Analysis of the Intermodal Transport Efficiency in the Central and Eastern Europe

Analiza intermodalne transportne učinkovitosti u Srednjoj i Istočnoj Europi

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Summary

The paper focuses on the problem of the efficiency of the intermodal transport system. Among the factors determining the transport system the key factors of the intermodal transport development in the Central and Eastern Europe were selected. The analysis included: intermodal transport units (ITU), means of transport and transhipment technologies, as well as organization conditions of intermodal connections. In addition, the costs structure of the intermodal delivery was analysed and its impact on the profitability of the whole supply chain. Observations have led to a number of detailed reflections and those are the basis of the following conclusions and recommendations of a general nature related to the region of the Central and Eastern Europe.

KEY WORDS
intermodal transport
transport economics
transport costs

Sažetak

Rad se bavi problemom učinkovitosti intermodalnog transportnog sustava. Među čimbenicima koji određuju transportni sustav odabrani su ključni čimbenici razvoja intermodalnog transporta u Srednjoj i Istočnoj Europi. Analiza je uključila intermodalne transportne jedinice (ITU), tehnologije transporta i pretovara, kao i uvjete organizacije intermodalnih veza. Osim toga, analizirana je struktura troškova intermodalne isporuke, kao i njihov utjecaj na profitabilnost cijelog lanca opskrbe. Promatranja su dovela do brojnih detaljnih razmišljanja te do sljedećih općih zaključaka i preporuka koji se odnose na Srednju i Istočnu Europu.

KLJUČNE RIJEČI
intermodalni transport
ekonomija transporta
troškovi transporta

1. INTRODUCTION / *Uvod*

Road transport is the most used transport branch, primarily due to its flexibility of door-to-door supply, but also because of the most developed and widely accessible infrastructure. Road transport simultaneously has the greatest negative impact on the environment. Additionally, this transport mode faces severe limitations due to the significant congestion on the roads. These two last indicators are increasingly important from the point of view of the efficiency of the transportation system. As a result, for many years political actions have been taken with the aim to limit the expansion of road transport and its market dominance.

An alternative to road transport is intermodal transport, which is supported by politicians in Europe. This transport system is understood as the carriage of cargo in one transport unit, using at least two different modes of transport without handling the goods themselves. The essence of the intermodal transport is the integration of the various transport modes, in such a way as to maximise their positive features, while minimizing the negative effects. The eco-friendly modes of transport, i.e. rail, sea shipping and inland shipping, are used on the longest stretch of carriage, and the road transport plays the supporting role.

The biggest difficulty in the implementation of the intermodal technologies is their low economic efficiency in comparison with the pure road transport. Further analysis will be devoted to the problem of the efficiency of the intermodal transport system. The analysis is based on market data representative for the South-Eastern Europe transport market. Hence the conclusions of the analysis can be applied to that entire region, which is seen as a European area of strong economic growth.

2. DETERMINANTS FOR THE DEVELOPMENT OF INTERMODAL TRANSPORT TECHNOLOGY / *Determinante za razvoj tehnologije intermodalnog transporta*

Bearing in mind the current stage of the whole transport system in Europe, the following key factors determining the economic and technical efficiency of the intermodal transport have been chosen and will be included in the following analysis:

1. the choice of intermodal transport units (ITU),
2. the choice of means of transport and transhipment technology,
3. organization of intermodal connection.

The most widely used ITUs in Europe are containers, swap bodies and semitrailers. Containers are mainly used in maritime based services, swap bodies are used in intermodal rail-road services, and semitrailers are used primarily in the pure road transport. The general development trend of ITUs is to maximize cargo capacity and facilitate handling processes. The process of harmonisation of ITUs parameters and the expansion of possible fields of application are also noticeable. It has an impact on the operating parameters of transport units, which is increasingly similar to themselves in the design and functionality.

A detailed comparison of design and performance features of the most important ITUs is shown in Table 1. It confirms the construction features of containers needed in the sea transport and the high functionality of swap bodies. The huge demand for road transport made semitrailers the most popular transport unit, but in practice they are least suited to the needs of intermodal transport. Swap bodies fully meet the requirements of the intermodal rail-road connections. Unfortunately, the use of swap bodies is subject to the necessary investments in production and distribution technology by shippers. Hence, this unit is very popular in Germany, Austria, Italy and other economically developed countries in the Western Europe. In emerging markets, which include the Central and Eastern Europe, intermodal technologies come down mainly to port-hinterland container services. For example, in Poland, although terminals declare the ability to handle all ITUs, c.a. 98% of their turnover are containers.

