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SUSTAINABLE PERFORMANCE INDEX FOR THE ASSESSMENT OF INLAND SHIPPING IN TERMS OF SUSTAINABILITY

Summary of the PhD theses

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1. The scope of work

The sustainable development turned into a daily concept by today. Similarly, the sustainable transport also appears increasingly often, primarily in transport policy, and in strategic plans.

Perhaps the best known and most comprehensive definition for Sustainable Transport is as follows:

"A sustainable transport system is one that:

- allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations;
- is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy;
- limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise."

This definition was created for the policy-makers, containing general guidelines that can be the basis for determining the priorities, along with the developments on state or regional level should be pursued.

Becoming familiar with the concept of sustainability, "how to live" guidelines for the individuals or smaller communities also can be stated. These can help them in everyday activities to be able to contribute to sustainable growth. This is particularly true for companies that act in fields of greater economic importance like energy-production, building industry, transport, etc., and as well as for those which can choose between several solutions. The shipping company – as part of the transport system – is a typical one.

The inland navigation can contribute to a more sustainable transport system. It is usually cheaper, more environmental friendly, reliable and safer than the counterparts. On the other hand it does not provide door-to door service, so it always means multimodality.

Today, the forwarders select the optimal alternative concerning only criteria related to the economic effectiveness of the transport task. In many cases, the shippers are not aware neither the concept of sustainable transport nor the harmful effects they also generate.

The sustainability and the modal shift is a major concern in the White Paper of the European Union. But, the half-time revision of the White Paper [1] has shown that to achieve modal shift lot of things should be done. Good examples could be the different new pricing systems based on the marginal social cost of transport or a comparison model that takes not only economical but environmental and social aspects into account.

Today, for this purpose there is no generally accepted evaluation system. This was the main reason to develop a valuation and comparison model, which contains

environmental and social aspects beside the economical dimension, and is maximally adjusted for the decision-making tasks of a forwarder. On the other hand – knowing that such a model is still unable to change the decisions of the economic actors – there was an other explicit goal for the model development, namely: effectively assist all participants (including the governmental level as well) interested in a sustainable transport to effective communication of the sustainability principles. Without these, it is very difficult to envisage the necessary change in thinking, which is an essential element of sustainable development.

2. Method of the research

In the 2nd chapter, after a wide literature research (to mention just a few: [2], [3], [4], [5], [6], [7], [8]) of sustainable transportation, I have chosen a definition for the sustainable transport. That was kept in mind throughout the whole work. I have also analyzed the existing relationship between transport and sustainability. I have found that today there are only attempts for integrating the concept of sustainability into the transport system [9], [10]. I have also examined the existing methods for assessing the sustainability of the transportation sector. According to my research, the indicators that are used at sector level, can be adapted to micro level, but should be modified according to the requirements of the forwarder's decision-making task.

In the 3rd chapter I first have laid down the requirements against the micro level indicators that are to be used in my model. After this, I analyzed the hundreds of indicators of the different systems (just to mention a few: [11], [12], [13]) used to assess the transport sector. Based on this experiment I built up an indicator system, and all data needed for their calculation are revealed. The indicators are summarized on Fig 1.

The indicators have various types, different dimensions and scale and that involves the multi-criteria decision aiding methods, as a practical assessment method. Hence, in the 4th chapter the general multi-criteria methods have been examined and checked that which are appropriate for the forwarder's task. As a result I found that simple additive weighting (SAW, [14]) and the outranking method PROMETHEE [15] seem to be equally applicable for the assessment of transport alternatives. To be able to compare the two theoretically different aggregation methods, the model has been built up in a way that the assessment results can be seen parallel. Finally, using the values of the indicators as input data for the aggregation, a „fineness index" as the sustainable performance index of certain alternatives could have been determined.

