A FREIGHT TRANSPORT CHAIN CHOICE TAKING ACCOUNT THE UTLITY

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Summary: The paper describes the problematice of a freight transport supply chain choice taking account the utility. The utility function is mostly calculated from the container transport statistics. Container transport refers to the transportation of goods in standardized re-sealable transportation boxes by rail and sea. The utility theory is mostly connected with the consumer and consumption theory. When thinking of transport services, demand (consumer) and suppliers influence the decision making process of transport. Three key factors are identified: environmental efficiency, time and transportation capacity

Key words: Utility, rail transport, water transport, freight.

INTRODUCTION

The choice of transport mode is a key decision in freight transport and has a direct influence on goods flows, congestion and other derived external costs. Today, most long distance shipments are transported in chains (1) as it is hereby possible to utilise advantages of the particular modes or vehicles in the most productive manner (2). With the increase in freight transport (3) there is an increasing need for selecting the most beneficial or efficient alternative in a given scenario in freight transport (4-6). However, what is deemed positively beneficial or efficient to one group, may be viewed as a negative alternative by others (7-9).

1. LITERATURE REVIEW

Although the concepts and mathematics of utility theory and its application to adjusting valuations to reflect the perspectives of decision makers with a range of risk preferences have been established for decades, utility functions are now extensively used to assist evaluation of freight transport (rail and sea not excluding) hedging and trading of financial and physical commodities from the risk preferences of the parties involved (10).

The notion of satisficing was echoed by Lindblom (1959) who felt that because of bounded rationality, and a deficit for information and time, decision-makers tend to incrementally muddle through the process of making tough choices (11). To a large extent, people's preferences and their support to investment decisions depend, among other factors defined by Penyalver et al. (2018); Lewis (2001); McLachlan and Gardner (2004) on their experiences and expectations on the positive and negative outcomes that may result from investments with capacity to constraint individuals' future choices (environmental impacts, travel time savings) (12-14).

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In transport systems theory, to simulate users' behaviour, the decision process is often based on Random Utility Models (RUMs), on the concept of rational users, and on the following assumptions (15-17).

The choice of transport mode is a key decision in freight transport and has direct influence on goods flows, congestion and other derived external costs (18-20).

The user considers mutually exclusive alternatives and adopts for each alternative a perceived utility function of a set of measurable characteristics (2,21-22).

Perceived utility is not completely known by the analyst for the user; the analyst represents perceived utility with a random variable and evaluates the choice probability for each alternative because of the probability that the perceived utility of the alternative is greater than the perceived utility of the other alternatives (23).

2. METHODOLOGY

The paper analysis datasets of the busiest cargo ports in Europe according to Eurostat statistics (24). Authors have described the SWOT analysis of water transport and SWOT analysis of rail transport.

Furher on, authors have analysis the derived utility function of transport services (rail and water/sea containter transport) of five countries. The countries have been chosen according to the Europe´s busiest cargo ports by tonnage (Port of Rotterdam and Amsterdam (Netherlands), Port of Antwerp (Belgium), Port of Hamburg (Germany), Port of Marseille (France), Novorossisk (Russia).

The data was analyzed in time period 2008 – 2017 corresponding OECD (25) container transport statistics refers to the transportation of goods in standardized re-sealable transportation boxes by rail and sea. Data are expressed in thousands of tons (Kt). The identification of derived utility function of rail and sea container transport consisted of selection, grouping and judging the indicators, weighting and calculating.

Selection, grouping and judging the indicators: First, proper performance indicators are selected covering different aspects of utility. Then, the indicators were grouped into categories (groups). For the purpose of this paper, the main groups of indicators were defined: environmental efficiency, transport time, availability and capacity.

Based on (26 - 27), defined the Value of Travel Time (VTT) as:

$$VTT = \frac{\mu}{\lambda} - \frac{(\frac{\partial U}{\partial T})}{\partial \lambda} \quad (1)$$

where μ is Lagrangian multiplier of the time constraint, λ is marginal utility of income, U is direct utility and T is travel time.

