PRACE NAUKOWE UNIWERSYTETU EKONOMICZNEGO WE WROCŁAWIU
RESEARCH PAPERS OF WROCLAW UNIVERSITY OF ECONOMICS AND BUSINESS

2020, vol. 64, nr 3 ISSN 1899-3192
e-ISSN 2392-0041

Andrzej S. Grzelakowski
Gdynia Maritime University
e-mail: a.grzelakowski@wpit.umg.edu.pl
ORCID: 0000-0001-7190-6115

THE CONCEPT OF INTERNALISATION OF THE EXTERNAL COSTS OF TRANSPORT IN THE EU AND ITS IMPACT ON THE EFFICIENCY OF TRANSPORT SYSTEMS AND THE PERFORMANCE OF LOGISTICS SUPPLY CHAINS

KONCEPCJA INTERNALIZACJI ZEWNĘTRZNYCH KOSZTÓW TRANSPORTU W UE I JEJ WPŁYW NA WYDAJNOŚĆ SYSTEMÓW TRANSPORTU ORAZ SPRAWNOŚĆ LOGISTYCZNYCH ŁAŃCUCHÓW DOSTAW

DOI: 10.15611/pn.2020.3.13
JEL Classification: F15, O18, O52, P47, Q50, R41, R42, R48

Summary: The subject of the study focuses on the implementation of the concept of internalization of external transport costs in the EU based on the SMCP formula. The research objective is to assess the expected effects this may cause with regard to sustainable mobility standards as well as transport and logistics supply chains operations. These effects are defined in the form of improving their efficiency and effectiveness. Qualitative research methods are principally used. The research results indicate that it will enhance the standards of driving sustainable mobility as well as transport and logistics macro-systems towards rationalization in terms of optimizing transport and inventory costs.

Keywords: transport external costs, internalization of external costs, social marginal costs pricing (SMCP), sustainable mobility, green logistics supply chain.

Streszczenie: Przedmiotem badań jest implementacja koncepcji internalizacji kosztów zewnętrznych transportu UE w formule PSKK. Celem badań jest dokonanie analizy i oceny oczekiwanych efektów jej wdrożenia postrzeganych w aspekcie budowy zrównoważonej mobilności oraz sprawności i efektywności realizacji procesów transportowych i logistycznych w łańcuchu dostaw. Oprócz analizy zastosowano głównie jakościowe metody badań. Uzyskane wyniki wskazują, że w efekcie bezpośrednia internalizacja spowoduje zmiany w układzie *modal shift*, wprowadzając wyższy standard zrównoważenia systemów transportu, racjonalizując je, a także makrosystemy logistyczne krajów UE w kategoriach optymalizacji kosztów transportu i magazynowania.

Słowa kluczowe: koszty zewnętrzne transportu, internalizacja kosztów zewnętrznych, społeczne koszty krańcowe (SMCP), zrównoważona mobilność, łańcuch dostaw zielonej logistyki.

1. Introduction

The main purpose of the study is to identify, analyze and assess the impact of the internalization of the external costs generated in the EU transport sector on the operational and functional sphere as well as the development of logistics macro-systems and supply chains. The potential effects of the comprehensive, direct internalization of transport external costs, based on the social marginal costs pricing formula (SMCP), defined in terms of a sustainable modal shift in EU transport systems as well increasing efficiency and effectiveness of transport and logistics operations, are the main subject of research. The external costs produced by any kind of transport activity have brought numerous economic, social and environmental burdens as well as drawbacks and inconveniences. Due to this, the direct internalization of a substantial part of these costs is regarded in the EU as an essential political tool and economic instrument that can enable the EU to bring into effect the primary goal of the European transport policy set out in the EC's White Papers of 1991, 2001 and 2011 (COM 494, 1992; COM 370, 2001; COM 144, 2011).

That objective aimed at promoting the sustainable development of member states' transport systems has been carried out for almost thirty years, however, without any of the expected significant results. The application by the EC in their previous transport policy framework of the mainly indirect and not fully coherent forms and methods of internalization of that transport costs category, predominantly connected with the practical application of different fiscal measures such as dues and fees, various indirect taxes and their other hidden forms, has produced not entirely satisfactory results. Hence the policy makers were strongly supported by researchers in order to bring about the spectacular effects expected by the EU economies and communities, put forward in 2008, a partially modified and much more progressive formula for the internalization of the external transport costs (COM 435, 2008; Ponthieu, 2008, p. 19). That dynamic concept is generally based on the idea of accelerating the whole process of internalization, and since then has been strongly oriented on the full and direct internalization of external costs, i.e. via the transport market mechanism.

