

Identification of Restricting Criteria for Comprehensive Assessment of Logistics Chains in Intermodal Transport

Stefan Kudlac¹, Jozef Gasparik¹, Milan Dedik^{1*} and Petr V. Kurenkov²

¹*University of Žilina, Department of Railway Transport, Univerzitná 8215/1, 010 26, Žilina, Slovakia, Czech Republic; Email: stefan.kudlac@fpedas.uniza.sk, jozef.gasparik@fpedas.uniza.sk, milan.dedik@fpedas.uniza.sk*

²*Moscow State Transport University, Institute of Management and Information Technology, Moscow, Obraztsova str., 9 bld. 9, 127994 Moscow, Russia; Email: petr.kurenkov@mail.ru*

***Corresponding Author:** Milan Dedik

Abstract: An effective functioning of logistic chains through the use of intermodal transport inevitably necessitates elimination of potential constraints, which have a negative impact on the logistic chains implementation. The objective of the contribution is the analysis, definition as well as classification of constraints related to the logistic chains in the intermodal transport, which should enable to compare levels of constraints in different alternatives of the logistic chain implementation. Based on the comparison of the restriction levels, it is possible to select a more convenient way of the logistic chain implementation. The defined relevant constraints are assessed using scientific methods. These identified constraints have formed the basis for establishing a methodology, which enables to determine weights of constraints as well as to compare their levels on the basis of specific needs of entities.

Keywords: Logistics chain, intermodal transport, constraints, effectiveness

1. Introduction

Goods transportation and the related increase of transported volumes in the international freight transport within the current context of globalization has an ever-growing trend. Nevertheless, this fact concurrently brings along a number of negatives features including air pollution due to carbon emissions, use of land, congestions as well as accident events having impact on the health of population, as well as on the environment pollution. Aiming at elimination of unfavourable effects of growing freight transport intensity, one of the possible solutions is to shift the transport volumes as much as possible from the land transport to more ecology-friendly modes, such as rail, sea or inland waterways. Due to that, at present, much attention has been drawn to the development and support of intermodal transport and

combined transport. To support the intermodal and combined transport it is inevitable to ensure its effective functioning. Besides other things this means to ensure its qualitative as well as quantitative parameters, such as reliability, safety, speed, capacity, acceptable economic intensity, just as well as the quality of customer service at a required level [1,2].

In order to ensure the required parameters of a specific logistic chain using the system of intermodal transport it is inevitable to consistently analyse the whole of the selected logistic chain and consequently to identify and assess all the relevant constraints in the chain with regard to specific requirements of the entity for which the logistic chain is being implemented.

Such entities may include logistics operators, consignors or consignees, carriers, or other entities. In this sense constraints represent all the bottlenecks of a logistic chain, potential risks and other limitations, which can negatively influence the resulting effectiveness of the logistic chain.

In this sense constraints represent all the bottlenecks of a logistic chain, potential risks and other limitations, which can negatively influence the resulting effectiveness of the logistic chain [3,4].

2. New Definition of Constraints in Logistic Chains for Needs of Comprehensive Assessment

The theory of constraints (hereinafter only toc), significant in the processing industry, defines constraints as the most important limiting factor, which stands in the way to reach the goal. the concept of a constraint in toc is often substituted by the term “bottleneck”. in the sense of TOC the bottleneck is any source, whose capacity equals or is smaller than the requirement imposed on the source.

Under the standard ČSN EN 14943 the constraint has been defined as any element or factor preventing the system to achieve higher performance with regard to the set goals.

Both the definitions perceive the constraint as an element or factor, restricting performance from the point of view of insufficient capacity. Within the analysis of logistic chains, though, it is the overall chain effectiveness, which is being assessed. Therefore it has been concluded that the limiting factor can be not only the low capacity, but also the too high one [3].

An excessively high capacity of a means of transport and means of transportation, or a too high production capacity of an element of the production system in respect to other system elements, in the long run appears as highly ineffective.

For example in case of a need to transport a consignment of a small volume on rail in Slovakia it is possible to implement the carriage just as a courier shipment, which, though, is considerably limited in terms of weight up to 5 kg and maximum size of 400x500x500 mm, or as a wagon shipment, i.e. as transportation of goods which necessitates at least one wagon.

In case of a shipment of 1 m³ in volume and 500 kg in weight it is possible to implement only wagon transportation, which is highly ineffective in terms of economy or time due to the unused carriage capacity of the wagon [5].

