LogForum

> Scientific Journal of Logistics <

2019, 15 (1), 93-105

http://dx.doi.org/10.17270/J.LOG.2019.312

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

ORIGINAL PAPER

HOW TO IMPROVE FREIGHT TRANSPORT EMISSIONS' MANAGEMENT?

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ABSTRACT. **Background**: To fight against climate change, the EU is committed to the world's most ambitious climate and energy targets, i.e. CO_2 reduction at least 20% by the year 2020 and 80-95% by 2050, in reference to 1990. This paper aims to look at the problem of freight transport emissions' measurement and management in order to reduce CO_2. The focus is on the chemical industry itself. The authors try to answer following research questions: (i) Do chemical and logistics companies in Poland measure and manage freight transport emissions? (ii) Where do they see the biggest challenges to emissions' management and how do they address them? (iii) Is a toolbox facilitating modal shift able to increase the usage of multimodal transport by chemical and logistics companies?

Methods: The research problem is investigated using a two-stage effort. Stage one is structured, in-depth interviews conducted among chemical and logistics companies operating in Poland. The results of this stage have provided the base for the toolbox developed to facilitate the modal shift in chemical transports. Stage two presents the results of the toolbox's beta-version tests conducted among chemical companies in Poland in 2017.

Results: Within the findings, the authors diagnose the obstacles which prevent companies from multimodal transport, and present toolbox consisting of: consulting services, multimodal planning guidelines, IT visualization, and CO_2 calculator. The toolbox facilitates transport partners' cooperation on shifting chemical freight from road to multimodal.

Conclusions: With technological developments, which strongly influence shippers and transport providers and offer improvement opportunities in efficient transport management, the topic of freight transport emissions' measurement and management in order to reduce CO_2 should be investigated in more detail.

Key words: sustainability, multimodal transport, intermodal transport, CO_2 reduction, chemical freight, logistics service provider (LSP).

INTRODUCTION

The Earth's climate is warming which results in serious damage to economies and the environment. The consensus among climate experts is that the main cause of recent warming are greenhouse gases (GHG) emitted by human activities, in particular the burning of fossil fuels and the destruction of forests. The 28 European Union (EU) member countries are responsible for around 9% of world GHG emissions. Nearly 80% of the EU's emissions come from the production and use of energy, including in transport [COM 2016]. According to the International Energy Agency (IEA), transport alone causes 23% of energy-related emissions, 75% thereof emitted by road transport [2014]. Emissions from freight transport account for approximately one third of total transport GHG emissions [Cefic and ECTA 2011]. To fight against climate change, the EU is committed to the world's most ambitious climate and energy targets, i.e. reduction CO_2 at least 20% by the year 2020 and 80-95% by 2050, in reference to 1990 [COM 2011].

While over the past decade most sectors managed to reduce their GHG emission levels, the transport sector has not seen the same gradual decline. The main reasons behind it

Citation: Cichosz M., Pluta-Zaremba A., 2019. How to improve freight transport emissions' management?. LogForum 15 (1), 93-105, http://dx.doi.org/10.17270/J.LOG.2019.312

Received: 13.09.18, Accepted: 08.11.2018, on-line: 28.12.2018.

are: globalization, longer supply chains, and related to it, increased population and goods mobility. Thus making transport more efficient, when ensuring Europe stays competitive and able to respond to increasing mobility, needs strategic, tactical and operational management of transport emissions in general, and freight transport emissions in particular [COM 2016]. To achieve it, governments as well as transport and logistics industry should start, firstly, measure and further manage energy consumption's reductions [Busse et al. 2017]. Despite an increasing number of logistics companies regarding environmental sustainability as an opportunity for improving competitiveness [Rossi et al. 2013, Liu et al. 2018], there is still a great deal of uncertainty on how to implement environmental strategies and how to translate green efforts into practice [Evangelista et al. 2017], and how digital technology can help transport and logistics companies to achieve modal shift and emissions' reduction.

This paper aims to look at the problem of freight transport emissions' measurement and management in order to reduce CO_2. The paper is focused on the chemical industry itself. The EU chemical industry ranks second, along with the United States [Cefic 2016]. In Central Europe (CE), chemical industry generates a 117 billion Euro turnover and employs 340.000 people [Eurostat 2016]. Polish chemical companies are important players in the region. In 2015 their total production sales amounted at 34 billion Euros. Chemical companies are important stakeholders of transport and logistics companies, as they are responsible for 8% of freight transport in CE. They transport large volumes at long distances and they are the object to freight transport emissions management [ChemMultimodal 2017].