2. EU transport systems and their modal shift – main barriers to the development of sustainable mobility

Sustainable mobility is the main objective of EU transport policy. A wholy efficient transport sector provided with modern infrastructure, intelligent transport systems (ITS) and effective market mechanisms can guarantee the necessary level of mobility of goods and people. Nowadays, in the age of globalization and highly competitive world economic environment driven by the 4.0 industrial revolution, mobility is becoming essential to the EU's economies and communities. It is key to a higher quality of life and welfare as well as fundamental for enhancing EU competitiveness and vital for increasing the effectiveness and efficiency of the EU's transport and logistics macro-systems on a global scale. Mobility, directly connected with the economic expansion (increase of GDP), has been growing rapidly in the EU since the mid-1990s. Goods transport grew by ca. 2.5% per year (1995-2009), i.e. more dynamically than GDP, and passenger transport by ca. 1.4% per year in the same period (European Commission, 2010).

As a result, goods and passenger transport grew by 34% and 17% respectively, in that time and what is more, this dynamic growth is envisaged to continue in the next decade. A characteristic trademark of the high mobility in the EU is, however, a relatively modal split. Roads accounted for 45.6 % of the total transport demand, whereas railways for 10.5%, inland waterways 3.3% and oil pipelines amount to 3.2%. Maritime transport then accounted for 37.3% and air transport for 0.1% of the total traffic (all referring to the EU27 in 2009). As a result of the formed modal split in the EU's transport sector in 2009, and as predicted realistically by 2020, there was no chance for any other shift towards more environmentally friendly modes of transport such as rail and inland waterways. The still rapidly growing transport activity has even diminished the chance for shifting towards sustainable mobility which means disconnecting the mobility from its many harmful effects for the economy, society and environment. The data from the European Commission (EC) proves that over a longer time, i.e. between 1995 and 2016, the volume of transport performance in tkm achieved in the EU transport macro-systems increased by 28.6%, i.e. on average only by 1.2% annually. The increase was observed, to the largest extent, in air transport (over 47%) and road transport (40.0%) as well as maritime transport – 26.9%. Rail transport was responsible for a relatively small part of the increase in demand for transport services, recording at that time an increase of only 0.3% annually, whereas the rate of growth related to inland waterway transport was three times higher – 0.9 %; however, between 2000 and 2016, the rate slowed down noticeably.

The total increase amounted to slightly below 13%. The largest increase within particular sectors referred to air transport (over 20 %) and road transport (19.5%). Inland waterways and maritime transport recorded an increase of 10 % and more (however, below the average for the EU market). On average, the annual increase in transport performance at that time amounted to 0.8%, and the increase in the typically pro-ecological transport sectors such as railways, maritime and inland waterways amounted to 0.1 and 0.6%, whereas between 2015 and 2016, the railways and inland waterway transport recorded a negative rate of growth in production measured in tkm, maritime transport saw an increase (6.4 %), exceeding the road transport (5.2%) and air transport (1.8%) (European Commission, 2018).

The EC and Eurostat statistical data reflecting the current modal split in the segment of the EU freight transport, and determining the scale and rate of changes observed on the transport markets in the last 21 years indicate that road transport has not only maintained its dominant market position but also strengthened its role, reaching in 2016 ca. 50% of the share in the EU transport market (based on the volume of transport performance). In second place, unchanged during that time, comes short sea shipping with nearly one-third of the total EU transport market. Rail transport ranks third, losing during the analyzed time only (-) 2.4% of share in the global market. Inland waterway transport is also losing its market share, although to a small extent, nowadays amounting to ca. 4%. A slightly lower level, namely ca. 3%, today refers to the pipeline transport, however its share in the total transport performance has been steadily decreasing. An insignificant, i.e. mere 0.1%, relates to air transport (cargo transport) and between 1995 and 2016 its share remained at the same level (European Commission, 2018).