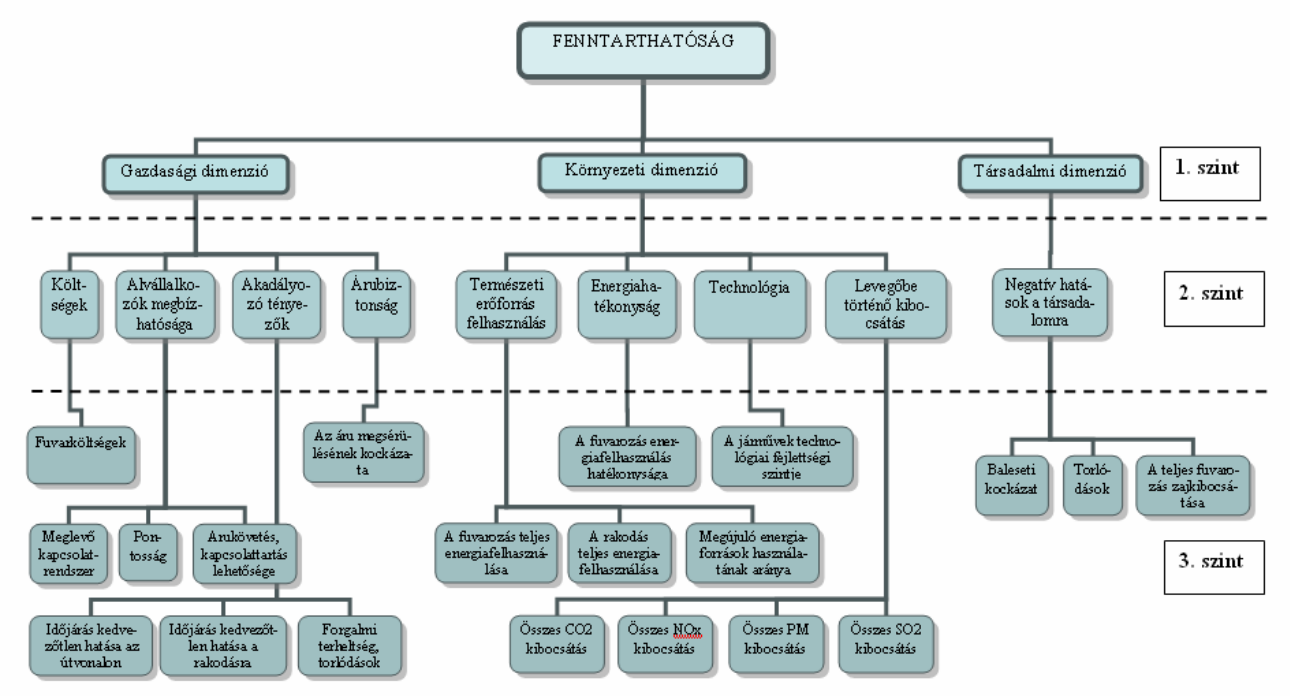

Fig. 1. – The indicators

The last part of this chapter deals with the structure of the model, the exact algorithm of the assessment, the weights used in the model, the definition of the Sustainable Performance Index, and the description of the sensitivity analysis.

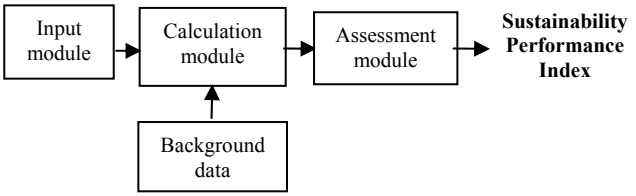

Fig. 2. – Structure of the model

In the 5th chapter the application of the developed model for concrete tasks was shown. I analyzed two typical multimodal transport tasks. Figure 3. shows the result of the analysis.

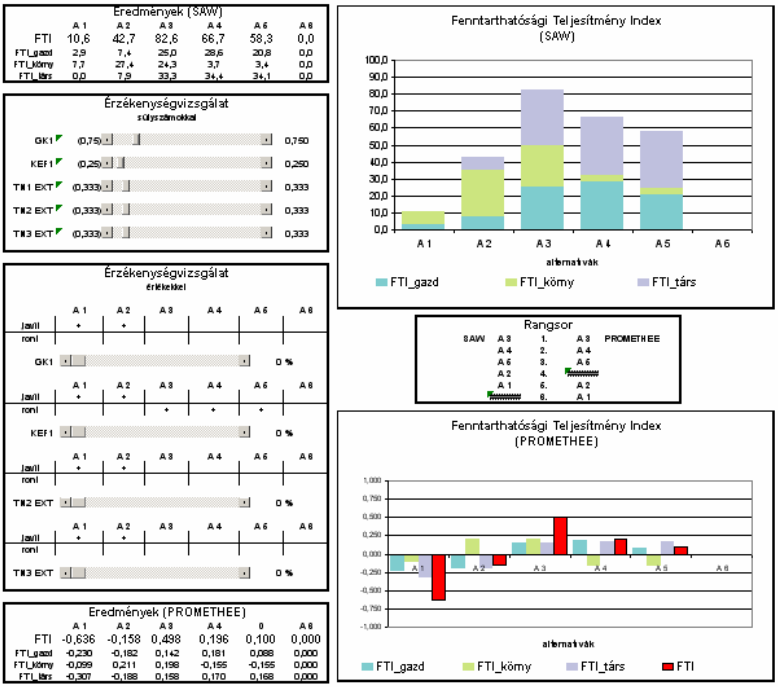

Fig. 3. – The way of representing the results in the model

3. New scientific results

The new results can be summarized in the following theses:

1.