The purpose of the study is to look at chemical and logistics companies cooperation and find answers for the following research questions: (i) Do chemical and logistics companies in Poland measure and manage freight transport emissions? (ii) Where do they see the biggest challenges to emissions' management and how do they address them? and finally (iii) Is a toolbox facilitating modal shift able to increase the usage of multimodal transport by chemical and logistics companies?

The empirical research to answer these questions is part of the "Promotion of Multimodal Transport in Chemical Logistics" project, run within the framework of INTERREG Central Europe Programme. The project is one of key logistics and chemical industries' responses to expectations and goals as set in the EU Transport Whitepaper. Its main objective is the promotion of multimodal transport of chemical goods by the coordination and facilitation of cooperation between chemical companies, specialized LSPs, terminal operators and public authorities in chemical regions in CE.

The paper is organized as follows. Section 2 presents a literature review providing the theoretical basis of the analysis. Section 3 is dedicated to the method of research. Section 4 presents the results and its discussion. It is focused on chemical and logistics companies' approach towards modal shift, and discussing the toolbox's application in order to facilitate overcoming modal shift barriers in chemical freight transport. Conclusions and implications for further research and practice are in Section 5.

LITERATURE REVIEW

To meet the ambitious carbon reduction targets, governments, industry sectors and individual companies will have to implement decarbonization strategies over the next few years. The first stage, to develop a transport decarbonization strategy, is the refinement of the carbon measurement process. Having measured these CO_2 emissions, the next stage for companies is to develop strategies for reducing them. The article examines a range of standards and methods of emissions' measurement and emphasizes factors affecting CO_2 emissions calculation.

Factors influencing emissions' measurement

The implementation of green initiatives is generally influenced by a number of factors, which may accelerate or hinder the adoption of such initiatives. These drivers and barriers could be divided into external and internal factors. Among external factors affecting companies' behavior and decisions, the strongest ones are: demanding customers and their attitude towards pro-environmental products and services [Lieb & Lieb 2010] as well as the competition, which adopts different environmental initiatives [Lammgard et al. 2012]. Very important factors are also political, legal and environmental regulations, which force companies to perform CO_2 measurement and mitigation, and finally technology development which allows for better analytics, as well as for the improvement of energy efficiency with better infrastructure, and more eco-friendly vehicles and equipment. Among the internal factors crucial for emissions measurement and management are: sustainability strategy focused on eco-efficiency [Evangelista et al. 2017], which could be reactive (i.e. limited to just obeying the legal restrictions) or proactive (i.e. work-out new competitive advantages related to building up a green image), a company's culture towards green practices and the environmental awareness of its leaders [Lin et al. 2008], and the presence of procedures and methodology to manage environmental routines and technical solutions.

Standards and methods of emissions' measurement

There are numerous standards applied to CO_2 measurement, such as GHG Protocol Initiative, British standard PAS 2050:2011, different types of ISO standards, or EN 16258:2013. There are also numerous EU-wide studies on calculation and reporting of GHG emissions such as Greenhouse Gas Protocol [Ranganathan et al. 2004], McKinnon's Input and Output-based Measures [2007], Calculating GHG emissions for freight forwarding and logistics services in accordance with EN 16258 [CLECAT 2012], G4 Sustainability Reporting Guidelines [GRI 2013]. The analysis of these documents allows to draw two main approaches to CO_2 calculation:

- An activity-based method, a more general calculation method, which uses the average CO_2 emission factor per ton-km by transport mode, transport volume and average transport distance by transport mode.
- An energy-based approach, which estimates the actual amount of work done and the energy consumed per unit of output. The 'output' of freight transport operations is generally measured by energy consumption by liters of fuel or kilowatt-hours of electricity used per ton-km and fuel/energy CO_2 emission conversion factor.