The analysis of the currently existing modal shift on the EU global transport freight and passenger markets leads to the conclusion that due to several reasons, a significant shift to less carbon-intensive transport modes is still far from being fully achieved. The results of the analysis conducted for the purpose of this study clearly highlighted that road freight is the dominant transport mode. Moreover, current projections seem to confirm that no particular shift between the modes occurred between 1995 and 2016, the and long-term prognosis for 2050 suggests that road transport will maintain its dominant position for both freight and passenger transport. Whilst the modal share for road freight transport is forecast to remain stable in the long run, this share for road passenger transport is envisaged to decrease from 74% in 2016 to 69% in 2050, expressed in p-km (TRAN Committee, 2018; Schade, Helfrich, and Peters, 2010).

This modal shift, practically unchanged for 21 years, remained in the EU despite intensive actions taken by the EU regulatory bodies for the implementation of the strategy of transport sustainable development and support for the construction of a new model of transport demand distribution, meeting the standards of sustainable mobility. Unfortunately, it has been not possible so far through legal and administrative activities as well as the proper financial instruments to decrease the growth rate of road transport, and obtain the expected market results regarding the promoted pro-ecological sectors of transport, i.e. rail, short-sea shipping and inland waterways. The EU transport policy in this area has failed to reach its ambitious goals. The transport market operating under unchanged principles proved to be the only regulator of the demand (European Commission M&T, 2018, pp. 2-9, 19-22).

In the meantime, emissions of hazardous gases and substances seriously threaten human health, lower significantly the local environment quality and make a major and still growing contribution to global climate change. The road sector's CO_2 emissions are nowadays 30% higher than in 1990 and it is the only transport mode where CO_2 emissions are predicted to increase in the coming years. Troublesome noise emissions, heavy congestion, road accidents and many other inconvenient burdens and disturbances also impose severe costs on the economy and society. All these, so-called, negative externalities (cost to society, known as external costs), are not directly borne by transport users (European Commission, 2016; European Commission, 2018; van Essen, 2018, pp. 16-18).

3. External costs – needs for their internalization and its effects

Currently, transport users have to pay only the costs that are directly related to the scale of the use of their mode of transport, i.e. fuel costs, insurance, wages, salaries, amortization and other capital costs, etc. Such costs are regarded being private in the sense that they are borne directly by the users. As opposed to them, the external costs also generated by the users, such as the costs accompanying any kind of mobility, are borne by communities and economies (states and their citizens). External costs are real, even if they do not always have explicit market values and have been fairly precisely estimated by experts since the end of the 1990s and are commonly known in theory and practice (Schroten, van Essen, van Wijngdarden, Sutter, and Andrew, 2019, p. 27).

The sum of the users' direct costs (private ones) and external costs of mobility makes up its social costs. In particular, the total social costs generated by transport users need to constitute the real base for the transport prices. Consequently, incorporating external costs into users' direct costs, i.e. estimating social transport costs, is a keystone for charging in the transport sector. In order to provide the basis for the future correct calculations of infrastructure charges, EU transport policy makers want to create an effective transport pricing system that is more efficient than the existing one. It should reflect more accurately the true costs incurred by the mobility. Such transport charges alone can give the right and optimal price signals to the providers and consumers of transport services and take account of the real needs of the services used as well as the consumption of scarce resources. The new, realistic transport price mechanism is expected to improve the efficiency of infrastructure use, reducing the need for new investment. Strong incentives for users to switch to clean vehicles, to speed up technological innovation and to use advanced logistics transport solutions should be created. Getting the transport prices right means users will bear the full costs they create, and subsequently will have a clear incentive to change their market behaviour and the whole medium and long-term decision-making process in order to reduce those costs. Transforming this main paradigm of sustainable mobility into practice means that in the EU internalization of external costs has to be effected as soon as possible (European Commission, 2008b).

There is a variety of taxes and charges connected with purchasing vehicles, their ownership and exploitation, e.g. fuel excise, registration fees, etc. In addition to them, there are policy instruments (Euro-standard engines in road transport connected with tolls, maximum levels of certain pollutants in fuels such as sulphur and lead, rules to reduce emissions during fuel storage and distribution, and many others), therefore some degree of internalization of external costs is already in place. However, all these fiscal and administrative instruments are sometimes not directly related to a particular external costs component and, as such are generally fragmented in their nature. In such form they are not able to compensate properly even a part of the existing social costs in the transport sector. Consequently, they cannot explicitly tackle the occurring transport market failures caused by the presently used deformed charging system (European Commission, 2012).