In Europe today, we can distinguish three fully implemented intermodal freight technologies:

1. Piggyback
2. Rollende Landstrasse (Ro-La)
3. Modalohr.

Piggyback system is characterized by a vertical transhipment of ITUs and their rail transport on standard platform wagons. Ro-La system is characterized by horizontal transhipment and involves the carriage of the whole road trains (tractors with semi-trailers) on the low-loading rail wagons. Modalohr technology is used to carry semitrailers (without tractors) loaded horizontally on special wagons with twisting bearing part. The last two technologies are less popular but Modalohr has a greater potential for development.

Table 2 shows the differences between the chosen three technologies. Ro-La and Modalohr technology stands out for their simplicity and speed of loading and Piggyback is the most universal intermodal system. All technologies allow to obtain economies of scale, especially using up dense network connections. In the Eastern Europe Modalohr technology is not yet available, for the main development barrier seems to be expensive specialized wagons. Previous attempts to implement the Ro-la technology encountered difficulties in the form of high operating costs.

Table 1 Comparison of characteristics of the intermodal transport units

Tablica 1. Usporedba značajki intermodalnih transportnih jedinica

	Containers	Swap bodies	Semitrailres
Construction	- solid frame - upper and lower corner castings - max. capacity of 33 europallets	- variety of constructions - the lower corner castings - folding supporting legs - max. capacity of 36 europallets	- lightweight frame with road wheels - lower corner castings - max. capacity of 36 europallets
Strengths	- global standard - possible high stacking - adaptation to maritime, rail and road transport - the versatility of usage	- very limited possibility of stacking - adaptation to road and rail transport - suited to the europallets dimensions	- widely used loading unit - adaptation to road transport - suited to the europallets dimensions
Weaknesses	- limited loading capacity - europallets dimensions mismatch	- European standard - flat and stable ground needed for supporting legs - not suitable for containerships	- stacking not possible - not suitable for containerships - high unladen mass

Source: own elaboration

Table 2 Comparison of intermodal transport technology

Tablica 2. Usporedba tehnologije intermodalnog transporta

Piggyback	Ro-la	Modalohr
- terminal handling equipment needed (gantry, reachstackers) - the medium and large size terminal - suitable for containers, swap bodies, semitrailers - vertical transhipment - landing time depends on the number of wagons and used handling equipment - standard wagons - effective gross mass/cargo mass ratio of loaded wagon	- terminal equipped with simple ro-ro ramp - low-cost small terminal - suitable for road trains - horizontal transhipment - landing time depends on the number of wagons - expensive wagons with high operating costs - highly ineffective gross mass/cargo mass ratio of loaded wagon	- terminal equipped with specialised transhipment stands - medium-cost small terminal - suitable for semitrailers - horizontal transhipment - speedy simultaneous loading of multiple cars - very expensive and hardly available wagons - ineffective gross mass/cargo mass ratio of loaded wagon

Source: own elaboration (Wiśnicki B., 2006) (Chwesiuk K.; Wiśnicki B.; Kotowska I., 2008)

Organisation of intermodal connections depends largely on the amount of ITUs to be transported. Direct terminal-to-terminal intermodal trains could be divided based on the following operational schemes (tab. 3):

1. block trains,
2. shuttle trains,
3. line trains.

A characteristic of block trains is direct carriage between origin and destination terminals without shunting operations on intermediate terminals. The number of wagons in the block train depends on the number of ITUs. The shuttle train is the high-speed train servicing according to a specific timetable while maintaining permanent wagons settings. As a general rule, operator's offers a large frequency of shuttle trains, minimum five times a week. Line trains core technology is based on the regular intermodal lines with possibility to transfer ITUs between trains in railway hubs.

The most cost-effective are shuttle and line trains. Subject to start these intermodal services is a high market demand balanced in terms of relationships. Economies of scale provide intermodal transport network in which trains' schedules are correlated and their distribution is tuned to the needs of the market.