The activity-based method of calculation is recommended for industrial companies that outsource transport operations and hence they have no direct access to energy or fuel consumption data. The companies can use average emission factors dedicated to a particular transport mode to calculate their carbon emissions in an easy and fast way. However, parameters of CO_2 emissions should be differentiated to the country according to broad international differences in the nature and efficiency of freight operations (i.e. the load factor, the share of empty running, the energy efficiency of the vehicle or train – diesel vs. electric locomotives), particularly in the average carbon intensity of the energy source (i.e. a source of electricity for rail transport or the nature of fuel types being obligatory used by vehicles – percentage of biofuels within the fossil fuels) and the condition of transport infrastructure [McKinnon 2007].

The energy-based calculation method is the more accurate way of CO_2 estimation, which is dedicated mostly for logistics or transport companies as they can collect their fuel consumption data and use the correct emission conversion factor. This method permits for much more accurate estimation of CO_2 emissions, however it may take even several years to migrate a company to use the energy-based method [McKinnon and Piecyk 2011]. Thus, McKinnon and Piecyk [2011] proposed a refined activity-based approach that is more precise but also demands closer collaboration between shippers and carriers. Logistics companies have to incorporate into the CO_2 calculation sample data on distances travelled, consignment routing, back loading and fuel efficiency provided by carriers, to permit the calibration of emission factors specific to the industry they are in. This could lead to operational, energy and carbon transparency between shippers and LSPs in the medium term, and encourage cooperation in management of transport emissions.

These three methods are useful to evaluate the potential of CO_2 emissions' mitigation in terms of modal shift from road to multimodal, rail, inland or short sea transport. However, it should be mentioned, that all three methods omit the CO_2 emissions of transhipment activities when intermodal is used [Tao et al. 2017], which may lead to an overestimation of the modal shift's potential influence on the CO_2 emissions' reduction.

The CO_2 emissions can be calculated ex ante and ex post transport activities. Ex ante measuring supports the planning and organizing of freights on functional and operational levels (i.e. decisions of transport modal shift, routes redesign and scheduling). The calculation of energy consumption and emission data of a worldwide transport chain can be done with the help of Internet platforms for CO_2 calculation. There are customized CO_2 calculators offered by consulting companies, as well as a few free-of-charge tools available on the market. Ex post emissions calculation, prepared mostly by the LSP, can be used to report and control CO_2 emissions. This method can enable managers to take strategic and tactical decisions related to the redesign of the logistics system and supply chain, modal split, determining factors of the logistics operator selection and conditions of cooperation in emissions management.

Initiatives to reduce the environmental impact of freight transport

To reduce the CO_2 emissions companies and managers can implement different types of green solutions, i.e. the set of actions and decisions necessary to mitigate the negative impact of transport on the environment, society and economy [Klassen and McLaughlin 1996]. These initiatives could be focused on a single company, through horizontal and vertical cooperation of business partners and competitors, to actions that consider an entire supply chain, its strategy and structure, as well as the stakeholders and policy makers involved [Evangelista et al. 2017]. The more partners involved in an initiative, the more challenging the process of its introduction is. Table 1 presents selected examples of initiatives described in the literature.

Table 1. Overview of selected initiatives to reduce CO_2 emissions from transport operations

Reference	Activities	Parties involved
M. Christopher [2016]	– reviewing product design – reviewing sourcing strategy – applying postponement strategies – reviewing transport options – improvement of transport utilisation	– Shipper – Shipper – Shipper – Shipper, LSP – Shipper, LSP
J. Mangan and Ch. Lalwani [2016]	– supply chains redesigning – using scale to reduce negative environmental effects – promoting various efficiency solutions for transport and handling goods	– Shipper – Shipper, LSP – Shipper, LSP
A. McKinnon [2010]	– modal split – redesigning supply chain structure – improvement of vehicle utilisation (loading, routing and scheduling) – improvement of energy/fuel efficiency (design, maintenance and driving) – revision of carbon intensity of energy	– Shipper – Shipper – Shipper, LSP – LSP, Vehicle manufacturer – LSP
Cefic and ECTA [2011]	– modal shift opportunities from road to "greener" modes of transport – supply chain management related opportunities, i.e. optimization of transport planning or logistics network optimization efforts – increasing vehicle utilization – increasing fuel efficiency of vehicles or reduction of fuel carbon intensity	– Shipper, LSP – Shipper – Shipper, LSP – Shipper, LSP, Vehicle manuf.
A. Woodburn and A. Whiteing [2010]	– transferring freight from roads to "greener" transport modes as rail and water – promoting freight transport modal shift and multimodality	– Shipper, LSP – Shipper, LSP
J. Woxenius and F. Bärthel [2008]	– applying intermodal road-rail freight transport	– Shipper, LSP