The EC is aware of the existing market failures and the huge external costs borne by society, estimated at a minimum of 5% of EU27 GDP (EUR 13.772 billion in 2009 and 5.7% of EU28 GDP (EUR 16553.08 billion), i.e. EUR 841.1 bn. GDP in the EU was worth 18748.57 billion US dollars in 2018 and the external costs accounted for 5.9% of its value (Conference Delft, 2018). Road congestion has been estimated to cost around 4.96% of EU28 GDP per year in the last 4 years (van Essen, 2018). That is why since the middle of the past decade, the Commission has evidently accelerated its efforts to internalize external costs and reach its transport policy goals by making the transport system greener and more sustainable, however it needs to take broader and much more complex, systematic action in this direction, bearing in mind that:

- demand for transport services, especially for road haulage, is still growing;
- leaving the existing situation unchanged would mean that the growing level of mobility will continue and even speed up generating external costs; if nothing is done, the environmental costs alone (air pollution, CO_2 emissions, etc.) will reach EUR 370 billion by 2025 and cause congestion on more than a quarter of the EU roads (van Essen, 2018, pp. 6-8; European Commission, 2019);
- the EU is obliged to meet the agreed international commitments as regards gas emission (Kyoto protocol) and fulfill many internal undertakings.

The EC has been trying to fulfill all these obligations since 2008, presenting several initiatives intended to make the EU transport sector more sustainable and subsequently maintaining both the efficiency and competitiveness of its economies (i.e. a package known as "Greening transport", GTP) (European Commission COM, 2008a). From the EC point of view, the internalization of external costs and its direct strong influence on transport prices should send right signals to transport users that they need to change their market behaviour. This will result in the reduction of negative externalities such as congestion, environmental damage caused by emissions, accidents, noise and vibration levels. However, this purpose should neither hinder the competitiveness of the EU member states economies nor create any additional burden to transport (Ricardo-AEO, 2019).

The formula of charging for the use of transport infrastructure with incorporated external costs proposed in the EU is called Social Marginal Costs Pricing (SMCP). As a result of such price setting, the process would not lead to the overexploitation of resources in the transport sector, but rather to the more efficient use of the existing transport infrastructure. As users would incur additional costs they generate for the society, this could also ensure the fair treatment of both transport users and non-users and might create a direct link between the use of shared resources on the one hand, and payment on the basis of the 'polluter pays' and the 'user pays' principles on the other. Such an approach is obviously possible only if the polluter fails to benefit from any form of compensation that could entirely eliminate the possible effects of internalization (Ricardo-AEO, 2019).

The marginal costs approach, however, may have other limitations in practice. It is not only that they sometimes significantly vary according to time and place which makes it difficult to assign their exact level, but the real trouble is that the fixed costs are high and in many cases traffic density is relatively low. In such situations it is not necessarily possible to include infrastructure costs, and a certain degree of simplification seems to be inevitable. Generally in such cases the marginal costs may correspond to the average of the variable costs. If necessary, the marginal costs may be combined with other approaches to make sure that the infrastructure is funded according to the 'user pays' principle, and the external costs are internalized according to the 'polluter pays' principle. Furthermore, for the same costs (such as those related to noise), a more pragmatic approach based on average costs may be more feasible, and what is important, better understandable and commonly acceptable.

The EU strives to succeed in internalizing the external costs and achieve its transport policy goals by using mainly economic instruments, such as charges, taxes and emission trading schemas. These instruments are regarded to be efficient enough to make all forms of mobility more sustainable. They are strong enough to stimulate transport users to switch to cleaner vehicles and to use more advanced technology as well as less congested infrastructure, and also to avoid traveling at peak hours. This concept will apply to all modes of transport (COM 435, 2008).

There is no doubt that the internalization method, based on the SMCP formula, besides generating financial gains for transport infrastructure managers, will bring many positive effects in the transport sector, significantly contributing to the improvement of the transport market mechanism due to the rationalization of market choices by the consumers of transport services. However, the problem remains, whether these effects will be transformed, and if any, to what extent, to the other actors of the existing supply chains and supply networks as the contemporarily most developed form of organization of economic activity in Europe.