3. MEASURES OF THE INTERMODAL TRANSPORT EFFICIENCY / *Mjerenje učinkovitosti intermodalnog transporta*

Important factor for the competitiveness of any transport system is the total time of door-to-door service. Comparing the total delivery time based on pure road transport and intermodal transport in most cases is beneficial for road transport. It should be noted that during the carriage of cargo by intermodal additional transhipment operations are necessary. During these operations a process of cargo delivery is "temporarily suspended", which significantly affects the total time of transport.

The biggest weakness of the road transport, which has a huge impact on the total delivery time are road congestions. It could be a number of reasons of congestions on roads, from unexpected accidents, through the change of traffic, infrastructure bottleneck, until the bad weather conditions. Another significant cause of delays in road transport, are temporary restrictions of heavy vehicles movement. Restrictions apply to traffic on certain roads, days (e.g. weekends) or certain daily hours.

Another factor of the utmost importance for the efficiency of the transport system are the costs of transport services. We assume that the costs are borne by the transport operator and shifted on a customer to whom the service is sold. In fact, the following costs could be distinguished (Bąk M., 2010):

1. the cost incurred by transport operator (internal transport costs),
2. the costs incurred by the State budget for public transport investments,
3. the costs incurred by the society (external transport costs).

In a market economy the internal transport costs are in full extent included in the prices of transport services. External costs are subject to external entities which are not associated directly with the transport service, that bear these costs without their consent. External transport costs, due to infrastructure constrains and unwanted side effects, manifest themselves in the form of:

1. excessive noise,
2. congestion,
3. accidents,
4. air pollution.

Currently, in the vast majority of cases, the calculation of the price for transport service takes into account only the internal transport costs. Budgetary and external costs are taken into account in the full economic analysis carried out for the purpose of the feasibility studies of the transport investment projects, in particular those funded by public money. However, the EU political strategy aims at gradual transfer of all costs, including external costs, to entities that have contributed to them. It can be assumed that in the few years the full cost analysis taking into account all of their forms will be the standard procedure.

Since each mode of transport has its own specific costs each of them has a different maximum distance to ensure the profitability of the services. For example, in Europe rail transport is profitable at distances above 500 km, based on the internal cost of that transport mode. The same distance refers to the profitability of the intermodal road-rail connections. The break-even distance should be significantly reduced if the external costs are taken into account. At the time being, the road transport, is the economic choice at short and medium distances. Intermodal transport uses the advantages of both modes of transport, combining them into a single smoothly functioning system.

4. ANALYSIS OF THE ECONOMIC EFFICIENCY OF THE INTERMODAL TRANSPORT CONNECTION / *Analiza ekonomske učinkovitosti intermodalne transportne veze*

The analysis is based on the selected transport relationship, i.e. Hamburg-Wroclaw, which is representative for the South-Eastern Europe transport market. The comparative analysis will cover two variants of the delivery systems, intermodal transport and road transport. It is assumed that in the relation 40' container is transported on door-to-door basis. The total distance of delivery is more than 600 km, depending on the choice of transport mode and routes. The analysis assumes the standard conditions of carriage services and costs associated with it.

Total delivery time for intermodal transport includes rail section (27h) and hauling (2,5h). The total duration of road transport with the inclusion of provisions relating to driver's working time is 9h 15min (table 3). The given delivery times relate to a situation where there are no obstacles on the road and rail infrastructure affecting the implementation of services.

Table 3 Distance and delivery time in road and intermodal transport

Tablica 3. Udaljenost i vrijeme isporuke u cestovnom i intermodalnom transportu

	Intermodal transport	Road transport
Distance	600 km	665 km
Total delivery time	29 h 30 min	10 h 15 min

Source: own elaboration

Intermodal rail-road transport costs include the costs of freight forwarding, rail carriage and container handling operations. The last cost covers the expenses related to several transhipment operations: rail wagon loading at the port of Hamburg, transhipment train-train at the intermediate terminal in Frankfurt/Oder, transhipment wagon-semitrailer at the terminal in Brzeg Dolny and final unloading at the place of destination. Road transport costs include the cost of freight forwarding, semi-trailer carriage, handling operations at the port of Hamburg and the motorways tolls. The costs of unloading at the final destination are not included as usually shall be borne by a recipient.