Source: own work

The authors see the need to review transport operations in order to reduce freight transport externalities. However, they look at the problem from different perspectives. McKinnon [2015] organizes its analysis around functional, strategic and commercial levels. A vehicle's fuel efficiency related to design, maintenance, the driving of a vehicle, as well as its loading, routing and scheduling, are examples of functional activities focused on managing CO_2 emissions from a single company's perspective. Strategic and commercial decisions could refer to a logistics system design of a single company or a supply chain structure. Supply chain perspective is also presented in Christopher's work [2016]. He indicates five steps which companies can take to decrease the transport-intensity of their supply chains. Mangan and Lalwani [2016] propose three ways to improve the sustainability of logistics and supply chain systems: redesigning supply chains, using scale to reduce negative environmental effects and promoting various efficiency solutions for transporting and handling goods.

According to Cefic and ECTA [2011], the majority of actions are the decision-making domain of industry companies. However, logistics service providers can play a proactive role in highlighting opportunities for CO_2 emissions mitigation, especially within logistics activities such as transport [Cichosz et al. 2017]. They can also have a direct impact on the fuel efficiency and loading factor as well as facilitate the switch from road to intermodal transport. These topics need further investigation.

METHODOLOGY OF THE RESEARCH

The research problem is analyzed on the basis of a literature review and structured, in-depth interviews conducted with twelve chemical companies operating in Poland and nine LSPs serving them. In the second part, the authors present the toolbox developed to facilitate chemical freight shift from road to multimodal transport. The research is part of the "Promotion of Multimodal Transport in Chemical Logistics" project, run within the framework of the INTERREG Central Europe Programme.

The ChemMultimodal project

The ChemMultimodal project is running from June 1st 2016 to May 31st 2019 with a budget of 2.388.840 Euro. 14 partners (regional authorities, chemical industry associations and scientific institutions) from seven countries (Austria, Czech Republic, Germany, Hungary, Italy, Poland and Slovakia) in CE are working together to improve safety and environmental protection of chemical transports on the one hand, but also to ensure competitively and economically feasible solutions on the other. The project is divided into three work packages (WP) (Tab. 2). Chemical companies are the object of the project, as they transport large volumes at long distances, being important stakeholders of transport and logistics companies. Besides, due to the hazardous nature of chemical products, the priority for chemical transport operations is safety and security, and that is why rail, including multimodal or intermodal transport, is more often the option.

Table 2. ChemMultimodal work packages

Work package	Time frame	WP description
WP1	6.2016 – 5.2017	Analysis & Tool Development **Output**: Tool for promotion of modal shift of chemical goods from road to intermodal transport
WP2	6.2017 – 5.2018	Pilot Testing **Output:** Pilot Projects and implementation in each country
WP3	6.2018 – 5.2019	Strategy and Action Plan **Output:** Transnational Strategy (1) and Action Plans (7)

Source: own work

Survey instrument development

A questionnaire for in-depth interviews was developed in English as a guide for the whole project, and was later translated into the Continental languages of project partners. The questionnaire included a mixture of open and multiple-choice questions. It comprised of the following sections:

- Relevance of CO_2 measurement,
- Importance and main routes of multimodal transport,

– Potential for modal shift,
– Drivers (advantages) and barriers (disadvantages) of modal shift,
– Potential internal and external improvements in modal shift (with emphasis on vertical and horizontal collaboration with supply chain partners).

A pilot test of the questionnaire was performed with an expert in the field of logistics and supply chain management in a chemical company, before the full sample of respondents were interviewed.

Data gathering

The questionnaire was sent out to 49 companies across Poland. Logistics and supply chain managers were approached as the most suitable informants. Twenty-one managers responded and interviews were performed by telephone and at-company sites, and lasted approximately one hour each. Statistical data was completed by e-mail. Finally, 21 questionnaires were collected: 12 from chemical companies (both producers and distributors) and nine from logistics companies (LSPs, carriers, rail and port operators). Both groups of respondents were rather diversified regarding their size. 58% of chemical companies were big players with more than 250 employees, 25% - medium, and 17% - small companies. The split of logistics companies was as follows: 45% - big, 22% - medium, and 33% - small players.