Weighting: Pair-wise comparison technique is used to derive relative weights of each indicator. This method is based on the analytic hierarchy process (28) Where ω represents a weighting of the dataset. The Ui value is calculated by multiplying each normalized indicator value with its weight and summing up all multiplications, where U is utility and ωij is the weight of indicator X, for the group of indicators j in time t. The weight of each dimension is estimated.

$$\omega ij = \sum_{ij}^{n} \omega_{ij} \quad (2)$$

Uijt= $\omega_{ij} \sum_{jt}^{n} X_{jt}$
(3)

Calculating: The utility function is modelled as a standard Cobb-Douglas function, where choice alternatives are represented by chosen determinants. The Utility function is formulated as:

U= A. $X^{\alpha}Y^{\beta}$ (4)

where X and Y are two different goods, concretely X – sea container transport and Y rail container transport. The Cobb-Douglas function is three dimensional with utility or output measured along the vertical axis. The Cobb-Douglas utility function has been transformed into a linearized version using the natural log function.

ln f(x)= ln(x^{α})= α.ln(x) (5)

ln U= ln $\left[AX^{\alpha}Y^{\beta}\right]$ (6)

ln U = ln (A) + ln (X^{α}) + ln (Y^{β}) (7)

ln U = ln (A) +α ln (X) +β ln (Y)

Measures of output of logarithmic value were calculated by the multiple linear regression coefficient:

$\mu= \beta_0 + \beta_1 x_1 + \beta_2 x_2 ... \beta_n x_n,$ *when*, $0< \alpha < 1, 0< \beta < 1.$ (8)

$\beta_0 = \ln (\beta_0)$
(9)

$\beta_0 = e^{\beta_0}$
(10)

3. RESULTS

Container shipping, as a transportation mode serving the interregional (intercontinental) carriage of freight, is operated under managed hub-and-spoke networks, which are subject to fixed time schedules, routes, and ship calls. Briefly, the typical process of container shipping consists of two parts: transportation in trunk and transportation in feeder routes. Container ships navigating a specific trunk route call only at designated major ports for loading and unloading, but not at small-scale regional ports. For container shippers close to a regional port (and far from a major port), port choices for transshipment are mainly determined by the minimization of “generalized” transportation costs including overland transportation costs and time costs in the feeder routes. Figures 1 and 2 describes the strengths, weaknesses, opportunities and threats of the water and railway transport.

Strengths	Weaknesses
• Water transport has got lower travel costs than other modes of transport (road or railway transport), • water transport can carry the biggest volume of goods (especially bulk cargo) in comparison with other modes of transport, • water transport is environmentally friendly; it has got the lowest impact on the environment in comparison with other modes of transport, • safety of navigation, • cooperation of water transport with other modes of transport (road and railway transport) in transport chains.	• Low transport speed of water transport, • low density of waterways in comparison with other modes of transport, • insufficient maintenance of water transport network, • high costs for modernization of fleet and infrastructure.
Opportunities	**Threats**
• Spare transport capacity of some european waterways, • raising demands for environmentally friendly transport modes.	• Water transport is depended hydrological and meteorological conditions (low, high water level, icebergs on waterways and their movement, freezing of waterway).

Source: Authors

Fig. 1 – SWOT analysis of water transport

Strengths	Weaknesses
• Railway transport has got lower travel costs than other modes of transport (road or air transport), • eco-friendly since most of the train are powered by overhead electric wire, no carbon emission is produced, • railway transport can carry bigger volume of goods (especially bulk cargo) in comparison with road transport, • cooperation of railway transport with other modes of transport (road and water transport) in transport chains.	• High maintenance cost, that can be found in every railway company, • lower density of railway network in comparison with other modes of transport (road and water transport), • low flexibility, with the limited choice of destination, • sound pollution produced from the engines sound.
Opportunities	**Threats**
• Technology improvement, • raising demands for environmentally friendly transport modes, • increasing employment rate.	• Losing market share, with the rise of air, water and road transport industry, • better services provided by the other modes of transport, • technology change, rapid improvement in the world of technology and high capital costs necessity.

Source: Authors

Fig. 2 – SWOT analysis of railway transport

When considering environmental efficiency, values of CO, CO2, HC, NOx, SO2, Particulates, VOC, have been assign weight a weight according a research results (29).

Tab. 1 – Derived Utility function

Country	Utility function	α+β
Netherlands	U= 1,06. $X^{0,9}Y^{0,1}$	1
Belgium	U= 1,05. $X^{\alpha 0,88}Y^{0,12}$	1
Germany	U=1,46. $X^{0,68}Y^{0,32}$	1
France	U= 1,31. $X^{0,78}Y^{0,22}$	1
Russia	U= 1,50. $X^{0,62}Y^{0,38}$	1

Source: Authors

As reported by the main results of Jong and Kouwnhoven (2018) and McLachlan (2004) studies is, the VTT in euro/hour (2010 prices) Train 9,25, Navigation 8,25 (including container transport), so navigation is assign weight higher than train (14,27)

Availability depends on geographic network, since the authors have calculated the data binding to European countries, they have valuated the availability of the rail network higher than the availability of ports.

