client B Brno	24t	496		354,75
The proposed total client cost A				793,01
The proposed total client cost B				854,40
Client weekly savings A				-102,99
Client weekly savings B				-287,20
Annual client savings A				-4 943,41
Annual client savings B				-13 785,63

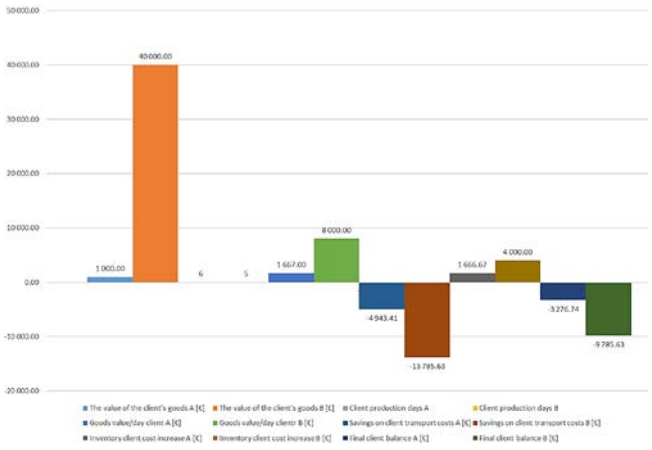

Figure 5. The comparison of transport savings and inventory losses of the clients A and B

The benefits for client A will be three thousand euro, and for client B will be almost ten thousand (Fig. 5).

4 CONCLUSIONS

Ongoing process of globalization changes needs and expectations of the business entities, which are the users of services offered on the transport market. An effect of economic changes is the growth of demand for transport, which, on the one hand, is a factor supporting globalization, on the other hand, it is also a subject of globalization.

Logistic centres providing consolidation services is a very significant element of the whole supply chain, supporting the process of delivery of goods to the point of destination.

The main goal of the authors of this article was to define the role of lowering the costs of transport as a result of consolidation of supply chain in the aspect of sustainable development of transport. The authors of this article:

- conducted an analysis of current transport organization of the client A and client B.
- assigned particular suppliers to the warehouses towards terminal network of Transport Enterprise providing consolidation services.
- presented calculation of the costs of cargo consolidation, considering transport and handling costs.
- conducted an analysis of the impact of change of a transport organization on inventory costs.
- conducted an analysis of costs of client A and B with proposed consolidation solution.

As a result of conducted research and analyses, it can be concluded that cargo consolidation lowers the costs of transport in the supply chains and also contributes to sustainable use of transport.

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