Table 4 Internal costs of intermodal transport and road transport

Tablica 4. Interni troškovi intermodalnog i cestovnog transporta

Categories of costs	Costs [EUR]	
	Intermodal transport	Road transport
Transhipment	153	95
Main carriage	1200	1100
Forwarding	120	120
Supporting road transport	100	-
Tolls	-	102
Total	1573	1417

Source: own elaboration

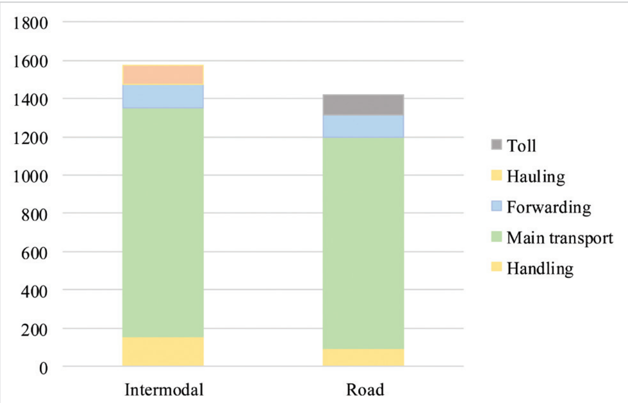

Figure 1 Internal costs structure of intermodal transport and road transport

Slika 1. Interna struktura troškova intermodalnog i cestovnog transporta

Source: own elaboration

Structure of internal costs of the intermodal transport shows that rail carriage has 76% share in total costs (fig. 1). Similarly, among the costs of road transport the largest 77% share has a main road carriage. Cargo handling constitutes 10% of the total costs in case of intermodal transport and only 3% in pure road transport. The comparison shows the huge impact of railway fares and service charges in road transport which largely determine the cost-effectiveness of both transport variants. Other internal costs do not significantly influence the aggregated costs.

In order to assess the external effects of transport the web-based calculator EcoTransIT (www.ecotransit.org) is used. The most important indicators of the negative effects on the environment is the consumption of energy and the emission of carbon dioxide (CO_2) into the atmosphere. There are also other harmful gases arising during transport, i.e. sulphur dioxide (SO_2) and oxides of nitrogen (NO_x), but their quantity is much smaller.

In rail transport, most important factors affecting the level of external effects are: a train load, a type of locomotive (diesel/electric) and a train speed. For the road transport, the key factors include: the quality of vehicle's engine, which partly depends on its age, the fuel type, vehicle's speed and load factor. It should be noted that a specific transport options on the route Hamburg-Wroclaw are very similar for both variants of transportation, which is about the reliability of the comparisons made.

Intermodal transport due to the use of locomotives supplied with electric traction it consumes half the energy in comparison with the road transport on the route Hamburg-Wroclaw (fig. 2). By comparing the level of CO_2 generated, which is the most harmful greenhouse gas, road transport (engine of euro IV class) shows three times higher emissions than the intermodal transport. Road transport emits significant quantities of NOx, which is responsible for the "acid rain" and harmful smog, and this emission is 83% higher than in the case of the integrated transport. Analysis of SO_2 emissions shows slight difference between the variants analysed.

In summary, intermodal transport generates up to 66% less harmful gases than the road transport on the Hamburg-Wroclaw route. The energy consumption is also reduced by 45% in the case of the intermodal transport, suggesting the ecological nature of the transport system. External effects presented give rise to determine the external costs of both transport variants. In order to calculate the external costs, these

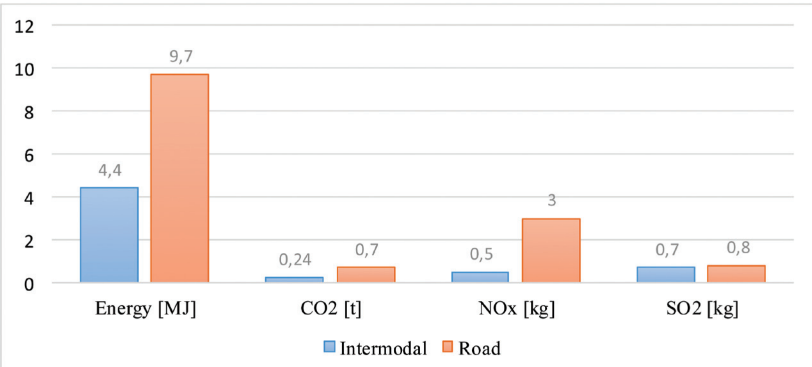

Figure 2 External effects of intermodal transport and road transport

Slika 2. Vanjski učinci intermodalnog i cestovnog transporta

Source: own elaboration (EcoTransIT)

web-based calculator EcoTransIT and other literature sources are used (Essen et al., 2008). Results are presented in tabular and graphical form (tab. 4, fig 3)