Therefore it is necessary that at the logistic point of the process assessment, which lies between the place of the source and place of consumption (Fig. 1), the constraints are assessed in the material flow, financial flow as well as information flow concurrently, whereas in all the cases there applies that the optimum situation occurs when the offer equals the demand and thus there applies the following relation:

$$P = D \quad (1)$$

where: P – offer, D – demand.

The above implies the following possible results of the analysis of the logistic cut point:

- a) $P = D$ optimum situation.
- b) $P < D$ bottleneck.
- c) $P > D$ ineffectiveness, which will appear as a bottleneck elsewhere within the cut.

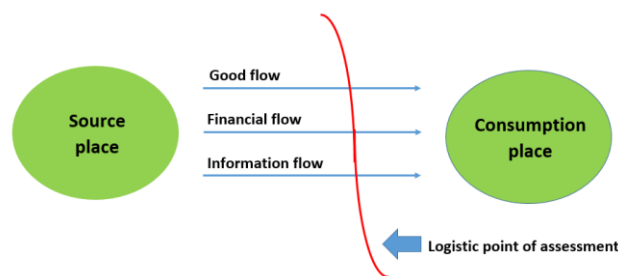


Fig. 1 Process assessment point in the logistic chain in terms of TOC. Source: [3]

The result is a new definition of constraints in terms of the logistic chains topic: „A constraint in the logistic chain is any active or passive element or technological procedure of implementation of the logistic chain, whose parameters adversely affect the very implementation, fluidity or effectiveness of the material, information or financial flow in the logistic chain” [6].

3. The Broader Set of Potential Constraints for Purposes of Variability of Assessment

In case of TOC assessment in the intermodal logistic chains it was necessary to determine a broader set of potential constraints. Procedures and methods suitable for setting up such a set of constraints should be based on scientific methods, such as the method for determination of weights, or method of decision-making analysis. In order to determine the broader set of potential constraints there have been used the FMEA method procedures. The broader set of constraints was established on the basis of personal consultations with specialists in the field of intermodal transport, i.e. with the academic community, logistics operators, consignors or consignees, as well as carriers that defined the potential constraints in the logistic chains of the intermodal transport regardless of the probability of their occurrence or significance of their consequences [3,7].

It has to be noted that the broader set does not contain all the possible constraints since, due to, so to say, an existence of an infinite number of variants of logistic chains the number of potential constraints at each logistic point of assessment can be equally infinite. Nevertheless, the broader set includes constraints, which are encountered in the practice most frequently.

Potential constraints, in terms of the logistic chains theory classification, have been divided to the constraints in the material, information as well as financial flows [8].

4. Identified Potential Constraints in the Material Flow

- **External environment:**
 - Legislation:
 - *Constraints of carriage of certain types of goods.*
 - *Constraints of driving of means of transport on certain days.*
 - *Requirement of an obligatory storing.*
 - Public infrastructure:
 - Rail and road transport:
 - *Possibility of transportation of ITU*
 - *Infrastructure capacity.*
 - *Safety of the system (accident rate).*
 - Water transport:
 - *Possibility of transportation of ITU Hold area capacity.*
 - *Safety of the system.*

- Air transport:
 - *Possibility of transportation of ITU*
 - *Aircraft cargo space capacity.*
 - *Safety of the system.*
 - Terminals of intermodal transport:
 - *Capability of ITU handling.*
 - *Performance in respect to the number of manipulated TEUs.*
 - *Handling safety.*
 - Ports:
 - *Possibility of transportation of ITU*
 - *The depth of the trans-loading edge.*
 - *Performance in respect to the number of manipulated TEUs*
 - *Safety during trans-loading.*
- Means of transportation:
 - *ITJ capacity.*
 - *Goods protection in ITJ.*
- Technology
 - On the transportation path:
 - *Time of transportation of the given transport system within a certain distance.*
 - *Reliability of the transport system (time delays, other types of delays).*
 - In the terminals:
 - *Duration of trans-loading.*
 - *Reliability of trans-loading (time delays and other types of delays).*
- **Internal environment:**
 - Internal company infrastructure:
 - *Connection to the public infrastructure.*
 - *Space for handling the ITUs in loading and unloading.*
 - *Capacity of storage spaces.*
 - Means of transport and equipment:
 - *Capability of handling (TEU).*

- *Time of handling, loading and unloading.*
- Internal company technology:
 - *Safety of handling with ITUs.*