The ChemMultimodal toolbox development and beta-testing

The results from in-depth interviews delivered the list of obstacles preventing chemical and logistics companies from using multimodal transport, and provided the framework for a toolbox development. The toolbox is aimed to overcome obstacles and facilitate modal shift in chemical freight transports by creating awareness of multimodal transport importance and presenting possibilities of carrying it out. It consists of four elements: (1) consulting services, (2) planning guidelines, (3) IT visualization, and (4) CO_2 calculator (Tab. 3).

Table 3. ChemMultimodal toolbox elements

(1) Consulting Services • Data base with stakeholders' contacts • Marketing platform	**(2) Planning Guidelines** • Backbone of toolbox • National legal regulations re chemical transport
(3) IT Visualisation • Intermodal Links Platform • Visualize intermodal routes (frequency, available LSPs, information of pre-and post-haulage)	**(4) CO2 Calculator** • Calculation of CO2 emission based on EN 16258 and McKinnon • Create awareness for CO2 savings

Source: own work

Each and every part of the toolbox plays an important role in the process of modal shift. Consulting services are marketing a platform dedicated mainly for chemical companies to improve their share of multimodal transport. Planning guidelines is a list of criteria with regulative national differences, such as loading and driving restrictions, which are required for planning a route of chemical intermodal chemical transport. They are used by a facilitator who helps to develop a close cooperation between logistics and chemical companies to discuss current transport patterns, existing potentials, and possible actions to promote modal shift for chemical loads. The IT visualization platform is an easy Intermodal Links Planner [https://intermodallinks.com] offering companies the best intermodal connections between the place of origin and destination. And the last but not the least the CO_2 calculator [https://ifsl50.mb.uni-magdeburg.de/] which allows for evaluating the effects of the modal shift and estimating CO_2 savings.

When working on the CO_2 calculator, the research team aimed to establish a general but sufficiently precise method for the calculation of CO_2 emissions from freight transport operations, allowing the chemical and logistics companies to measure the CO_2 emissions of various transport routes and determine their transport carbon footprint. The activity-based calculation method was recommended for the use of chemical companies, as most of their transport operations are outsourced and they have no direct access to energy or fuel consumption data. The research highlighted difficulties in calculating emission values according to transport modes and freight destination. A challenging step in the approach was establishing the most appropriate freight emission factor for each transport mode and a particular country (in accordance with the EN 16258 standard). According to project assumptions and constraints, the same average emission factor, derived from international studies, was applied by chemical and logistics companies regardless of the carbon intensity of freight operations in a particular country. Another limitation of the CO_2 calculation methodology was disregarding the energy consumption of handling trans-shipment activities between road and rail or water transport modes which may cause the overestimation of potential of intermodal transport CO_2 emissions reduction. Despite these listed limitations, developing the standard calculation methodology is aimed to enable chemical companies to measure and compare CO_2 emissions across different modes of transport.

According to the project work plan, a peer review of the beta-version of the toolbox with the CO_2 calculator had been planned before the individual items were finalized and prepared for further testing in the project's pilots. The peer reviews took place in 2017. The peer reviews were carried out remotely as desk-based and required the participation of at least two people. The peer review itself required only a few hours of time, including the completion of a review form. For the peer review, an imaginary case example had been used, reflecting a chemical company existing in real life. When performing the peer review, one person acted as the project representative using the toolbox to give advice to the other person(s) who acted as a representative of the company.

RESULTS AND DISCUSSION

The section is arranged with a focus on: (1) presenting chemical and logistics companies' approach towards barriers and emissions measurement and management, as well as their attitude towards modal shift , and (2) discussing tests results of a beta-version of the toolbox used to facilitate modal shift in chemical freight transport.

Chemical and logistics companies' approach towards emissions' management

The in-depth interviews, conducted within the first stage of the research, have shown that measurement and management of CO_2 emissions from chemical freight transport operations are still at an early development stage in Poland. Most chemical companies (70% of those interviewed) do not measure emissions and half of them declared that they do not plan to do it in the nearest future. They admitted that "it's not their problem as they outsourced transport and logistics operations to LSPs", "they had already paid for it", "they did not have tools for it", and "they were not going to do it until it's required by regulations".

