THE TRADE-OFF BETWEEN ROAD AND RAILROAD FREIGHT TRANSPORT – COST BENEFIT ANALYSIS FOR SLOVENIA

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ABSTRACT: *The choice of transportation mode for freight transport has a profound effect on logistics companies, infrastructure providers and society as a whole. The efficiency of freight transport is important because it has a profound effect on several economic and environmental factors. The paper analyses the costs difference between railroad and road freight transport. The stakeholder analysis is used to enable the identification of the interests of various groups. The government is identified as the focal stakeholder. The governmental decision support model that focuses on the Slovenian case of road and railway freight transport is proposed. The proposed model can serve the government with its decision-making process when adopting policies that concern road and railroad transport such as subsidies or increased road tolls in order to promote railroad transport.*

Keywords: *freight transport, road transport, railroad transport, government, stakeholder analysis*
JEL Classification: R42, O18

1. INTRODUCTION

The choice of transportation mode has a profound effect on logistics companies, infrastructure providers and society as a whole. Often the transportation modes that are optimal for society are overlooked due to the interests of particular stakeholders. Further, strategic decisions in practice are often made based on quick calculations without clearly outlining the underlying assumptions. On the other hand, academic research often suffers from a lack of relevance and is lost in complex mathematical models that do not lead to direct practical use.

A typical example of such a decision is the trade-off between road and railroad freight transportation. For environmental reasons the use of railroads is preferred, whereas due to the costs, time and convenience the road transport usually prevails (Ricci & Black,

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2005). Both the financial and non-financial costs of various choices have to be considered, although this often proves difficult. Such decisions are namely typically made without a careful consideration of all stakeholders. Often, the focus is solely on a few indicators or a single one. A typical example is an exclusive focus on reducing CO_2 emissions, disregarding other, perhaps even more important factors, such as particulate matter, noise and water pollution. Therefore, a more scientific approach is to monetise all the decision variables and to provide a cost-benefit analysis (Annema, Koopmans & Van Wee, 2007).

The interests of various actors (government, infrastructure operators, carriers, shippers) need to be analysed. An important contribution of our paper is thus the identification of variables that influence governmental decisions when promoting either road or railroad transport. We identify and compare different costs associated with rail and road freight transport and assess the costs of changing modes for such transport. In order to make such comparison possible we monetise all the identified costs. The analysis is deliberately simple enough to allow it to be repeated in various environments and with different input variables. In addition, the variables and factors not included in the calculation are clearly stated to assure the greater validity and better interpretation of the results.

The structure of the paper is as follows: in the next section we describe different stakeholders and their interests within the scope of the stakeholder theory. We identify the government as the focal stakeholder. We then introduce influencing factors the government as the central stakeholder needs to take into consideration. This is followed by the presentation of the results of the cost benefit analysis. In the last section we summarise the results as well as outline the limitations and proposals for further research.

2. ACTORS AND THEIR INTERESTS

2.1. Stakeholder theory in transport

The paper examines the trade-off between railroad and road freight transport using the existing infrastructure. Stakeholder analysis is used to enable the identification of the interests of various groups and identifying the focal stakeholder via stakeholder mapping. Stakeholders are defined as groups which can affect and/or are affected by the achievement of an organisation's purpose (Freeman, 1984). Stakeholder theory then describes the constellation and cooperation of their cooperative and competitive interests. It also recommends practices, attitudes and structures that constitute stakeholder management. All stakeholders with legitimate interests cooperate to obtain benefits and there is no prima facie priority of one set of interest and benefits over the other (Donaldson & Preston, 1995). Multiple interdependent stakeholders' demands need to be accommodated and organisations need to respond to the simultaneous influences of various stakeholders (Rowley, 1997).

While the stakeholder analysis is most often used to examine stakeholders at the organisational level it can be used to examine the industry-level situation as well. See e.g. Byrd

(2007) who analysed stakeholders in tourism development to investigate how planners and developers should involve stakeholders in the development of tourism. The development of transport infrastructure can be approached in a similar way.

