COMPARISON OF OPERATIONAL AND ECONOMIC ASPECTS OF DIRECT ROAD TRANSPORT AND CONTINENTAL COMBINED TRANSPORT

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Abstract

The aim of this paper is to compare economic and operational aspects in the transition from direct road transport to unaccompanied CT using intermodal road semitrailers. A comparison of specifications of transport units was carried out as well as the risk assessment, considering the probability of a critical situation occurrence. Both of these factors are key for the final decision making.

As a main part of this research paper, a comparative case study was conducted. For the purposes of this comparison, data from actual transport orders were used on a route starting in the Czech Republic, going through the industrial Northwest of Germany and then to Belgium and the Netherlands.

As a result of this research, the direct cost of road transport and CT were compared considering the lifespan of the used equipment. Besides that, the investment cost for a road carrier to enter the CT system was quantified, which is essential for the CT system development.

Keywords: Intermodal transport, semi-trailer, road transport, economic comparison.

1. Introduction

Intermodal transportation is the therm being used to describe the movement of goods in one and the same loading unit or vehicle which uses various modes of transport [1]. It has become an important sector in decreasing transport costs. As the problems in this area are often very complex, the number of intermodal transportation researches has recently increased. A detailed literature survey is reviewed in [2], where authors described the scientific knowledge base. Research [3] is focused on the operational research techniques being applied to support decision making in various modal transfer problems. A scientific papers [4] and [5]analyses the handling technology as well the economic effectiveness of transhipments of good with usage of combined transport.

There are a lot of scientific papers, such as this one, is focused directly on specific case study. This paper deals with transferring a part of road transport to the railway, where the Modal Split is still developing negatively.

To reverse this unfavourable trend, it is necessary to transform a part of road transport into different modes of transport that are more environmentally friendly. The main aim of purchasing transport units is to support more environmentally friendly types of transport.

Transforming a part of road transport into other, more environmentally friendly modes of transport using combined transport ("CT") creates favourable conditions for reducing the traffic-related environmental burden of the territory. This aim is in line with the general strategy of the Ministry of Transport ("MT") (i.e. mainly to improve the availability of transport services and the quality of infrastructure in the Czech Republic while respecting the

principles of sustainable development). MT intends to reduce the negative impacts of transport on the environment and improve the living conditions in the Czech Republic using a motivational tool, i.e. support from public resources (Czech state budget, EU Structural Funds) [6].
The support will predominantly encourage the implementation of those measures that will increase the continental transport using transport units. The support in question will serve as a motivation for the forwarder (carrier, shipper) that has been so far using road transport, to use CT. The potential risk connected with entering a new segment will be offset by the reduction of costs of investment into necessary technological equipment as continental CT transport units can be used.
The aim of this paper is to compare economic and operational aspects in the transition from direct road transport to unaccompanied CT using intermodal road semitrailers. For the purposes of this comparison, data from actual transport orders were used on a route starting in the Czech Republic, going through the industrial Northwest of Germany and then to Belgium and the Netherlands. The data came from the period between 01/2016 and 05/2016. The comparison was based on actual traffic in identical streams of traffic on the sample route Prague (CZ) -Venlo (NL, B) -Prague (CZ) for direct road traffic; for continental CT, the same route was used with container freight stations in (CZ) CD-DUSS Lovosice and DUSS Duisburg.
The sample transport was performed in direct road transport with a one-man crew; in CT, transport on the first and last miles was performed with a one-man crew as well. The shipping volume was identical; what is only discussed are intermodal road semitrailers in terms of the cost of investment and direct and indirect costs related to the transition from direct road transport to combined transport.

2. Comparison of specifications of transport units

For road transport, a regular road semitrailer (SDP 27 ELB) was used; for continental CT, an intermodal road semitrailer (SDP eLHB 3-CS) from the same manufacturer (Krone) was used. The following table contains data relevant for investment decisions in purchasing a transport unit (see Table 1) [7 and 8].