Their attitude towards decarbonization of transport operations is shaped by external and internal factors as well. Among the main external barriers respondents emphasized:

- lack of legal and social requirements forcing companies to measure and mitigate CO_2 emissions,
- lack of customers' requirements for pro-environmental freight (i.e. there is no pressure from customers to use more environmentally friendly transport modes and vehicles),
- lack of free access to tools (including IT tools) and emission calculators which could help companies to assess the pollution level they generate in an easy way, which could motivate them to care more about being greener,
- cost and inflexible rules of access to rail infrastructure and terminals, which in great majority are owned by Polish national infrastructure manager PKP PLK who, according to respondents' opinion, is not a customer-focused company with

insufficient communication systems, non-transparent processes and many managerial inefficiencies.

In most cases, transport activities are not included in Corporate Social Responsibility (CSR) strategies of chemical companies, which do not help in shifting road transport to rail. This is even the case for chemical companies that organize chemical freight transport on their own. This is mainly due to the fact that chemical companies focus on reducing emissions from their core business (i.e. production), which generates a large amount of their pollution. Those respondents, who outsource transport operations to LSPs, regard CO_2 measurement as the LSP's duty, however they do not require from LSPs measuring and reporting CO_2 emissions. Moreover, in most cases they do not specify pro-ecological criteria for LSPs regarding, for instance, transport mode selection, fuel used or loading factor. In addition, they do not take into account costs of transport externalities when estimating the cost of transport services. As a result, the main criteria for the selection of transport service providers are punctuality, reliability, and cost of service.

Critical internal factors, limiting shifting road transport to rail, are the habits of transport planners who are accustomed to applying door-to-door road connections because of their convenience, reliability of delivery, and significantly easier transport planning. Respondents admitted that development of multimodal connections, especially international ones, requires extra time and effort for extended planning and organizing operations and thus does not stimulate planners to change their habits and attitude towards modal shift, until timely delivery is assured. The research has showed that there is a strong need to change the mentality of operational workers as well as managers and their attitude towards the sustainability of transport solutions and measurement of CO_2 emission. Interviews reviled that IT tools visualizing different route options and calculating CO_2 emissions could facilitate the process.

On the other hand, the survey showed that logistics companies seem to pay more attention to environmental issues of chemical freight transport. Transport is their core activity and they see the potential of CO_2 emissions' mitigation by modal shift, and appreciate the advantages of multimodal solutions concerning reduction of transport externalities, which supports their CSR strategies. However, in Polish very proliferated market, the percentage of logistics companies who actually measure and manage CO_2 emissions is still very low (30% of those interviewed). Few of them offer their clients the option of measuring the carbon footprint of transport operations even ex ante or ex post. They provide access to CO_2 emissions' platforms and calculators, deliver emission data on invoices, or develop annual reports of transport operations' externalities. In most cases the information on emissions related to freight transport are available as a service at the offer of big logistics players. The interviews revealed that the market for eco-efficient logistics operations will be growing in the future, which can encourage logistics providers, intermodal transport companies and forwarders to invest in the extension of intermodal terminals (i.e. near chemical factories or sea ports) and to improve the quality of existing terminals and their capacity increase, create new multimodal connections and offer additional customized multimodal services dedicated to pooled small-size shipments, which are nowadays carried by trucks.

The infrastructure development and the improvement in quality of multimodal services should enforce chemical companies – LSPs cooperation on shifting chemical freight from road to rail. Survey results show that nowadays the main motivation for shifting chemical freight transport from road to rail is safety and security, as well as necessity to carry higher tonnages. In most cases logistics companies cooperate with chemical producers at arm's length what results from the fact that the logistics market in Poland is very fragmented as the majority of logistics companies are small players with very limited market power [Cichosz 2017].

Chemical and logistics companies' approach towards the toolbox with CO_2 calculator

The toolbox developed within the ChemMultimodal project was aimed to support chemical and logistics companies in cooperation on chemical freight transport shift from road to rail in order to manage transport chains' economic and environmental efficiencies. The toolbox includes a module dedicated to CO_2 calculation, however it is not limited to it. It consists of four elements (Tab. 3) which are important in managing transport chain reconfiguration when reducing CO_2 emissions. Within pre-tests of the beta-version of the toolbox, respondents evaluated every element of the toolbox on a scale of 1 (very useful) to 5 (not useful). Respondents were also asked to briefly explain how they applied the certain elements of the toolbox. The survey showed that the most appreciated element of the toolbox was the consulting services, which constitute a marketing platform integrating stakeholders of multimodal transport, such as chemical and logistics companies, terminal operators and others. Consulting services by definition are based on close cooperation, which is critical when companies share information on current transport patterns, existing potentials and possible actions to establish and promote modal shift.