The stakeholder analysis is particularly appropriate for the analysis of logistics because of the multiple and sometimes ill-defined and conflicting objectives expressing the values, needs and aspirations of the various stakeholders involved in and affected by the planning and operation of inter-modal transport facilities (Zografos & Regan, 2004). Further, the decisions affect a wide array of individuals and companies, not only primary but also secondary stakeholders (e.g. individuals who suffer in traffic jams or due to transport-caused pollution). A typical example is the State of Georgia's Department of Transportation that conducts stakeholder audits to identify stakeholders' interests and obtain their cooperation. All these are needed to succeed in its mission of providing a safe, seamless and sustainable transportation system in Georgia that supports the state's economy and is responsive to citizens' concerns and its numerous other primary and secondary stakeholders (Thomas & Poister, 2009).

There are many evaluation criteria for evaluating decisions, e.g. financial costs, hazardous gas emissions, congestion levels or energy consumption. Evaluation criteria for each stakeholder need to be determined (Brewer, Button & Hensher, 2005). Analysing the positions and interests of stakeholders is vital for effective environmental conflict management (Elias, Jackson & Cavana, 2004). In order to encourage meaningful commitment from industry, government has a major role to play in facilitating the environment for such participation in the provision of transport infrastructure (Hensher & Brewer, 2001). Different aspects have to be taken into account and the consequences of the projects are usually far reaching and the different policy alternatives are numerous and difficult to predict (Macharis & Bontekoning, 2004). The analysis of stakeholders assists in identifying the types of strategies, responses and postures that may be adopted by firms in addressing transport reform, e.g. the effects on climate change (Martin & Rice, 2010).

Several different stakeholders are involved when considering road transport vis-à-vis railroad transport. Each actor has its own interests which can lead to conflicts between the actors. In the following subsection we identify and analyse the stakeholders that are likely to be affected by activities that promote either road or railroad transport. The government is identified as a focal stakeholder that tries to pursue goals that are best for society as a whole. Other stakeholders such as infrastructure operators, transport providers and shippers are also discussed as vital stakeholders since the policies directly affect them.

2.2. Government and other stakeholders

The government is often seen as just another stakeholder, analogous to the way in which some popular political models portray business as just another interest group competing for political favours. However, government is far more than that because it is the major player in the public policy process. The government is the only entity with the legitimacy to speak for society as a whole and can thus change the way corporations and industries are governed and managed (Buchholz & Rosenthal, 2004).

One of the foremost concerns for the government is economic growth which is importantly influenced by the country's capability to provide its business environment with state-of-the-art transport infrastructure (Sanchez-Robles, 1998). However, building such infrastructure is costly. Compromises are therefore made when deciding on which infrastructure to invest in. With the limited governmental budgets it is not possible to build the entire necessary infrastructure for all transportation modes. Therefore, it is in the government's best interest to invest in the transport infrastructure that will yield the best results as measured by monetary or some other gains (Sanchez-Robles, 1998). External cost variations can also have different impact on distribution network design (Ortolani, Persona & Sgarbossa, 2011). There are several reasons why infrastructure investment and planning execution is difficult: a lack of relevant data and in-depth analysis, a lack of transparency in national investment planning, biased ex-ante appraisal and a lack of ex-post analysis of investment projects (Short & Kopp, 2005). A cost-benefit analysis should provide a single method across different infrastructure projects overseen by different ministries. However, in Dutch case only half of the analyses of infrastructure projects helped in the decision-making process, while the other half had weaknesses with respect to their methods and assumptions (Annema, et al., 2007).

Another important interest of the government is tax and duty collection. Fuel taxes and duties vary significantly between different countries but they nevertheless represent an important state income. The share of taxes in fuel prices can be high such as in Europe (64% in the United Kingdom, 63% in Germany, 62% in France, 51% in Slovenia (OGRS, 2006) or low such as in the United States (18%) (Davis, Diegel & Boundy, 2011). Therefore, when optimising its tax and duty gains the government needs to evaluate whether to promote road or railroad transport. Yet, other types of costs connected to either transport mode also need to be considered (Macharis & Bontekoning, 2004). The evaluation also needs to include the available energy resources and the impact on the environment which will be discussed next.

