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The New Silk Road as an green alternative for China-European Union transport – CO_2 emission analysis

Nowy Jedwabny Szlak jako zielona alternatywa dla transportu między Chinami a Unią Europejską – analiza emisji CO_2

Abstract. The current climate policy of the European Union is aimed at reducing carbon dioxide emissions. This has a significant impact not only on the functioning of transport within the Union but also with its key partners. China has been the European Union's biggest partner for many years. Since 2013, that is, after the launch of the New Silk Road, along with sea and air transport, rail transport has also remained a viable transport alternative on that route. The conducted research showed that, taking into account CO_2 emission measured with WTW and TTW method, rail transport between China and the European Union can be treated as a relatively green solution in comparison to other modes of transport. The shortcomings of these methods were indicated and the need to correctly present the length of the route for which the emission measurement was performed. Attention was also paid to the infrastructural limitations related to the further development of rail transport within the New Silk Road.

Key words: New Silk Road, CO_2 emission, green transport

Synopsis. Obecna polityka klimatyczna Unii Europejskiej nakierowana jest na ograniczenie emisji dwutlenku węgla. Ma to istotny wpływ nie tylko na funkcjonowanie transportu wewnątrz Unii ale także z jej kluczowymi partnerami. Największym partnerem handlowym Unii Europejskiej pozostają od wielu lat Chiny. Od 2013 roku, to jest od momentu uruchomienia Nowego Jedwabnego Szlaku, obok transportu morskiego i lotniczego realną alternatywą na tej trasie pozostaje także transport kolejowy. Przeprowadzone badania wskazały, że biorąc pod uwagę pomiar emisji CO_2 metodami WTW i TTW, transport kolejowy w relacji Chiny – Unia Europejska może być traktowany jako relatywnie ekologiczne rozwiązanie transportowe w porównaniu do innych dostępnych alternatyw. Wskazano przy tym na niedostatki tych metod oraz na konieczność poprawnego przedstawiania długości trasy dla której pomiar emisji jest dokonywany. Zwrócono także uwagę na uwarunkowania infrastrukturalne związane z dalszym rozwojem transportu kolejowego w ramach Nowego Jedwabnego Szlaku.

Słowa kluczowe: Nowy Jedwabny Szlak, emisja CO_2, zielony transport

JEL codes: F18, Q50, L91

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Introduction

In recent years, the move towards a greener, more environmental friendly economy has started to play a significant role in setting the course for development. In the European Union, such thinking is manifested in legal regulations affecting various areas, including the proposed concept of Fit for 55 [European Council]. Regardless of how the scope of the reported regulations may be treated, it is undoubtedly aimed at reducing the external costs of transport activities, which include the impact on the environment. This impact is most often expressed through CO_2 emissions, however, it is not the only form of transport's impact on the climate and the environment. Role of CO_2 in climate changes has been widely studied for a long time, and although it has mostly supporters, there are also some opponents. Undeniably one of the most significant activity related with carbon dioxide emission is transport. Transport external costs are widely recognized problem in European Union [European Commission 2019]. Incontestably, each mode of transport should contribute to the costs of environmental protection proportionally to its impact and be gradually forced to introduce improvements that reduce this impact [Kageson 2009]. This problem is widely discussed in scientific literature [see for ex. Rajkovic et al. 2015, Zhao et al. 2015, Ehrler et al. 2016, Wang et al. 2019]. Based on observations, especially when looking at CO_2 emissions per one tkm, the following relationship in transport environmental impact is assumed: maritime < rail < road < air. General goal of Fit fir 55 politics is to make European Union carbon neutral. That means also to make transport carbon neutral or as close to neutral as possible.

Table 1. The share of the modes of transport in servicing trade between China and the European Union between 2013 and 2020
Tabela 1. Udział poszczególnych gałęzi transportu w obsłudze wymiany handlowej między Chinami a Unią Europejską w latach 2013–2020

	Value [EUR]				Volume [t]			
Year	maritime	rail	road	air	maritime	rail	road	air
2013	65.98	0.63	7.15	26.24	98.96	0.08	0.61	0.34
2014	66.19	0.84	6.76	26.21	94.12	0.54	3.44	1.90
2015	63.74	1.14	6.91	28.2	94.10	0.65	3.53	1.72
2016	93.59	2.04	6.52	27.86	92.74	0.92	4.82	1.53
2017	62.44	2.71	6.19	28.66	93.61	1.22	3.25	1.92
2018	62.44	2.70	5.96	28.89	93.31	1.38	3.31	2.01
2019	62.97	2.76	5.94	28.33	94.04	1.33	2.88	1.75
2020	58.87	4.32	7.05	29.75	92.85	2.22	3.24	1.68

Source: [Eurostat].