Consequently, author suppose, that vessel transport capacity is far greater than the rail transport, for example, a 10.000 t ship is generally equivalent to the load capacity of 250 to 300 wagons (29).

All the data have been divided into four datasets. ωen (weighting of environmental efficiency), ωtt (weighting of transport time), ωa (weighting of availability), ωca (weighting of capacity).

The deterministic utility of a mode is defined from a number of relevant attributes X describing sea container transport, Y describing rail container transport and U describing utility, derived from the determinants of the environmental efficiency, transport time, availability and mode capacity. All the results are described in Table 1.

The authors assume the concept of utility maximization, when making a purchase decision, a consumer attempts to get the greatest value possible from expenditure of leas amount of money. Customer objective is to maximize the total value derived from the available budget.

When consumer choose to deliver goods throug the rail or sea, it is not possible to deliver the same cargo simultaneously, so the customer replaces one mode of transport with another. This rule, combined with the budget constraint, give us a two step procedure for finding the solution to the utility maximization problem.

4. CONCLUSION

The paper describes the utility maximization problems of consumer choice of sea (water transport) and rail transport in case of five countries. The primary data have been divided into four datasets of ωen (weighting of environmental efficiency), ωtt (weighting of transport time), ωa (weighting of availability), ωca (weighting of capacity).

The utility of the use of water transport is constantly growing. Water transport has lower freight costs than other modes of transport (road and railway transport). Water transport can carry the largest amount of cargo (especially bulk cargo) compared to other modes of transport. Water transport is friendly to the environment, has the least negative impact on the environment compared to other modes of transport.

Ultimately, based on estimated utility values, and considering determinants of time, transport cost, transport time and geographical information about available terminals at origin or destination of the shipment it is possible to derive a utility function and estimate the utility of consumption. In case of the water and rail transport it is possible to derive the utility of consumption of ports and train networks and model the demand function not only according to transport volumes.

REFERENCES

(1) GUILBAULT, M. *Enquete echo Envois Chargeurs*. Opérations de transport Résultats de reference, 2008.

(2) KONINGS, R.; PRIEMUS,H.; NIJKMAP, P. *The Future of Intermodal Freight Transport Operations. Design and Policy,* 2008, Edward Elgar Publishing

(3) WOODBURN, A., ALLEN, J., BROWNE, M., LEONARDI J. *The Impact of Globalisation on International Road and Rail Freight Transport Activity – Past Trends and Future Perspectives*. OECD/ITF Global Forum on Sustainable Development: Transport and Environment in a Globalising World, Guadalajara, Mexico (2008)

(4) GORTNER, H. F.; NICHOLS, K. L.; BALL, C. *Organization theory: A public and nonprofit perspective* (3rd ed.), 2007, Belmont, CA: Wadsworth.

(5) MADLENAKOVA, L.; MATUSKOVA, M.; MADLENAK, R. Solutions of the Roller Conveyor in Terms of Logictics Provider. *Advances in Science and Technology Research Journal*, 2018, vol 12 (4), pp. 1-9

(6) HANSUT, L.; DAVID, A.; GASPARIK J. The Critical Path Method as the Method for Evaluation and Identification of the Optimal Container Trade Route between Asia and Slovakia. In *17th International Scientific Conference on Business Logistics in Modern Management*, Osijek, Croatia, October 12 – 13 2017. Book Series: Proceedings of International Scientific Conference Business Logistics in Modern Management pp. 29-42.

(7) WILLIAMS, CH. M.; HESTER, P.T. A Readiness Decision Model for Canceling Navy Ship Maintenance Availabilities, in Kenneth D. Lawrence , Gary Kleinman (ed.) *Applications of Management Science* (Applications of Management Science, Volume 18), 2017, Emerald Publishing Limited, pp.147 – 166.

(8) COREJOVA, T.; AL KASSIRI, M. The Power of Knowledge-Intensive Services. In *4th International Conference on Social Sciences and Society* (ICSSS 2015), Paris, France, May 20-21 2015. Book Series: Advances in Education Research, vol.70, pp. 354-357.