Environmental protection is another important interest of the government. It is in the government's interest to lessen the environmental impact of transport. There are differences between the environmental impact of each of the discussed transportation modes on a micro or a macro scale, where the micro scale includes areas in the proximity of the transport routes and the macro scale is the effect on the wider areas.. One example of decrease of environmental effects is the Russian-Finnish case where a modal shift from roads to railroads has been proposed in order to promote green transport practices. This shift has largely been prevented by insufficient infrastructure and equipment (Padilha & Hilmola, 2010).

The interests described above are interwoven which means that the government needs to weigh the different effects. This can be done by monetising the effects and seeking the financial optimum.

Highway and railroad operators share the same interest: to maximise profit. Both can either be publicly-owned or private companies. In either cases a public-private partnership is established in the form of concessions or franchises where a private company either operates the service, provides the infrastructure or both (McQuaid & Scherrer, 2005). Generally, the companies operate within a certain governmentally imposed framework; the government is therefore always involved as a stakeholder, either directly via governmental ownership or indirectly via governmental regulations.

Transport via highways or railroads means more revenue for operators on one side, but also higher maintenance costs on the other, irrespective of who owns the infrastructure. However, an increase in traffic does not linearly increase operating costs due to the automation of some of the operating processes such as toll collection (Massiani & Ragazzi, 2008). Another limitation is the capacity of the infrastructure (Abril et al., 2008).

Similar to operators, transport providers also follow the same goal, namely, to maximise profit. Transport providers can use different transport modes to meet the needs of their customers. For example, a road transport provider can load their vehicles on trains for a certain part of the route. However, they are limited by the costs of infrastructure use. Other limitations include fuel prices, labour costs, emissions (Macharis & Bontekoning, 2004), information quality (Popovic & Habjan) etc. Their interests are therefore to reduce costs in order to lower the cost price and eventually their selling price.

If the desired cost price is not achieved then transport companies need to be stimulated by subsidies from outside stakeholders such as government. There are several programmes at EU and national level which promote the use of railroads as a transport mode (EEA, 2007). According to the European Environment Agency (Best et al., 2007), non-infrastructural subsidies (subsidies not related to infrastructure investments) for rail are significantly higher than for other modes, with rail receiving EUR 33 billion of non-infrastructural subsidies in comparison to only EUR 7 billion of non-infrastructural subsidies received for roads. One such example is the Belgium government which subsidises rail transport in order for it to be able to compete with other transport modes (Pekin et al., 2008).

In most cases, customers do not prefer one of the two discussed transportation options per se. The major deciding factors for shippers are not solely related to transport costs but also include other criteria such as service reliability and connectivity (Cook, Das, Aeppli & Martland, 1999). The choice of mode itself depends mainly on the shipment size (Holguín-Veras, Xu, de Jong & Maurer, 2011).

Based on the stakeholder mapping approach which evaluates power and interest of each stakeholder we can identify the government as the focal stakeholder. (Eden & Ackermann, 2013). The interest in this case is the interest of a particular stakeholder to impose their expectations on the particular decisions regarding road and railroad transport, while the power is the ability of each stakeholder to do so (Olander & Landin, 2005).

The government is identified as a high power high interest stakeholder. Other identified stakeholders are identified as low power, high interest stakeholders.

3. INFLUENCING FACTORS

Based on the descriptions of the interests of different stakeholders in the previous section we conclude that the only stakeholder which does not have a predetermined stance is the government. It has to coordinate the different interests of various other stakeholders by looking for the societal global optimum. Based on a literature review, the major influencing factors involved in such optimisation are economic and environmental.

The first group of factors are economic factors which include economic development and a balanced budget. Economic development can be catalysed by developing transport infrastructure (Sanchez-Robles, 1998). Further, the maintenance of existing infrastructure in itself provides a boost to economic growth (Ighodaro, 2009). A study of governmental capital transport investments in over 50 countries has shown that investments in infrastructure are an important element of economic development (Boopen, 2006). For example, the gap in economic growth between different Chinese provinces was caused by different levels of investments in transport networks (Demurger, 2001). Due to limited budget resources governments need to selectively invest in various projects, including infrastructural ones. A balanced budget is therefore also an important influential economic factor.

The second group of influencing factors encompasses environmental factors associated with different types of transport. Freight transport has undesirable effects on the environment, out of which greenhouse emissions are often considered to be the most prominent (Bauer, Bektas & Crainic, 2010). Emissions from land transport and from road transport in particular, have significant impacts on the atmosphere and on climate change (Uherek et al., 2010). Yet the environmental impact is not limited to CO_2 emissions. For example, fine particulate and sulphur oxide-related pollution are associated with all-cause, lung cancer, and cardiopulmonary mortality (Pope et al., 2002).