Trade exchange between European Union and China is one of the biggest trade flows in the world. The flow volume is constantly increasing. Goods exchange can be handled by various modes of transports with maritime transport being dominant one (see Table 1). Since 2013, when the New Silk Road started stable operations, the role of rail traffic between China and European Union is constantly increasing, with the number of trains sent and TEU units transported growing rapidly each year [UTLC 2019, 2020]. Intensified rail traffic not only results from the overload of other modes of transport, but also from an attractive offer – looking from a perspective of transport economics, offer. Due to the shorter time of transport than in the case of transport (by about 40–50%) and significantly lower price than in the case of air transport, many customers consider the New Silk Road to be an important solution in their supply chains. Despite that and taking in mind a global drive towards a greener transport it is important to consider whether using rail transport is more environmentally friendly then dominant maritime and air alternatives

Aim of the paper and methodology

The main aim of the study was to find if the New Silk Road can be treated as green, ecological transport solution in terms of CO_2 emission, in comparison to maritime and air transport in service of China – European Union trade exchange. Road transport has been excluded from the study due to a relatively small amount of data of uncertain quality.

The key element of the comparison between different transport branches is based on Carbon Emission Counter published by Eurasian Rail Alliance Index. This index takes weight in tons and TEU volume transported between China and Europe as benchmark and then compares and simulates CO_2 emission related that amount in maritime, air and road transport. Data are presented in two perspectives – direct emission (TTW – tank-to-wheel) only and direct and indirect emission together WTW – well-to wheel) [for information on the emission types, see an ex. EcoTransIT World 2020]. Detailed methodology can be found at Index1520 webpage [ERAI]. Using the information given it is possible to determine the kgCO_2 production per t and single TEU transported via given route. The emission parameters obtained in this way are consistent with those obtained in other scientific research [see for example OECD 2010].

There are two major problems with numbers presented under Index1520 website. First one is related to the carbon emission measures. WTW (well-to-wheel) shows general emission of given transport mean. It is constructed from two separate segments. TTW (tank-to-wheel) represents exploitation only, or in other words emission from energy consumption during vehicle operations. Then WTT (well-to-tank) segment is related with upstream process which can be described precisely as energy supply, production and distribution. However, emissions related to the production of the infrastructure and the construction of vehicles using it are not included here. Therefore, emission measurements with the use of WTW, TTW or WTT parameters do not reflect changes in emissions in a broad context, but are limited only to significant, but selected areas. The emission of harmful substances is responsible only for part of the external costs of transport. Only after taking all of them into account can a reliable assessment of its impact be made. Perhaps, therefore, in order to obtain better results and a more complete picture of the actual impact of individual modes of transport on the environment, more precise methods should be used that also take into account other areas of transport impact. The introduction of such methods in the future seems to be a necessity to present reliable research results allowing for drawing appropriate conclusions. These methods will require the measurement of the additional amount added and the application of appropriate processing procedures. Despite these shortcomings, this article will be limited only to these commonly used measures already implemented inside Index1520 (so WTW, TTW).

Second problem is that the distance used to estimations is the distance between two rail terminals in Dostyk (Kazakhstan) and Brest (Belarus) which is 5,454 km. This is not complete and representative transport distance since it is only a part of transit via CIS countries