Table 4 External costs of intermodal transport and road transport

Tablica 4. Vanjski troškovi intermodalnog i cestovnog transporta

Categories of costs	Costs [EUR]	
	Intermodal transport	Road transport
Greenhouse gases	17	159
Noise	6	12
Congestion	2	76
Accidents	8	56
Total	33	303

Source: own elaboration (EcoTransIT) (Essen et al., 2008)

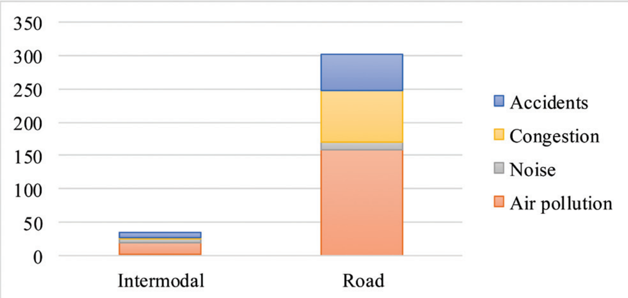

Figure 3 External costs of intermodal transport and road transport

Slika 3. Vanjski troškovi intermodalnog i cestovnog transporta

Source: own elaboration (EcoTransIT) (Essen et al., 2008)

The comparison shows a significant advantage of intermodal transport comparing to pure road, transport, because the first generates 87% less of the external costs. It is confirmed the economic efficiency resulting from the positive environmental impact of the intermodal transport. The analysis indicates that the highest amounts of the road transport external costs are related to air pollution (49%), and in the next place are the cost of congestion (24%) and cost of accidents (17%).

5. CONCLUSION / *Zaključak*

One cannot make firm conclusions on the development of transport technologies and their profitability in the longer term. The intermodal transport is particularly difficult to assess in that context, because the amount of factors determining the development is greater in comparison with other transport systems. These factors apply to technical and economic issues, but also political ones, since the intermodal transport is largely supported by the actions implemented in the framework of transport policy strategies. The political issues were not the subject of the analysis, which included the selected key factors of the intermodal transport development in the Central and Eastern Europe. The analysis included: intermodal transport units (ITU), means of transport and transhipment technologies, as well as organization conditions of intermodal connections. In addition, the costs structure of the intermodal delivery were analysed and their impact on the profitability of the whole supply chain. Observations have led to a number of detailed reflections and those are the basis of the following conclusions and recommendations of a general nature, relating to the region of the Central and Eastern Europe:

1. Dominance of the standard container units is justified by the low demand on the alternative ITU generated by companies in the region. Implementation of modern logistics solutions, increase of the continental trade between EU countries, investments in transport infrastructure – should change the generic structure of ITU on the regional market. It is reasonable to claim that increase share swap bodies, primarily in transport relations with the Western Europe and Scandinavian countries.
2. Total delivery time has a big influence on the choice of the means of transport and transport technologies and in the vast majority of cases, it speaks for the resignation of intermodal technology. Investments in the field of linear railway infrastructure and intermodal terminals should change this situation by encouraging shippers to move away from the road transport. Road transport door-to-door services shall lose its competitive advantage of speed in a situation of congestion on the road, that this negative effect is incomparably less probable in the rail transport.
3. Supply chain based on the intermodal transport is are more efficient if direct shuttle trains are used. Their regular scheduled service gives a very important the performance guarantee for shippers. To encourage the intermodal operators to launch new shuttle trains and reduce the economic risk associated with it is recommended to introduce preferential rail infrastructure access fees for this scheme of trains.
4. The process of internalisation of external costs in transport is the most important prerequisite for the implementation of the European sustainable transport strategy. Road transport covering the social costs generated by itself significantly worsen its competitive position on the transport market. The rail transport would gain the customers, because its minimum profitability distance would drop to the level of. 300 km. More demand for railway services would be the most effective factor in stimulating the development of intermodal transport.
5. The process of internalisation of external costs in transport should be accompanied by a process of increasing awareness of the negative social effects of the production and logistic processes. End customers through the inclusion in their purchasing preferences such factors as emission of greenhouse gases and congestion, will exert effective pressure on logistics operators influencing the choice of eco-friendly modes of transport.

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