Of the two transport modes compared here, road transport is much more polluting than rail transport per tonne-km of goods transported (Santos, Behrendt & Teytelboym, 2010). Rail external costs are about four to five times lower than trucking external costs (Forkenbrock, 2001). These external costs include costs of noise which is the same for both modes, greenhouse gasses and air pollution costs which are about eight times higher for road transport, and costs of accidents which are about three and a half times higher for road transport (Forkenbrock, 2001). Traffic congestion is another important type of external cost (Janic, 2007). It accounts for roughly a third of all road delays (McKinnon, Edwards, Piecyk & Palmer, 2009).

Both groups of influencing factors are interwoven which means that decisions that are made to appease one group affect another. A shift towards the greater use of rail in freight transport is desirable in order to lower the environmental impact. The available railroad infrastructure needs to be able to absorb the cargo shift from roads. If it does not, the investments into the infrastructure need to be considered. In terms of cargo transportation it is better to invest in railroad infrastructure than in highway infrastructure because of the mentioned positive externalities in the form of the environmental impact while also improving the speed of shipments (Pazour, Meller & Pohl, 2010).

4. DECISION MODEL

The model focuses on the Slovenian case of road and railway freight transport. Its goal is to show an example that can serve the government as a decision-support mechanism and what-if analysis tool when deciding whether to subsidise rail transport and how that decision impacts the national budget. The potential drivers for shift from road to railroad transport are explained in the previous section.

In the Slovenian case both the highway and the railroad operator are owned by the government. In addition, the railroad operator is also the main provider of rail transport services. The public ownership of both gives the government the ability to directly manage both of them in order to pursue optimisation on the national level.

4.1. Data collection

The data were collected from several different sources. The first two sources were internal data from the Motorway Company in the Republic of Slovenia (DARS) and from the Slovenian Railways. These data were supplemented from various public sources such as the Slovenian Roads Agency, and the Statistical Office of the Republic of Slovenia. The last group of data sources were previous research papers.

The proposed model includes the following input data obtained for the year 2010:

1. prices of highway tolls for different types of heavy goods vehicles based on engine types, provided by DARS (Motorway Company in the Republic of Slovenia);
2. number of heavy goods vehicles passing through specific toll stations, provided by DARS, and number of heavy goods vehicles passing through different highway check points across the country, provided by the Slovenian Roads Agency;
3. costs of infrastructure maintenance provided by DARS;
4. available cargo transport capacity of railway infrastructure (Brezigar, February 19, 2013);
5. the model assumes heavy goods vehicles weighing 40 tonnes, which is the highest permitted mass in Slovenia;
6. the fuel consumption rate used is 32.5 litres per 100 kilometres (Schittler, 2003);
7. the assumed average speed of road freight vehicles is 62km/h (Cornillier, Laporte, Boctor & Renaud, 2009; Fabiano, Curro, Palazzi & Pastorino, 2002);
8. depreciation period for road freight vehicles is 22,000 working hours and the price

for a new road freight vehicle EUR 100,000 (Heavy-duty truck and bus engines);
9. costs of CO_2 and the price of petrol were assessed on 14.12.2010; and
10. the gross salary of truck drivers is based on the average gross salary for the road freight industry, as provided by the Statistical Office of the Republic of Slovenia.

4.2. Assumptions

Based on the data available some assumptions had to be made and certain limitations imposed on the calculations. The assumptions made are as follows:
1. each truck is assumed to travel entirely through at least one of the four highway sections in Slovenia (see Figure 1);
2. all marginal costs and revenues are constant;
3. the customers (shippers) are looking for the lowest price;
4. there are no data available that would provide us with the elasticity of demand for transport services, therefore it is assumed that the first unit of road transport that moves to railroad transport has the same financial effects than the last unit;
6. infrastructural investments are not taken into consideration; and
7. financial consequences for road and railroad freight transport companies are neglected since the model assumes the Government's point of view.