4. Transport costs and their role in the logistics supply chain management

Transport system, which joins separate activities, is a key element in the logistics chain. Hence transport, and in much broader concept, transport markets, play a very important role in each supply chain. This is a real driving force influencing its effectiveness and elasticity as well as determining the ability to survive under turbulent conditions, e.g. economic and financial crises (Eft & Jda, 2019, pp. 7-9).

In fact, any supply chain success is closely linked to the appropriate use of transport, i.e. the suitable choice of transport mode and transport operator. This is a general guideline known by each logistics supply chain operator who needs to use in the most effective way the responsive transport systems on a European or global scale in order to lower their overall costs. Transport is a vital component of their globally oriented strategy which states that the supply chain's goal is to minimize the total cost while providing the desired level of responsiveness to customers (Tseng, Yue, and Taylor, 2005). Transport consumes one-third of the amount in the logistics costs, and therefore transport systems greatly influence the performance of logistics systems (Conference Delft, 2018; Garner, 2017).

A transport system is also the most important economic link among the components of business logistics systems. Around one-third to two-thirds of the costs of enterprises' logistics are nowadays spent on transport, storage, warehousing and parallel services. Hence, a transport system which makes goods and products movable and provides timely and regional efficacy to promote value-added under the least cost principle, affects the results of logistics activities and obviously, influences production and sales. In the logistics system, transport costs could be regarded as a restriction of the objective market. The value of transport services varies with different products and industries. For products with a small volume, low weight and high value, transport cost simply take up a very small part of sales and is less considered; for big, heavy and low-value products, transport constitutes a very big part of sales and affects profits more, and therefore it is more relevant. The value of transport services is a derived unit of transport costs which in turn depend on the structure and elements in the SCM framework. It displays the details of the entire process from purchasing, management, production, and distribution to customers. The product flow that proceeds through the whole production process from material supply via manufacturers to providing the finished products to consumers, serviced by various transport modes, determines the transport costs. Its character (type of product), intensity and forms of proceeding (direct flow, storage, etc.) affect the total transport costs as well as their structure. Such relations existing between the use of different transport modes and the two main transport related cost elements are reflected in Figure 1.

Figure 1 shows the principle of transport costs for different transport modes. Airfreight is generally much more expensive than both the indicated land transport

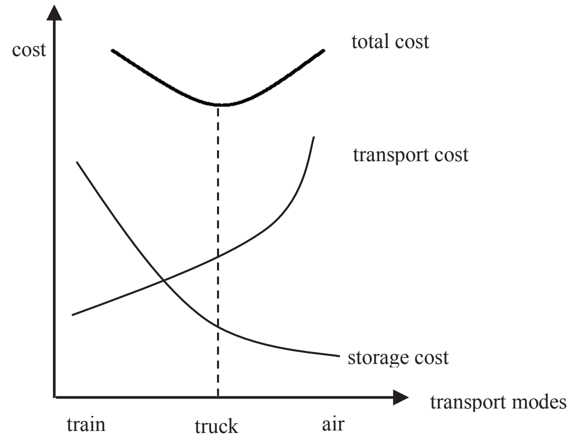

Fig. 1. Transport costs relating to the logistics supply chain transport patterns

Source: (Chang, 1998, p. 49).

modes but the storage cost might here be lower. Thus, in terms of total cost, airfreight for the supply chain logistics operator might be the most reasonable transport mode for a particular transport purpose, example e.g. the transport of manufactured goods with a high value and small volume, or particularly fresh products with a relatively high value per unit, e.g. cargo ton.

As regards the total transport costs and their numerous components within a logistics supply chain as well as their function and role in SCM optimizing, especially while taking into account the schedule in the EU for this decade, the internalization of transport external costs by implementing social marginal costs (*SMCP formula*) pricing for transport infrastructure, creates a great deal of new problems. These refer to key economic relations existing between transport costs regarded as a significant part of the total logistics costs generated by the supply chain, and generally speaking, the time factor which plays a decisive role in the smooth and efficient proceeding with all transport operations within the product flow (Branch, 2009, p.30). These relations are closely connected with the level of intensity of the traffic flows as a reaction of the transport system to the demand for transport services which subsequently determines the ratio of vehicles' flow by the existing throughput of transport infrastructure and the total price incurred by consumers of transport services. Such correlation which reflects the existing level of congestion in the transport infrastructure system as well as the obtained conditions of the transport market (demand and supply side), is presented in Figure 2.