3.1 Identified Potential Constraints in the Financial Flow

- **External environment:**
 - Fees, constraints:
 - *Fees for railway infrastructure.*
 - *Tolls for charged road sections.*
 - *Airport taxes.*
 - *Port charges.*
 - *Fees for ITUs handling.*
 - *Fees for ITUs storing.*
 - *Fees for ITUs rental.*
 - *Taxes, duties and insurance.*
 - *Illegal payments.*
 - Reliability of business partners:
 - *Reliability and solvency of suppliers.*
 - *Reliability and solvency of customers.*
 - Technology:
 - *Safety of transactions.*
 - *Speed of transactions processing.*
- **Internal environment:**
 - Capital costs:
 - *Equity capital costs.*
 - *Borrowed capital costs.*
 - Internal transport and transportation costs:
 - *Costs for ITUs procurement and maintenance.*
 - *Costs for unloading and loading.*
 - *Costs for storing.*

3.2 Identified Potential Constraints in the Information Flow

- **External environment:**
 - Public information infrastructure:
 - *Accessibility to information networks.*

- *Information on the delivery time.*
 - *Information on the movement of the consignment.*
- Information technology:
 - *Information security.*
 - *Speed of information processing.*
- **Internal environment:**
 - Company information infrastructure:
 - *Level and compatibility of the software equipment.*
 - *Level and compatibility of the hardware equipment.*
 - *Level of connection to the public information infrastructure.*
 - Company information technology:
 - *Security of internal information.*
 - *Speed of information processing.*

The broader set was elaborated as a database for selection of a short list of constraints, which will form a constituent part of the final multi-criteria assessment of constraints in the logistic chains in the intermodal transport [3,9].

5. The Set of Restricting Criteria for Purposes of Multi-criteria Assessment of Constraints

The set of restricting criteria for purposes of the multi-criteria assessment has again been determined on the basis of personal consultations with specialists in the field of intermodal transport, i.e. with academics, logistic operators, forwarders or transport operators, as well as carriers. In this case, though, there was taken account of the significance of individual constraints, available information about their level as well as general effectiveness of the multi-criteria assessment itself [10].

The aim was to create a set covering all the relevant constraints in the logistic chains in such a way, as to have the very multi-criteria assessment affective also in terms of the time demands imposed on its elaboration. The consultations with specialists also affirmed that due to the need of flexibility as well as speedy reaction to any possible market changes, the excessively demanding implementation of the assessment prevented using of this assessment in practice [9].

Based on these requirements some of the constraints of the broader set have been kept in an unchanged form, some constraints have been consolidated under a different common title due to making the assessment more effective, and some other, due to their low relevance, have not been included in the short list of constraints at all.

Nevertheless, it has to be noted, that in case of specific requirements of the given entity, that will implement the constraints assessment for his purposes, this entity can replace any of the constraints in the short list by a constraint defined in the broader set. This enables high variability of the resultant multi-criteria assessment on the basis of specific requirements of this entity.

Similarly, due to the effectiveness of the multi-criteria assessment, as well as due to specificities of the used mathematical methods, also the classification of individual sub-categories has been modified, nevertheless, the basic classification in terms of the logistic chains theory dividing constraints in the material, information and financial flows, has remained unchanged [3,11].

Table 1 The set of restricting criteria, their structure and categorization Source: [3]

	Level 1	Level 2	Level 3
	Flows	Flows categories	Restricting criteria
Logistic Chain	1. Material flow	1.1. Material flowfluidity	1.1.1. Total transportation time
			1.1.2. Technology of customs clearance
			1.1.3. Operators' flexibility
			1.1.4. Reliability references of operators
		1.2. ITU suitability	1.2.1. Structure and capacity of ITU
			1.2.2. Technological possibilities of the ITU use
		1.3. Safety of the material flow	1.3.1. Accident rate
			1.3.2. Political situation
	2. Financial flow	2.1. Level and conditions of the financial flow	2.1.1. Total costs
			2.1.2. Payment conditions
			2.1.3. Securing of financial losses
			2.1.4. Credibility and solvency of operators
		2.2. Security of the financial flow	2.2.1. Security of financial transactions
			2.2.2. Illegal fees
	3. Information flow	3.1. Level and technologies of the information flow	3.1.1. Information on the accurate time of delivery
			3.1.2. Technologies for information on the progress of the process
			3.1.3. Speed of information on the changes
			3.1.4. Communication with operators
		3.2. Security of the information flow	3.2.1. Internal information security
			3.2.2. Information technologies for securing the saved information

Since the constraints in the resultant set form a part of the multi-criteria assessment, for the needs of this assessment these constraints have been designated as restricting criteria. The final narrow list of restricting criteria for the purposes of the multi-criteria assessment and their dividing to individual levels is shown in Table 1.