Comparison of specifications of transport units Table 1

Item		Regular road semitrailer (Krone SDP 27 ELB)	Intermodal road semitrailer (Krone SDP eLHB 3-CS)	Difference
1	Purchase price [EUR]	24,350	25,400	1,050
2	Additional equipment T&T [EUR]	---	1,000	1,000
3	Total purchase price [EUR]	24,350	26,400	2,050
4	Tare weight [kg]	6,400	6,980	580
5	Maximum gross weight [kg]	36,000	39,000	3,000
6	Lifespan [years]	6	6	0
7	Loading capacity [m^3]	100	100	0
8	Maximum net weight in CT [kg]	---	28,520	28,520
9	Maximum net weight [kg]	25,100	24,520	-580

Source: Krone, [9], authors

The used transport technology is to meet requirements as to loading capacity, carrying capacity, manipulation in loading and unloading of goods and transport security. The transport units compared meet these basic parameters with the exception of payload; if the SDP eLHB 3-CS semitrailer is used for direct road transport, the carrying capacity is lower by 2.3%. This difference is caused by the presence of a construction necessary for vertical manipulation, and it is not a limiting factor. The inner loading capacity, construction of closures and load fixing are identical with the road type.

What is a decisive factor is the cost of investment and lifespan of the individual types. As for the lifespan, it can be noted that when renewing the fleet every six years (72 months), this factor is comparable for both modes of transport (for bookkeeping purposes). In comparing the prices of a regular road semitrailer and an intermodal road semitrailer, higher costs of investment are to be expected for the SDP eLHB 3-CS semitrailer. For comparison, prices of investments made in 01/2016 were used. The present value is the same, and therefore the data used is considered sufficiently current, and even the future price development of the semitrailers in question will not be very different. The long-term development of prices is around +/- 3.5% (this variation is related to the demand for intermodal road semitrailers). If the demand increases, the price will likely remain on the current level. Another price element allocated in the investment is the independent tracking unit (T&T). This device is similar to the one used in direct road transport, where it is situated in the vehicle (truck). As we were comparing identical transport operations, the carrier was to maintain the same level of services including on-line transport tracking, and to meet insurance conditions, i.e. to track the goods carried. As can be seen from the comparison of total costs of investment per unit, the SDP eLHB 3-CS semitrailer was more expensive by EUR 2,050, i.e. 8.42%, having comparable lifespan and technical specifications [10 and 11].

3. Risk analysis

Another factor in decision making is the risk index for critical situations in CT. We compared the impact rate, having considered the probability of occurrence of the risk 16 (see Table 2). The risk level was established based on key indicators in performing the transport in accordance with the SLA (Service Level Agreement). For comparison, a 1-5 scale was used; 1 being a low risk and 5 being a high risk [12 and 13].

Comparison of risks in performing the SLA

Table 2

Item		Regular road semitrailer (Krone SDP 27 ELB)	Intermodal road semitrailer (Krone SDP eLHB 3-CS)
1	Risk of accident	3	2
2	Capacity of infrastructure	2	4
3	Impacts in case of (traffic closures, strikes, etc.)	2	4
4	Flexibility in extraordinary events	3	4
5	Optimisation and flexibility in selecting (un-)loading sites	2	3
6	Impacts of transport restrictions	3	2
	Average risk weight	**2.5**	**3.17**

Source: [12 and 13], authors

This comparison is a very important factor in decision making. Generally, the risk in CT is by 0.67 point higher. In the future, the risk can be generally eliminated in section 2 (capacity of infrastructure), where an improvement in rail capacity can be foreseen; however, this improvement will occur over a longer period of time. For sections 3 and 4, where the impacts of extraordinary events can be very negative, there is a potential for improvement in the development of continental CT (increasing the number of connections and container freight stations). The progressing rail liberalisation could also lead to greater flexibility and reliability of rail carriers.

4. Comparison of performance on a sample of transport operations

For the purposes of the comparison, traffic data was used from a sample of transport operations made on the route between Prague (CZ) and Venlo (NL) and back. As a basis, we used the volume of transport performed by direct road transport in comparison with the volume of transport performed by CT in a way that the volume of goods transported was the same for the period between 01/2016 and 05/2016. The number of transport operations is a set of operations with a common starting and finishing point – an area close to Prague and Venlo (see Table 3). What was compared was the number of units necessary to perform the same number of transport operations. The difference of one transport operation [6] was caused by the fact that the date of completion was postponed, which has no significant impact on the result of the analysis. In comparing the data, the difference in allowable weights for CT was taken into account. However, the advantage of a greater allowable weight cannot be used very often, and it cannot be relied on for the following reasons [14 and 15]:

1. in case of rail failure, such cargo cannot be transported,
2. the volume of transport with a higher weight varies between destinations,
3. the dual system of shipment dispatching road/rail is problematic for clients.