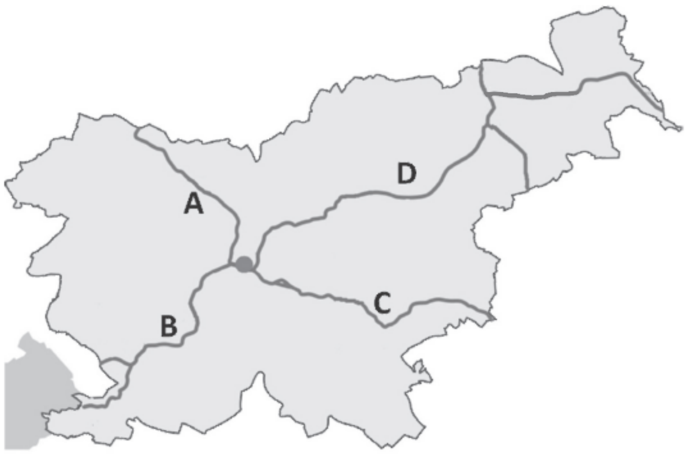
4.3. Results

We analysed the impact of possible governmental decisions on the costs and incomes of the stakeholders. These include tolls, infrastructure wear, fuel consumption, fuel taxes, equipment depreciation and CO_2 pollution.

Firstly, we calculated the difference between the costs of road and rail freight transport on the national level at a yearly aggregate level. The cost of rail freight transport is 155% higher in this case.

However, since the calculation is based on the aggregate level the results could be misleading. This is due to the fact that the costs of railroad freight transport are provided in EUR/km and are decreasing with transport distance. Therefore, the distances need to be separated into different sections in order to ascertain the cost differences by sections. We decided to base the sections on the Slovenian highway cross. We therefore used the four different sections with the junction in the centre of Slovenia. For each of the sections average values for one heavy duty vehicle route are calculated. These amounts are also multiplied by the number of vehicles in a certain time period in order to arrive at aggregate data. The sections are labelled A, B, C, D and can be seen in Figure 1.

Figure 1: *Slovenian highway scheme*



The sections have different lengths. The shortest is section A which is 69km long, followed by section B which is 101km long, section C is 118km long, while the longest section is section D which is 198km long.

Table 1 shows different financial effects with regard to the four different highway sections. The financial effects can be costs for one stakeholder and income for another as outlined in section 2.2.

Table 1: *Results on a yearly level*

Highway section	A	B	C	D
no. of kilometres	18,683,672	175,347,543	46,712,103	298,770,312
time spent (in hours)	301,350	2,828,186	753,421	4,818,876
tolls (in €)	6,742,028	38,156,411	9,567,458	67,817,061
road wear (in €)	1,522,418	14,288,001	3,806,284	24,344,969
fuel consumption (in litres)	6,072,193	56,987,952	15,181,433	97,100,351
fuel costs (in €)	6,153,136	57,747,601	15,383,802	98,394,699
fuel tax (in €)	2,551,596	23,946,907	6,379,390	40,802,539
CO_2 pollution (in tonnes)	16,626	156,034	41,567	265,863
CO_2 costs (in €)	230,766	2,165,753	576,951	3,690,173
driver costs (in €)	1,822,368	17,103,050	4,556,205	29,141,460
depreciation costs (in €)	1,369,771	12,855,392	3,424,641	21,903,982

For shippers the costs of rail are significantly higher than road freight transport. The difference is lowest on the longest section (D) where the costs of rail transport are 123% higher than costs of road transport. The biggest difference is in section B where it is 202%, with sections A and C being in the middle (199% and 163%, respectively).

This clearly shows that the total costs of railroad transport are considerably (at least two times) higher than those of road transport. An interesting question is what the government can do to promote more railroad freight transport in order to lower the environmental impacts of the transport as outlined in section 3.

The extent of potential shift of transport depends on the excess capacities of the current railroad infrastructure. These cumulative data for all four sections were obtained from the railroad network operator (Brezigar, February 19, 2013). The number of road transports on the entire road network is 2.6 million per year, and the extra free capacity of the railroad network is 0.35 million equivalent units per year. The railroad network could therefore transport around 13.5% of current road transport. For larger shifts, the model would have to be expanded to include infrastructure investments.