Figure 2 shows clearly the market-oriented behaviour of all transport operators adapting typical types of vehicles using the public transport infrastructure, who need to bear the cost reflecting the level of congestion on the transport network and payment for access to the infrastructure they use. The marginal cost curve measures

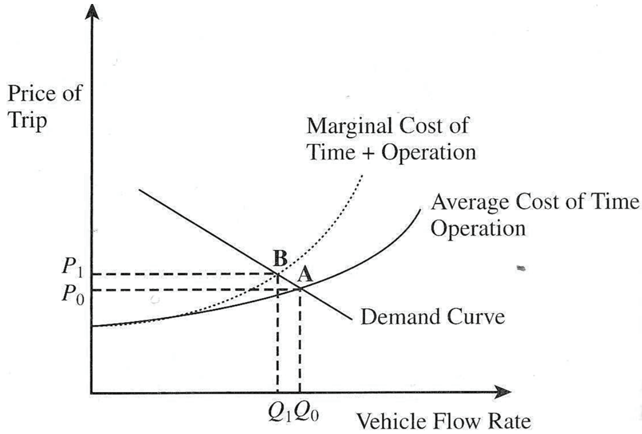

Fig. 2. Fluctuation of marginal and average cost of time and operation of transport vehicle flow (train, truck) as a result of changing effective demand – potential supply constellation on the transport market

Source: (Chopra and Meindl, 2010, p. 392).

the marginal increase in total transport cost as a result of the additional traffic flow and consequently the growing density of the flow of vehicles. This cost curve is higher than the average cost curve, which means that the marginal impact of any individual vehicle (the presence of a new transport operator) on total cost is much higher than its, or their, share of this impact (on the traffic flow). From the marginal cost perspective (Figure 2), especially bearing in mind the upcoming EU SMCP formula, transport operators (vehicles) should be charged a higher toll: $P_1 - P_0$ so that the cost they bear by such a vehicle flow rate is the true cost they are imposing on the transport infrastructure subsystem, e.g. highway, railway network, etc. The toll lowers the vehicle flow rate when it falls to Q_1 level. All these relations are closely connected with the demand price elasticity, existing potential supply of transport services limited by maximal throughput of the related infrastructure network and holding applied methodology of payment for access to transport infrastructure (Schroten, van Essen, van Wijngaarden, Sutter, and Andrew, 2019, pp. 8-11).

Summing up, the absence of a congestion toll and scarcity charges results in:

1. Uncontrolled growing demand for services provided by transport infrastructure and consequently causes a significant overuse of such scarce public capital-intensive resources.

2. Growing congestion costs which have to be incurred by all infrastructure users, irrespectively of their character and frequency of use of transport infrastructure component or traffic intensity.

3. Rising or even escalating external costs, especially these related to the time factor – the total time needed to satisfy mounting up demand for transport services.

4. Fall in efficiency, effectiveness and elasticity of product flows in logistics supply chains as well as the supply network on a global scale, which generates additional logistics costs for SC operators and the involved businesses.

Moreover, the application of quasi-market prices for the use of the transport infrastructure or methodologically incorrectly calculated on the basis of realistically generated costs by transport users might also cause serious economic, social and environmental problems. Such constructed tolls like those nowadays in the EU, otherwise result in higher prices at peak locations and hours and lower prices. Consequently, they can not only lower the effectiveness of product flows in logistics supply chains but also distort to some extent the processes of optimal resources allocation on the macro as well as global scale (Branch, 2009, pp. 117-119).

5. Criteria of optimal transport mode selection in the logistics supply chain

The product flow, whose efficient and smooth proceeding is determined by transport operations and processes, links the whole supply chain from supplier and manufacturer to consumer. Unimpeded product flow supported by information flow could increase the operation accuracy for cost-saving and promote the competitiveness of firms involved in the logistics supply chain. Hence, transport operations and transport costs which reflect the usage of a certain transport mode with all its pros and cons constitute a decisive factor determining the supply chain performance. That problem refers directly to the so-called trade-offs in transport design in the logistics supply chain and is connected with the appropriate, from the logistics point of view, selection of transport mode. In concise form this issue is presented in Table 1.