At the other end of the convenience evaluation spectrum was the CO_2 calculator. Chemical companies felt it was not useful at all as in general, they are not interested in measuring and managing their transport emissions. This results from the fact that the transport emissions' measurement and management have not become obligatory yet. Moreover, during tests of the beta-version of the toolbox, chemical and logistics companies complained that the CO_2 calculator is not integrated with other transportation systems. Eventually, chemical companies considered it as a "nice-to-have" element of the toolbox, which can help in reporting emission savings. At the same time, logistics companies perceived the CO_2 calculator as a helpful tool, which could support them in convincing customers to shift chemical freight to intermodal transport, especially on the routes within European transport corridors.

Planning guidelines and IT visualization received, on average, scores between 2 and 3. Respondents appreciated planning guidelines but complained that it was not integrated with transport management systems. The IT visualization, provided by Intermodal Links Planner, which is an easy to use platform with more than 150 partners involved in providing and up-dating actual data on the scheduled railway connections, intermodal terminals, and their operators, was perceived as a helpful tool suggesting a range of connections between point of origin and destination. However, a disadvantage of the Intermodal Links Planner, highlighted by respondents, is the lack of specific information on the chemical freight handling equipment available at the intermodal terminals. Respondents admitted that this information would be received in quotation but they would appreciate to know it when selecting a multimodal route.

Summing up, the toolbox was recognized as a tool facilitating chemical freight modal shift, which still needs some improvement. Its improved version is being tested in five pilots across project member countries, i.e. Austria, Germany, Poland, Hungary, Italy, Czech Republic and Slovakia. It is a first step towards using the toolbox by chemical companies and this way increasing sustainability of its freight transport.

CONCLUSIONS

The results of the analysis show that in chemical freight transport in Poland, similarly to other European countries, there is still a need to reduce CO_2 emissions. The problem requires the strategic approach of both chemical and logistics companies as well. Chemical companies, even if outsourcing transport operations to logistics providers, should include sustainable transport in their CSR strategies. They should establish long-term strategic objectives for environmentally, socially, and economically responsible transport and logistics which should be translated into tactical and operational plans and metrics. Chemical companies, as buyers of transport and logistics services, could specify the environmental criteria such as the level of CO_2 emissions, source of energy, and others which give clear signal to logistics market that they prefer environmentally friendly LSPs as partners in their supply chains.

Conversely, logistics companies, especially big global players, in many cases have already had sustainable transport and logistics strategies. However, very often they give up on using multimodal solutions in accordance with their corporate goals as they try to please customers who are not ready to accept longer delivery times or take a risk related to load transfers in intermodal transport. As one LSP said, the concept of multimodality was great, there were just operational problems with convincing the customer and delivering it. Thus, significant changes are needed not just at the corporate level of transport management, but firstly the multimodality should be put into action at the EU and national levels by the multimodal infrastructure development (including ICT infrastructure) and the EU and national regulations' supporting more sustainable transport modes such as rail, inland and short sea transports. This way the EU would create equal market conditions for every transport mode.

The toolbox, prepared within the framework of the ChemMultimodal project and presented in the article, promotes multimodality and facilitates collaboration among different parties during the process of modal shift. This toolbox fulfills the gap for a tool, which is not just presenting railway connections with its transport time, frequency and number of transshipments, but integrates consulting services and planning guidelines with on-line platform visualizing available multimodal routes and CO_2 calculator. The toolbox is a complex solution. Project partners, who have developed it, are still working on its improvement. They are going to expand on-line version of Intermodal Link Platform and broaden its functionalities into cost analysis of different transport options.