Based on the experience with the general, sector-level indicator systems **I laid down the specific requirements** for the company-level indicators to be used for sustainability comparison of a transport chain. **(3.1)**. Taking these requirements into account **I built up an indicator system** that could be used for the comparison of the different transportation modes in a transport chain in terms of sustainability. **(3.3)**. In this system there are 8 economical, 11 environmental and 4 social indicators.

2.

I revealed the methods and necessary input data for the calculation of the indicator values, and **I** also **gave the source** of these data **(3.4).**

For the modelling, I examined the general multi-criteria decision aiding methods, and based on this **I selected those weighting (4.2.2.2)**and **aggregation methods (4.2.2.3)**, that could possibly used for the sustainability comparison of the transportation alternatives. According to my examination I stated that the **PROMETHEE and additive (e.g. SAW) methods have no major differences (4.2.2.5)** concerning the priorities of the forwarder decision makers.

3.

With this knowledge **I built up the assessment model (4.3).** Using the definition of the sustainability **I define the restrictions for the weights** of the indicators and **gave a proposal for the weight values**. **(4.3.3.1)**. In the model I used two aggregation methods, either for being able to compare them or to increase the reliability of the model results. **By defining the "Sustainable Performance Index" I quantified the "goodness" of a transport option**, and with this it could be clear for the forwarder and for the customer as well which alternative is the best concerning also the environmental and social aspects. **(4.3.3.2 and 3)**.

In the model for the indicator values I applied a robustness analysis technique with that it is possible to take the real relationships between the criteria into consideration **(4.3.3.4).**

4.

Finally I applied the model to two typical multimodal transport tasks. (5.1 and 2). I made robustness analysis with the weights, and **found that with the restrictions for the weights of the three main dimensions of the sustainability rank reversal does not occur while changing the weights in a realistic range.**

I also made robustness analysis while changing the indicator values and found that the ranking is more sensible for the uncertainties in the values than in the weights.

In the two case studies the two aggregation methods (the **SAW and PROMETHEE) do not show differences** that could be practically relevant, concerning either the robustness analysis of the weights and the values or the final ranking.

5.

Examining the two case studies the followings could be stated:

It can be seen after the comparison that – assuming equal weight for the 3 main aspects of sustainability – **those solutions that contain inland navigation are generally better than the pure road transport solutions**.

On the other hand the analysis has shown that:

- **the reason for this is that those solutions always have high social scores;**
- **in some cases due to some possible uncertainties in the values of the energy consumption the inland navigation alternatives could loose their good positions.**

Although the conclusions in Thesis 5 were drawn from the two typical case studies, the generalization of these statements needs further investigations.

4. The practical application of the new results

The practical application of the model could be either on the governmental or the company level.

The most important characteristics of the model are: simplicity combined with proper details, and flexible variability. This could be easily completed by a sophisticated computer background and one gets an easily usable, vividly described technique for aiding such a decision-making process in that all sustainability aspects are to be taken into account.

The model can effectively assist all participants (including the governmental level as well) interested in a sustainable transport to effective communication of the sustainability principles. The model is also ideal to be used for educational purposes. It can be a tool in the training of the transport and logistics professionals with that the young professionals at the beginning of their career become familiar with not only the economic interests, but with equally important social and environmental aspects. Without these, it is very difficult to envisage the necessary change in thinking, which is an essential element of sustainable development.

Of course, the presented model provides a good opportunity for further analysis. The tests and analysis already done – beside they have shown the versatile utility of the model – have also highlighted that the multi-criteria decision aiding methods can help in the effective communication of the spectacular aspects of sustainability and provide an easily understood comparison of the freight alternatives. The developed model offers possibilities to examine not only specific freight tasks but more general topics related to freight transport. Only a few examples:

- the effect on SPI of payload loss in inter-modal chains due to container and truck tare weight;
- impact of systematic variation of input parameters on SPI (for example: how the distance of different legs of inter-modal chain change the effectiveness of an alternative);
- comparison of currently feasible and not yet feasible alternatives could give a good basis for company strategic planning (for example: start operation of a scheduled container liner service on relations with great amount of cargo flow);
- modelling can help to identify the weak points of a chain.