Table 1. Ranking of transport modes in terms of supply chain performance (1-worst; 6 – best)

Size	Lot Inventory	Safety Inventory	In-Transit Cost	**TRANSPORTATION TIME**	**TRANSPORTATION COST**
RAIL	5	5	5	2	5
TL	4	4	4	3	3
LTL	3	3	3	4	4
PACKAGE	1	1	1	6	1
AIR	2	2	2	5	2
WATER	6	6	6	1	6

Source: (Chopra and Meindl, 2010, p. 394).

Table 1 shows the impact of using different modes of transport on the most important elements determining the final supply chain performance, i.e. inventories, response time and costs. Each transport mode is ranked along various dimensions, with 1 being the worst and 6 being the best. With regard to the ranking of transport modes presented in Table 1, following remarks can be made:

- faster modes of transport are preferred for products with a high value-to-weight ratio for which reducing inventories is important,
- cheaper modes of transport are preferred for products with a small value – to – weight ratio, for which reducing transport costs is important,
- apart from the cost of transport, the selection of transport mode needs to take into account cycle, safety and in-transit inventory costs.

A general remark concerning the appropriate choice of transport mode by the shipper or supply chain logistics operator can be formulated in the form of a guideline indicating that ignoring inventory costs when making transport decisions always results in choices that worsen the performance of the supply chain (Reuters, 2020, pp. 15-17).

6. Conclusion

Any decision made by shippers or logistics operators in a supply chain network always needs to take into account its potential impact on inventory costs, facility and processing costs as well as the cost of coordinating all operations and the level of responsiveness provided to customers. As regards transport costs and their optimization in the supply chain, shippers and logistics operators need to evaluate different transport options connected with the choice of transport mode in terms of various costs and revenues. Then they should rank these options according to coordination complexity and, as a result of such an evaluation, the appropriate transport decision can be taken. When making such a complex transport decision with regard to transport mode selection, any shipper/operator or company manager involved in SCM has to consider the following trade-offs:

- transport and inventory costs trade-off,
- transport costs and consumer responsiveness trade-off.

In selecting a transport mode, supply chain operators or shippers have to balance both transport and inventory costs. Otherwise for some modes of transport they cannot optimize the transport and logistics costs as it may result in relatively low transport costs which do not necessarily lower the total costs for the supply chain. Cheaper modes of transport usually have longer operation times (longer production cycles) and larger minimum shipment quantities, both of which result in a higher level of inventory in the logistics supply chain. In turn, transport modes that allow for shipping in small quantities might lower inventory levels but they tend to be more expensive in terms of time and operation costs.

However, such operational and market choices are made nowadays almost always by logistics supply chain operators and shippers, who do not take into account the real existing transport and inventory costs. These costs, being a subject of calculation and evaluation of transport processes, are almost exclusively private costs, i.e. they do not incorporate external costs in their full extent. As a result, such choices and decisions are in fact not optimal both from a micro as well as macroeconomic point of view. They cannot bring expected value added to consumers and other entities involved in the supply chain operations, and what is more, they hamper the whole process of enhancing the supply chain management (SCM) towards the more efficient form of cooperation among its partners. The EC-proposed direct internalization of external costs in the transport sector along with the launch of the new, SMCP-based method model of charging for the use of transport infrastructure, can substantially change the currently existing distorted pattern of transport mode selection. A new charging system, based on tolls directly linked to all factors determining external costs, such as time, type of vehicle, form of infrastructure usage, etc., will provide logistics supply chain operators and shippers via transport markets with appropriate signals with regard to the full social costs attributed to each mode of transport and vehicle. As a result, a new pricing mechanism in the transport sector will create a new system of preferences as far as the selection of particular transport modes is concerned.

These strongly market oriented preferences can significantly change the traditional ranking of transport modes based on criteria closely linked to the supply chain performance (see Table 1). Therefore, under the new transport market (price) regime, supply chain logistics operators and shippers aimed at optimizing transport costs will be forced to reconsider a new distribution pattern of costs and revenues while evaluating different transport options. Due to the implementation of the SMCP model, they predominantly need to take into account the new dimension and assessment of transport and inventory costs and their trade-offs. Consequently, the rationalization of supply chain operation and development will be launched and in the aftermath the existing modal split will be reshaped and a new one established. The new modal split should reflect not only the criteria set by the EU transport policy oriented towards promoting sustainable mobility, but also the prerequisites of the supply chain logistic operators aimed at the optimal selection of the transport mode.