(Kazakhstan, Russia, Belarus). In reality shortest distance between the two closest rail terminals in European Union countries and China, which are Małaszewicze in Poland and Xi'an, is approximately 7,500 km (137%). Brest and Małaszewicze are located quite near to each other but the distance between Dostyk and Xi'an is noticeable. Thus difference between Index1520 measurement and real distance has to be considered as significant. Moreover, the distance measure used on the Index1520 website is even less suitable for maritime transport. If consider the port of Shanghai as the main seaport on the Chinese side, and the port of Hamburg (Germany) as the main port on the European side, the distance, converted from nautical miles to kilometers, is nearly 20 000 km (367%). This distance may be shortened after adopting the ports in the south of China and in the Mediterranean basin as reference points (for example, for the Hong Kong – Taranto (Italy) pair, the distance is slightly over 15,000 km, still 275%), however, even then it is significantly greater than the measure adopted for the purposes of Index1520. In case of air distance it's also longer since main airports are located in coastal area of China (Beijing, Shanghai or Shenzhen) or in Sichuan region (Chengdu, Chongqing) and main airports in Europe are located closer to its center (Germany, France and Benelux countries). Taking as an reference Beijing and Frankfurt am Main (Germany) distance is around 7,800 kilometers. However for longest connections from China to Portugal distance may reach almost 11,000 kilometers. Therefore, in order to correctly compare rail, maritime and air transport, it is necessary to use the real distance measures. Taking into account the real distance to the calculations proposed under Index1520 will be the main contribution of this work.

Results

Table 2 presents CO_2 emission in kilograms based on rail traffic measured in tons and TEU in 2020 between China and European Union (both westbound and eastbound). Also there is direct comparison to potential emission using alternative maritime or air transport for the same amount of weight and TEU. The first three rows gathers information based on real distance between chosen pair of destinations while other three are related to distance measure implemented in Index1520 Carbon Emission Counter. Table 3 extends this comparison by presenting percentage difference in CO_2 emission where rail transport is treated as a reference point (100%) both for distance and traffic volume in tons and TEU.

Looking at absolute numbers presented in Table 2 it should be noted that taking into account only the railway section between the China/Kazakhstan and Belarus/Poland border crossing points significantly lowers the results obtained when real distance is in use. Focusing only on the measurements with the use of real distance, it can be seen that the rail transport leads in the TTW emission, while the maritime is superior in case of the WTW emission. This is true for both mass in tons and TEU. In both cases, air transport performs the worst in terms of environmental harm.

When examining the data from Table 3, it can be noticed that the advantage of rail transport over sea transport in TTW increases significantly if the real distance is taken. Importantly rise is slightly more visible in case of weight then TEU (from 545.81% up to 1455.49% in weight and from 477.58% up to 1273.55% in TEU). Moreover, in the case of WTW, where sea transport had a huge advantage when using the Dostyk – Brest distance, the use of the real distance reduces the difference and improves the competitiveness of rail transport. Again improvement for rail is more visible in case of weight then TEU (from 15.44% up to 41.16% for weight and from 11.82% up to 31.51% for TEU).

Table 2. Comparison between CO_2 emission in kilograms for rail, maritime and air transport between China and European Union taking volume transported via rail in 2020 as an reference
Tabela 2. Porównanie emisji CO_2 w kilogramach dla transportu kolejowego, morskiego i lotniczego na trasie Chiny – Unia Europejska przy założeniu wolumenu przewozów kolejowych z 2020 roku jako punktu odniesienia

	Vehicle type	Route	Distance [km]	Weight [t]	10 000 000	TEU	500 000
				TTW [kgCO₂]	WTW [kgCO₂]	TTW [kgCO₂]	WTW [kgCO₂]
Real route	ship	Shanghai – Hamburg	20 000	592 676 824	649 468 190	584 558 330	640 571 768
	train	Xi'an – Brest (Mała*)	7 500	40 720 152	1 577 887 044	45 899 877	2 032 683 367
	air	Beijing – Frankfurt am Main	7 800	26 761 430 704	32 709 955 880	25 200 398 011	30 801 937 278
Index 1520	ship	Dostyk – Brest	5 454	161 622 970	177 109 975	159 409 057	174 683 921
	train	Dostyk – Brest	5 454	29 611 694	1 147 439 459	33 378 391	1 478 167 345
	air	Dostyk – Brest	5 454	18 712 415 777	22 871 807 612	17 620 893 686	21 537 662 297

TTW – tank-to-wheel; WTW – well-to-wheel
*Mała – Małaszewicze

Source: own work based on Index1520 Carbon Emission Counter [ERAI 2021].