5. Publications related to the topic

1. AZ EURÓPAI KÖZÖSSÉGEK BIZOTTSÁGA: *Tartsuk mozgásban Európát! - Fenntartható mobilitás kontinensünk számára.* Az Európai Bizottság 2001. évi közlekedéspolitikai fehér könyvének félidei felülvizsgálata
2. Centre for Sustainable Transportation: *Sustainable Transportation Performance Indicators (STPI) Project,* Report on Phase 3. 2002
3. Herman Daly: *Steady-State Economics*, Island Press, Washington DC, 1991
4. Organisation for Economic Cooperation and Development (OECD) és az Austrian Federal Ministry for Environment, Forestry, Environment and Water Management (BLFUW): *est! Futures, Strategies, and Best Practices*. OECD International Conference, Bécs, Október 4-6., 2000 http://www.oecd.org/dataoecd/15/29/2388785.pdf, elérhető: 2004 márc. 30
5. Gudmundsson, Henrik – Höjer, Mattias: *Sustainable development principles and their implications for transport.* Ecological Economics Vol. 19, pp.269-282. (1996)
6. Pearce, A. R., and Vanegas, J. A.: *Defining sustainability for built environment systems.* Int. J. Environ. Technol. Manage., 2002, 2(1), 94–113.
7. Transport Canada. Transport Canada Annual Reports 1996-2002. http://www.tc.gc.ca/pol/en/anre/transportation_annual_report.htm
8. World Commission on Environment and Development (Brundtland Commission). *Our Common Future.* Oxford University Press, Oxford, England, 1987.
9. 5 konzorciumi résztvevő a ZLU – Zentrum für Logistik und Unternehmensplanung GmbH vezetésével: *Study on Freight Integrators To the Commission of the European Communities, Final Report,* 2003.
10. Dr. Bokor Z.: *Az intermodális logisztikai szolgáltatások helyzete, fejlesztési lehetőségei*, Logisztika, BME-OMIKK, 2005 p. 22-64
11. Working group on the state of the environment: *Indicators for the integration of environmental concerns into transport policies.*
12. SUstainable Mobility, policy Measures and Assessment *Operationalising Sustainable Transport and Mobility: The System Diagram and Indicators,* Deliverable D3, Workpackage 2
13. *TERM report 2002*. Copenhagen.
14. Churchman, C.W., Ackoff, R.L., Arnoff, E.L.: *Introduction to Operations Research*, Wiley, New York., 1957
15. Brans, J.P. and Vincke, Ph.: *A preference ranking organization method*, Management Science, 31, 647-656., 1985

6. Personal publications related to the topic

Dr. Rohács, J.- Hadházi, D.- **Simongáti, Gy**.- Hargitai, L.Cs.: Methods for Evaluation of Sustainable Transport Performance Index (STPI), European Inland Waterway Navigation Conference 2005, Szeged,

Simongáti, Gy.- Dr. Rohács, J.: The Role of Inland Waterway Navigation in a Sustainable Transport System, Transport Magazin, Kaunas, Lithuania, Vol. XXII, No. 3, 2007.

Rigo, N., Hekkenberg, R., Ndiaye, A. B., Hargitai, L. Cs.- Hadházi, D.- **Simongáti, Gy**.: Performance assessment of intermodal chains, European Journal of Transport and Infrastructure Research, 2007.

Dr. Rohács, J.- Hadházi, D.- **Simongáti, Gy**.- Hargitai, L.Cs.: Sustainable Transport Performance Index (STPI) of the Inland Water Navigation, International Conference of Transport Means, Kaunas, Lithuania, 2005.

Simongáti, Gy.- Dr. Rohács, J.: Komplex közlekedési mutatószám (STPI) kidolgozása a belvízi hajózásra, Közlekedéstudományi Szemle, 2007,.

Dr. Rohács, J.- Hadházi, D.- **Simongáti, Gy**.- Hargitai, L.Cs.: The Feasibility Study of the Budapest-Constanta Container Service, CREATING Project, 2005

Dr. Rohács, J.- Hadházi, D.- **Simongáti, Gy**.- Hargitai, L.Cs.- Bogár, Gy.: Prospects and possibilities to RoRo shipping in the frame of a European intermodal transport concept, CREATING Project, 2005

Simongáti, Gy.: Többkritériumos döntéstámogató modell a fuvarfeladatok alternatívák fenntarthatóság szerinti értékeléséhez, Közlekedéstudományi Szemle, 2009, június. (under edition)

Simongátii, Gy.: Multi-criteria decision making support tool for freight-integrators - for selecting the most sustainable alternative, Transport Magazin, Kaunas, Lithuania, 2009, (under edition)