The first option to promote more railroad freight transport would be to subsidise the railroad freight transport providers so they can lower their prices to achieve competitive prices compared to road transport providers. In addition to the costs of subsidies, the government would also collect less fuel taxes while, on the other hand, the road wear would be less and CO_2 pollution would decrease. The amount of road tolls collected would also be lower which would indirectly impact the government budget in the Slovenian case since the highway operator is owned by the government.

If we take highway section A for example, subsidising one freight transport on railroad would cost the government EUR 137.69 in subsidies to match the price of road freight transport providers. On the other hand, the government's direct income would be EUR 9.42 lower due to lost fuel taxes, while the direct cost would be EUR 0.83 lower due to the reduced CO_2 pollution. The changes in the income of the highway infrastructure provider are lost tolls which are EUR 24.38 in this case, while the cost of road wear would also go down by EUR 5.62. All in all, it would cost the government EUR 165.04 to redirect one freight transport on section A from road to rail. The costs of other sections can be seen in Table 2.

Table 2: *Governmental costs for redirecting one unit of freight transport from road to railroad*

Section	Costs per unit of freight (in €)
A	165.04
B	201.80
C	191.83
D	265.22

The costs of subsidizing the amount of transport that the current railroad infrastructure can absorb (13.5%) are therefore EUR 78 million per year. If the entire road freight transport were switched to railroads, the costs would be EUR 578 million per year. However, such a shift would have to include the costs of railroad infrastructure investments.

Another option for the government to promote the use of railroad freight transport would be to increase highway tolls, thereby increasing the costs of road freight transport. Taking the data that we provided in Table 1 into consideration, the tolls would have to be raised by 492% in order to make the road freight transport costs equal to the railroad freight transport costs. Obviously the shift of all road transport to railroad can only be theoretical, since the railroads can only absorb 13.5% of road transport. Based on these calculations we conclude that the shift from road to railroad transport within an existing network can be costly and therefore has a questionable financial feasibility.

5. CONCLUSION

We provided an insight into the difference between railroad and road freight transport by using stakeholder analysis. We identified the government as the focal stakeholder. The developed decision model can serve the government with its decision-making process when adopting policies that concern road and railroad transport within an existing network infrastructure. Although it includes only a small segment of possible relevant data it does enable the inclusion of additional variables. In such a way new policies can be thoroughly analysed. Furthermore, the paper highlighted a complex system of different stakeholders. Several assumptions needed to be made and the way they are made strongly affects the results.

The paper has several limitations. The calculation included only the data for one country. In reality, most transport routes are trans-national, therefore longer routes can be taken into consideration when comparing railroad and road transport since railroad transport is more competitive over long distances (Posner, 2008) and a breakeven point could be calculated for railroad freight transport when comparing it to road freight transport. Differences in railroad distances, traffic patterns, competition, capacity constraints and passenger traffic prioritization between different railroad systems such as EU and in North America (Clausen & Voll, 2013) also affect the calculations. Further, the calculation is valid for current prices (e.g. fuel or highway tolls); inter-modal logistics networks are very sensitive to changes in costs (Ishfaq & Sox, 2010). In our case very detailed data was available for roads while only limited data was available for railroads. Further analysis would also be facilitated if the price elasticity of the demand for highway freight transport were known so that the effects of incremental toll changes could be assessed. In this respect, the analysis of elasticity of demand and its evolution over time is particularly important (Fouquet, 2012). The calculation is also limited by the capacities of the railroad and road network because it does not include infrastructure investments. Such investments are also one of the main topics for further research.

Further research should delve into a more in-depth understanding of the objective functions of various stakeholders and how the end result can be modified with further constraints without reducing the profit too much. Such an approach can help define different mechanisms that would induce companies to focus on other aspects besides profit; for example, reducing carbon emissions without a considerable impact on their profits (Hua, Cheng & Wang, 2011). Logistics decisions need to examine multiple decision criteria pertaining to multiple stakeholders (Brewer, et al., 2005). The inter-relationships amongst all stakeholders are complex as one group may initiate actions that become impediments for others. Developing systems-based sustainable alternatives to traditional, environmentally-harmful transport modes (e.g. automobiles, trucks) requires the network of relationships between stakeholders and impediments to be considered (Byrne & Polonsky, 2001).

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