However, with the technology development and hyper-connectivity becoming a reality, the future of efficient and effective intermodal chemical transport belongs to the solutions such as synchro-modality [Pleszko 2012, Cichosz et al. 2018]. Synchro-modality assumes that, based on prior client delivery requirements such as e.g. price, time, CO_2 emission factor, LSP can freely decide which transport mode to use and flexibly change its decision depending on the situation during the transport process itself. The synchro-modality aims at making the best use of an entire network of intermodal services. Well managed "synchronized intermodality" can deliver advantages for both: chemical and logistics companies as well.

This study presents some limitations. The main one relates to the small number of investigated companies who were asked about the barriers of multimodal transport, and those who tested the toolbox. To achieve empirical generalization, it would be necessary to increase the number of case studies. Moreover, further research is needed on effective operational suggestions and solutions to develop low-carbon chemical freight transport. It would be also interesting to investigate: case studies on the reconfiguration of global chemical supply chains to reduce transit distances and externalities related to it; the measurement of the energy consumption of handling or trans-shipment activities between road and rail or inland transport modes to calculate the overall CO_2 emissions' decrease of modal split, as well as safety and security of these activities; and finally the estimation of the modal shift influence on profitability of industry and logistics companies as well. However, in the authors' opinion with technological developments in the field of Internet of Things (IoT) as well as trends coming from the fourth industrial revolution (Industry 4.0) which strongly influence the field of transport and offer improvement opportunities in efficient transport management, the topic of freight transport measurement and management should be investigated in more detail.

ACKNOWLEDGMENTS AND FUNDING SOURCE DECLARATION

The article is a result of ChemMultimodal Project implementation and is co-financed by Interreg Central Europe Programme.

Scientific work financed from funding for science in the years 2016-2019 granted for the implementation of the co-financed international project.

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W JAKI SPOSÓB POPRAWIĆ ZARZĄDZANIE EMISJAMI W TRANSPORCIE TOWARÓW?

STRESZCZENIE. **Wstęp:** Chcąc walczyć ze zmianami klimatycznymi, UE zobowiązała się do realizacji ambitnych celów klimatycznych i energetycznych, tj. redukcji CO_2 o co najmniej 20% do 2020 roku i 80-95% do 2050 roku, w odniesieniu do 1990 roku. Celem tego artykułu jest spojrzenie na problem pomiaru i zarządzania emisjami w transporcie towarów w celu ograniczenia emisji CO_2. Artykuł koncentruje się na przemyśle chemicznym. Autorzy starają się odpowiedzieć na następujące pytania badawcze: (i) Czy firmy chemiczne i logistyczne w Polsce mierzą i zarządzają emisjami transportu towarowego? (ii) Gdzie widzą największe wyzwania związane z zarządzaniem emisjami i jak je adresują? (iii) Czy zestaw narzędzi ułatwiających zamianę gałęzi transportu, przyczyni się do zwiększenia wykorzystania transportu multimodalnego przez firmy chemiczne i logistyczne?

Metody: Problem badawczy jest analizowany dwustopniowo. Pierwszy etap to ustrukturyzowane, pogłębione wywiady przeprowadzone wśród firm chemicznych i logistycznych działających w Polsce. Wyniki tego etapu posłużyły do

przygotowania narzędzia ułatwiającego zamianę gałęzi transportu chemicznego. Drugi etap prezentuje wyniki testów beta wersji narzędzia wspierającego zamianę transportu drogowego chemii na transport multimodalny, które to testy przeprowadzono wśród firm chemicznych w Polsce w 2017 roku.
Wyniki: Autorzy dokonali diagnozy przeszkód uniemożliwiających firmom transport multimodalny oraz przygotowali i przedstawili narzędzie obejmujące: usługi konsultingowe, wytyczne do zmiany gałęzi, wizualizację IT rozwiązania multimodalnego oraz kalkulator CO_2. Celem narzędzia jest ułatwienie współpracy partnerów w zakresie zamiany transportu drogowego towarów chemicznych na transport multimodalny.
Wnioski: Ze względu na zmiany technologiczne, które mają znaczny wpływ na załadowców i dostawców usług transportowych oraz oferują możliwości usprawnienia zarządzania transportem, należy bardziej szczegółowo zbadać kwestię pomiaru i zarządzania emisjami transportu towarowego w celu ograniczenia emisji CO_2.

Słowa kluczowe: zrównoważony rozwój, transport multimodalny, transport intermodalny, redukcja CO_2, transport chemii, usługodawca logistyczny

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