Comparison of performance on a sample of transport operations Table 3

Item		Regular road semitrailer (Krone SDP 27 ELB)	Intermodal road semitrailer (Krone SDP eLHB 3-CS)		Difference
1	Sample of transport operations [number]	600	599		-1
2	Number of units deployed [number]	10	18		8
3	Average number of trucks [number]	10	4*	6**	0
4	Average number of journeys per unit [number]	60	31.53		-28
5	Kilometres by road [km]	466,800	68,885		-397,915
6	Average duration of one order per one unit [hour]	48.50	71.25		22.75
7	Other non-productive time	1.5	5.50		4
8	Utilisation index (ratio of full and empty kilometres) [%]	93	89		4
9	Number of incidents (accidents, damages)	1	3		2
10	Indirect costs (parking fees, etc.) [CZK]	6,000	8,000		2,000
11	Number of delays shorter than 2 hours [number]	6	12		6
12	Number of delays shorter than 5 hours [number]	0	20		20
13	Number of delays longer than 5 hours [number]	0	5		5
14	Number of delays longer than 12 hours [number]	0	15		15

** Note: 4 trucks were sufficient mainly for short collections and distributions to/from CT container freight stations in the Czech Republic (fewer kilometres driven); also due to greater quality of services provided by CT container freight stations and longer time windows at customers'.*

*** Note: 6 trucks were deployed due to longer collections and distributions to/from CT container freight stations* *in Germany (more kilometres driven); also due to lower quality of services provided by CT container freight stations and limited time windows at customers'.*

Source: [16], authors

The comparison of number of units deployed is 10/18 to CT's disadvantage. This is directly related to the average number of journeys made by one unit (approx. 32 for intermodal road semitrailers). This data is very important as it directly influences the amount of investment necessary in the transition from direct road transport to CT. In the following assessment of transit times and economic comparison, a ratio of 10/18 will be considered. This difference between the actual number of units and the number of units technically possible is caused by what has been outlined in the risk analysis, i.e. by the influence of a greater risk of unreliability and seeking solutions in extraordinary events, where it is necessary to increase capacities, reserve spare capacities, etc. For the calculation of economic impacts, we considered a more favourable ratio (1/1.47) (see Table 4). However, this ratio can only be used when there are more units deployed (at least 12 - 15).

The duration of one transport operation and other non-productive times are a limiting factor for the transition to CT for two reasons:

1. profitability of investment is on the side of the carrier,
2. customer's need to increase the volume of goods to ensure the continuity of supplies, i.e. the increase of stocks transported by road.

This aspect was not quantified as the amount of data is not sufficient and its exact allocation would be very problematic. However, it can be said with certainty that the costs of investment increase dramatically as a result of this ratio, i.e. by approximately 70% as compared to road transport.

The comparison also discusses costs related to the stay of semitrailers at container freight stations or parking lots in non-productive times (the number does not express amortisation, but parking fees). Due to a higher number of non-productive hours and higher parking fees, the costs for CT are by approximately 70% higher; however, in absolute terms this increase is not significant. Nevertheless, it is included in the economic comparison for the sake of objectivity.

The number of trucks necessary was also compared. Due to schedules and related risks, the number of trucks is the same. What is limiting for CT is the necessity to supply goods in a continuous way. This is due to the nature of orders and the transition from road transport that is very competitive in terms of flexibility and speed. In the future, this can be improved by a higher train frequency or schedule optimisation (or a greater capacity provided by train connections) so that non-productive (waiting) times could fall outside of working hours in which customers dispatch or receive goods.

5. Comparison of transport cycle duration

For both types of transport, the comparison of transport cycle duration was based on the time of the loading of shipment and time of goods reception, where the working hours of the recipient and dispatcher were the same (see Table 4). Besides that, actual train schedules were considered.

Comparison of transport cycle duration per one transport operation Table 4

Item		Regular road semitrailer (Krone SDP 27 ELB) [hour]	Intermodal road semitrailer (Krone SDP eLHB 3-CS) [hour]
1	Time spent loading	1.00	1.00

2	Time spent driving the "first mile"	---	1.50
3	Time spent reloading goods at container freight station, waiting for connection	---	11.25
4	Duration of journey	10.75	17.00
5	Safety breaks	9.75	0.00
6	Time spent reloading goods at container freight station, waiting for connection	---	1.00
7	Time spent driving the "last mile"	---	1.00
8	Time spent unloading	1.00	1.00
9	Time spent driving to loading site	1.00	1.00
10	Time spent loading	1.00	1.00
11	Time spent driving the "first mile"	---	1.00
12	Time spent reloading goods at container freight station, waiting for connection	---	2.00
13	Duration of journey	10.75	18.00
14	Safety breaks	9.75	0.00
15	Time spent reloading goods at container freight station, waiting for connection	---	1.00
16	Time spent driving the "last mile"	---	1.50
17	Time spent unloading	1.00	1.00
18	Average duration of idle time spent in congestions	2.5	11.00
19	**Total duration of transport**	**48.50**	**71.25**
20	**Ratio of transport cycle duration**	**1.00**	**1.47**