References

Branch, A. E. (2009). *Global supply chain management and international logistics*. New York and London: Routledge Taylor & Francis Group.

Chang, Y. H. (1998). *Logistical management*. Taiwan: Hwa-Tai Bookstore Ltd.

Chopra, S., and Meindl, P. (2010). *Supply chain management; strategy, planning, and operation*. London: Fourth Edition, Pearson.

COM 494 final (1992). *The future development of the common transport policy – a global to the construction of the community framework for sustainable mobility*. White Paper, Brussels: Communication from the Commission EU.

COM 264 final (2001). *A sustainable Europe for the Better World. A European Union Strategy for sustainable development*. Brussels: Communication from the Commission EU.

COM 370 (2001). *European transport policy for 2010: time to decide*. White Paper, Brussels: EC EU.

COM 435 final (2008). *Strategy for the internalization of external costs*. Brussels: Communication from the Commission EU.

COM 370 final (2011). White Paper: *Roadmap to a Single European Transport Area – towards a competitive and resource efficient transport system*. Brussels: Communication from the Commission EU.

COM 144 (2011). White Paper. Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. EC, Brussels.

Conference Delft (2018). *Multimodal sustainable transport – which role for the internalization of external costs?* Retrieved 05.03.2020 from http://ec.europa.eu/transport/sites/transport/files.

Eft & Jda (2019). *The global logistics report*, Washington.

Essen, H. van (2018). *Sustainable transport infrastructure charging and internalization of transport externalities*. Delft: CE Delft.

European Commission (2008a). *Greening Transport.* Brussels: COM (2008) 433 final.

European Commission (2008b). *Summary of the Impact assessment on the internalization of external costs*. Commission Staff Working Document accompanying the Strategy for an internalization of external costs, Brussels: SEC(2008) 2209.

European Commission DG T&E (2010). *Transport in figures.* Part 3. Brussels: EC DG for Energy and Transport.

European Commission (2012). *Towards low carbon transport in Europe*. Brussels: EC Communicating transport research and innovation.

European Commission (2016). *European Commission: A European strategy for low-emission mobility*. Brussels, EC COM (2016) 283.

European Commission (2018). *EU transport in figures*. Luxembourg: EC Statistical Pocketbook 2018, Connecting Europe, EC Mobility and Transport.

European Commission M&T (2018). *Transport in the European Union. Current trends and issues*. Brussels: EC Mobility and Transport.

European Commission (2019). *Handbook on the external costs of transport.* Economic analysis and better regulation, Version 2019, Brussels: EC DG Mobility and Transport Directorate A – Policy Coordination Unit A3.

Garner, H. (2017). *European Logistics Report*, Antwerp-London: By Haley Garner, CLECAT, Head of Research and Content.

OECD. (2010). *Sprawozdanie dotyczące przygotowania Strategii Zielonego Wzrostu*. Retrieved from http://www.oecd-ilibrary.org

Ponthieu, E. (2008). *Towards an integrated and coordinated sustainable logistics and transport policy for Europe*, Rome: European Economic and Social Committee (EESC).

Reuters (2020). Supply chain hot trends report: 2020 & beyond, Retrieved from http://file/t/ReuterSupply%20Chain%report

Ricardo-AEA. (2019). *Update of the Handbook on External Costs of Transport.* Final report. Brussels: Report for the European Commission DG MOVE AEO.

Schade, W., Helfrich, N., and Peters. A. (2010). A transport scenario for Europe until 2050 in a 2-degree world, Lisbon, 12th. WCTR.

Schroten, A., van Essen, H., van Wijngaarden, L., Sutter, D., and Andrew, E. (2019). *Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities: Executive summary.* Delft: CE Delft and INFRAS.

TRAN Committee. (2018). *Modal shift in European transport: a way forward,* Strasbourg: Study requested by the TRAN Committee. Research for TRAN Committee – Policy Department for Structural and Cohesion Policies, Directorate-General for Internal Policies, PE 629.182.

Tseng, Y., Yue, W. L., and Taylor, P., (2005) The role of transportation in logistics chain. *Proceedings of the Eastern Asia Society for Transportation Studies*, (5).