(9) HUDAK M.; MADLENAK R. The research of driver´s gaze at the traffic signs. In *CBU International Conference on Innovations in Science and Education* (CBUIC), Prague, Czech Republic, March 23 – 25 2016. Book Series: CBU International Conference Proceedings, pp. 896-899

(10) WOOD,D.A., KHOSRAVANIAN, R. Exponential utility functions aid upstream decision making, *Journal of Natural Gas Science and Engineering*,Volume 27, Part 3,2015,Pages 1482-1494,ISSN 1875-5100, https://doi.org/10.1016/j.jngse.2015.10.012.

(11) LINDBLOM, C. E. The science of "muddling through". *Public Administration Review*, vol. 19(2), 1959, pp. 79–88.

(12) PENYALVER, D.; TURRÓ, M.; ZAVALA-ROJAS, D. Intergenerational perception of the utility of major transport projects. *Research in Transportation Economics*, vol. 70, 2018, pp. 97-111.

(13) LEWIS, A. A focus group study of the motivations to invest: "Ethical/Green" and "ordindary" investors compared. *Journal of Socio-Economics*, 30, 2001, pp. 331-341.

(14) MCLACHLAN, J.; GARDNER, M. A comparison of socially responsible and conventional investors. *Journal of Business Ethics*, 52 (1) 2004, pp. 11-25.

(15) VON NEUMANN, J.; MORGENSTERN, O. *Theory of Games and Economic Behaviour*, 1944, Princeton Univ. Press, Princeton

(16) BEN-AKIVA, M.E.; LERMAN, S.R. *Discrete choice analysis: theory and application to travel demand MIT Press*, 1985, Cambridge

(17) CASCETTA, E. *Transportation System Analysis: Models and Applications*. 2009, Springer, New York

(18) DAVID, A., PIALA, P.; STUPALO, V. Cargo Containerisation and its Impact on the Development of Maritime Transport. In *3rd International Conference on Traffic and Transport Engineering (ICTTE)*, Assoc Italiana Ingn Traffico Trasporti Res Ctr, Belgrade, Serbia, Nov 24-25, 2016, pp. 306 – 311.

(19) DAVID, A., PIALA, P. Transport of Tropical Fruits to Central Europe. *NASE MORE*, 2016 vol 63, pp. 62-65

(20) STALMASEKOVA, N., GENZOVORA, T., COREJOVA, T. The impact of using the digital environment in transport. In *12th International Scientific Conference of Young Scientists on Sustainable, Modern and Safe Transport* Location: High Tatras, Slovakia, May 31- June 02, 2017. Book Series: Procedia Engineering, vol 192, pp. 231-236

(21) MADLENAK, R.; MADLENAKOVA, L.; STEFUNKO, J.; REINER, K. Multiple approaches of solving allocation problems on postal transportation network in conditions of large countries. *Transport and Telecommunication Journal*, vo. 17 (3), 2016, pp. https://doi.org/222-230, 10.1515/ttj-2016-0020

(22) DEDIK, M.; GASPARIK, J.; ZAHUMENSKA, Z. (2018) Proposal of the Measures to Increase the Competitiveness of Rail Freight Transport in he EU. NASE MORE, vol. 65, Issue 4, pp. 202-207.

(23) VITTEA, A. A quantum utility model for route choice in transport systems. *Travel Behaviour and Society*, vol. 3, 2016, pp. 29 – 37. Available at: https://www.sciencedirect.com/science/article/pii/S2214367X15000241#b0020

(24) EUROSTAT (2018) Statistics. Available at:https://ec.europa.eu/eurostat

(25) OECD (2018) Statistics Available at: http//www.oecd.org

(26) DESERPA, A.C. A Theory of the Economics of Time. *The Economic Journal* Published by: Wiley on behalf of the Royal Economic Society, Vol. 81, No. 324, 1971 pp. 828-846 Available at: https://www.scribd.com/document/376623980/De-Serpa-1971

(27) JONG, G.; KOUWNHOVEN, M. *Productive use of travel time, values of time and reliablity in The Netherlands*. OECD, 2018. Available at:https://www.itf-oecd.org/productive-use-travel-time-values-time-and-reliability-netherlands

(28) SAATY, T.L. Resource Allocation. *Analytical Hierarchy Process: Planning, Priority Setting*, 1st ed.; Thomas L. Saaty; McGraw-Hill: New York, USA, 1980; pp. 20–108.

(29) VINNES, H.; FRIDELL, E.; YARAMENKA, K.; NELISSEN, D.; JASPER, F.; AHDOUR, S. *No_x controls for shipping in EU Seas*. Commissioned by Transport and Environment, 2016, pp 1-84. Available at: https://www.transportenvironment.org/sites/te/files/publications/2016_Consultant_report_shipping_NOx_abatement.pdf