6. Conclusion

Development of the intermodal transport can be significantly promoted by increasing the effectiveness of the intermodal transport system, which means it is necessary to ensure the quantitative as well as qualitative parameters at the required level. An effective organization and management of logistic chains necessitates identifying and assessing all the relevant constraints, which can negatively influence the logistic chains implementation [3].

The essential aim of the contribution was to define and classify constraints in the logistic chains in the intermodal transport for the need of a comprehensive assessment. Consequently, there were defined potential constraints for the purposes of variability of assessment in the area of the material, financial as well as information flows within the external as well as internal environments.

In the third chapter there was established a set of restricting criteria for purposes of the multi-criteria assessment of constraints in the intermodal transport logistic chains at the level of individual flows, their categories and in the follow-up at the level of specific restricting criteria. This method of their classification will consequently enable a comprehensive assessment as well as comparison of levels of constraints in different implementation variants of the intermodal transport logistic chains on the basis of used technology, techniques, processes, procedures, involved entities and other relevant restricting factors.

Classification of constraints has been made in consideration of specific needs, requirements as well as possibilities of the relevant entities in real time of the assessment, whereas the entities, for which the assessment has been implemented, can be logistic operators, consignors, freight forwarders as well as carriers themselves [12].

Acknowledgement

The paper is supported by the VEGA Agency by the Project 1/0791/18 "The Assessment of Economic and Technological Aspects in the Provision of Competitive Public Transport Services in integrated Transport Systems", that is solved at Faculty of Operations and Economics of Transport and Communication, University of Žilina.

References

- [1] Černá, L., Klapita, V. & Mašek, J. (2015). Technical basis of intermodal transport (1st ed.). Bratislava, Slovakia: DOLIS s.r.o.
- [2] Máca, J. & Leitner, B. (2002). Operation analysis (1st, 2nd ed.). Žilina, Slovakia: University of Žilina.
- [3] Kudláč, Š. (2018). Proposal of a methodology for assessing bottlenecks in logistic chains in intermodal transport. Doctoral dissertation, University of Žilina, Žilina, Slovakia.
- [4] Matejko, P. (2012). Methodology of assessment of logistic processes in transport. Doctoral dissertation, University of Žilina, Žilina, Slovakia.
- [5] Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. (2011). European Commission Document COM 144/2011 titled White Paper. Luxembourg: Publications Office of the European Union.
- [6] Marco Polo Programme. (2003). EP and Council Regulation (EU) No. 1382/2003/EU on the granting of Community financial assistance to improve the environmental performance of the freight transport system. European Union.
- [7] Mašek, J., Kendra, M. & Čamaj, J. (2016). Model of the transport capacity of the train and railway track based on used types of wagons. In: Transport means proceedings of the 20th international conference, 5-7 October 2016 (pp. 584 – 588). Kaunas University of Technology, Kaunas, Lithuania.
- [8] Buková, B., Brumerčíková, E. & Kondek, P. (2017). Determinants of distribution logistics in the construction industry. Open Engineering: formerly Central European journal of engineering. 7(1), 14-18.
- [9] Majerčák, J., Kudláč, Š. & Ponický, J. (2016). Innovative management of supply chains. Logi: scientific journal on transport and logistics. 7(1), 98-107.
- [10] Gašparík, J., Gáborová, V. & Ľupták, V. (2016). Process Portal for Railway Cargo Operator with CRM Support. In: Transport means proceedings of the 20th international conference, 5-7 October 2016 (pp. 584 – 588). Kaunas University of Technology, Kaunas, Lithuania.
- [11] Bartuška, L., Černá L. & Daniš, J. (2016). Costs comparison and the possibilities of increasing the transport capacity with a selection of the appropriate railway wagons. Naše more = Our sea: znanstveno-stručni časopis za more i pomorstvo. 63(3), 93 – 97.
- [12] Stopka, O., Černá, L. & Zitrický, V. (2016). Methodology for measuring the customer satisfaction with the logistics services. Naše more = Our sea: znanstveno-stručni časopis za more i pomorstvo. 63(3), 189 – 164.