Source: [4], authors

The results provide a clear insight into productive and non-productive times (see Table 4). To a great extent, this sample can be generalised for other CT routes as well.
In CT, the greater share of non-productive times is largely caused by the lower frequency of trains, i.e. by the necessity to park the transport units at container freight stations when waiting for the train connection according to the schedule. This factor probably cannot be offset completely; however, with the increasing number of users and transport units involved in the CT system, it can be assumed that there will be more train connections, i.e. more frequent train departures, and these non-productive times will be partially eliminated. Nevertheless, this ratio will always be significantly higher.

6. Comparison of direct costs

The transition to intermodal transport is considered both in terms of increasing costs and savings. These set values are related to a set sample of transport operations, allocated to units with a set time of use of six years (72 months).
The higher costs are mainly generated by the higher purchase price of intermodal road semitrailers; however, the decisive factor is the necessity to purchase a significantly greater number of these specialised semitrailers, than it is the case for direct road transport (at least 12). In terms of savings, road tax relief can be considered; however, there is a significant risk in the event the carrier cannot use the rail even for objective reasons (closures, strikes, etc.). In those cases, the carrier is to pay the tax (or a certain percentage of the tax based on the number of journeys made in CT). Costs related to tyres and servicing can also be saved.
Drawing a general comparison, the cost of investment for a road carrier to enter the CT system is higher by 48% compared to investment in vertically manipulatable units. From this point of view, the investment support within the Operational Programme Transport is very appropriate. The difficulties of maintaining sustainable operation of CT by a road carrier (i.e.

further development, renewal, etc.) are known from previous experience, as in 2009, public support was granted primarily for the purchase of intermodal road semitrailers (see Table 5).

Comparison of direct costs of directs road transport and CT for a lifespan of 72 months

Table 5

Item		Regular road semitrailer (Krone SDP 27 ELB)	Intermodal road semitrailer (Krone SDP eLHB 3-CS)	Difference	
				EUR	%
1	Purchase price [EUR]	24,350	26,400	2,050	8.42
2	Indirect costs (parking fees, etc.) [EUR]	2,667	3,556	889	33.33
3	Road tax [EUR]	2,777	0	-2,777	-100.00
4	Servicing costs (tyres, etc.) [EUR]	9,500	3,500	-6,000	-63.16
5	Ratio of transport cycle duration	1.00	1.47	-0.47	47.00
6	Actual ratio of transport units, taking into account the risk index	1.00	1.74	-0.74	74.00
7	**Total costs (investment cost ratio)**	**39,294**	**58,070**	**18,776**	**48.00**
8	Indirect conversion costs (operating control, transport management, education, etc.) [%]	4.50	7.00		2.50

Source: [17-22], authors

There is currently no difference between the price of transport on the rail route Lovosice - Duisburg - Lovosice and direct road transport. Distance passed by the road carrier by rail is approximately 650 km in one direction. The difference in prices increases with increasing prices of fuels. What can be foreseen is a considerable lack of drivers. This fact can make the decision making easier, albeit only as an indirect factor.

7. Conclusion

The values stated above were established for a set of intermodal road semitrailers. For other types of transport units (swapbodies, inland containers), it can be assumed that the conditions of support will be the same as in the case of intermodal semitrailers. The only difference between these two groups of transport units will be their price (Table 5, section 1). However, it can be counted on the same support for the elimination of risk connected with entering a new market segment, i.e. of approximately 40% (Table 5).

For the interest of the whole society, transport policies aim to reduce the environmental burden and damaging of public health caused by road freight transport, by transferring certain transport operations to more environmentally friendly modes of transport - rail and ship transport. The support will predominantly encourage the implementation of those measures that will increase the continental combined transport using transport units, mainly intermodal semitrailers and swapbodies.

The main aim of public support within this proposed programme is the purchase of transport units for continental combined transport, which is in line with the aims of the European Union, especially the White Paper – Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, i.e. 30% of road freight over

300 km should shift to other modes such as rail or waterborne transport by 2030. A similar commitment was implemented in the approved Transport Policy of the Czech Republic for 2014-2020 with the Prospect of 2050. It is also in full accord with the approved Operational Programme Transport for 2014-2020, i.e. the specific objective 1.3 Creation of conditions for a greater use of multimodal transport.

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