Table 3. Comparison between CO_2 emission in percent's for rail, maritime and air transport between China and European Union taking volume transported via rail in 2020 as an reference
Tabela 3. Porównanie emisji CO_2 w procentach dla transportu kolejowego, lotniczego i morskiego na trasie Chiny – Unia Europejska przy założeniu wolumenu przewozów kolejowych z 2020 roku jako punktu odniesienia

	Vehicle type	Route	Distance [km]	Weight [t]	10 000 000	TEU	50 0000
				TTW [%]	WTW [%]	TTW [%]	WTW [%]
Real route	ship	Shanghai – Hamburg	20 000	1455.49	41.16	1 273.55	31.51
	train	Xi'an – Brest	7 500	100.00	100.00	100.00	100.00
	air	Beijing – Frankfurt am Main	7 800	65 720.36	2 073.02	54 902.97	1 515.33
Index 1520	ship	Dostyk – Brest	5 454	545.81	15.44	477.58	11.82
	train	Dostyk – Brest	5 454	100.00	100.00	100.00	100.00
	air	Dostyk – Brest	5 454	63 192.65	1 993.29	52 791.32	1 457.05

TTW – tank-to-wheel; WTW – well-to-wheel
* Mała – Małaszewicze

Source: own work based on Index1520 Carbon Emission Counter [ERAI 2021].

New Silk Road – infrastructural potential

Regardless of the degree of environmental impact, a very important factor in the assessment of a given mode of transport should be its potential to handle a given flow of loads. Even the greenest means of transport must first and foremost fulfill its transport task. If this is not the case, then either this means of transport has to be replaced by another one that will fulfill the task or make such changes on the demand and supply side to reduce the demand for specific transport services. Additionally, each transport solution should be analyzed through the prism of its broadly understood effectiveness and efficiency. The CO_2 reduction measures may not be desirable due to the low efficiency of the processes. They can lead to a reduction in emissions in the area of transport, while increasing it elsewhere as a result of the loss of efficiency of the transport system. The assessment of emissivity, or more broadly the environmental impact, is therefore only one of the components of the assessment of a given transport solution, which should take into account the balance of costs and benefits covering many categories.

Taking into account the data for the last ten years, the trade of goods between China and the European Union countries is gradually increasing. This is happening despite the economic turmoil (inflation increase at the end of 2021 in Europe) or the COVID-19 crisis. As mentioned in the introduction (Table 1), sea transport dominates the handling of this exchange. The choice of a transport solution most often depends on three basic variables: time, price and availability. Maritime transport has the lowest price, the highest availability, but the longest transit time. Air transport is the shortest but has the lowest availability and the highest price. Rail transport is between these two ingenious solutions. Price is closer to maritime transport and availability closer to air. Importantly, in 2020 and 2021 its price (for a 40 'container) fluctuates relatively close to the price in sea transport. With a comparable price and significantly shorter transport time, the choice of rail seems to be a good alternative to sea transport. However there is a problem of relatively low accessibility in comparison to maritime solution. Its ability to handle huge flows of cargo makes it basically the only solution for significant volumes of goods at the moment. It is known, however, that maritime transport reaches the limits of its capacity and all its disturbances are acutely felt by the involved economies. This suggests the need to develop other means of transport.

Despite the fact that in recent years rail transport has significantly developed under the New Silk Road initiative, it seems that without new and significant investments, the existing infrastructure system is slowly reaching its limits. According to general system logic, a given system is as efficient as its weakest element. Thus it is necessary to conduct a coherent and coordinated investment policy by all countries involved in the project of the New Silk Route. It should be emphasized that due to the fact that most of the route leads through sparsely populated areas, the development potential for linear infrastructure is very significant.

An example of significant infrastructural limitation may be the border crossing between Poland and Belarus located in the Terespol commune. It is the main border crossing point between the European Union countries and the CIS countries. As indicated by information from PKP PLK (the Polish railway line administrator), the capacity of this section is fully used [Madrjas 2021]. This means that in order to further increase the volume of goods sent by trains, it is necessary to rapidly increase the capacity through new investments. Such actions are initiated. During 2021 the railway bridge over the Bug has been modernized, which allows for an increase in the number of trains running. New investments in intermodal rail terminals in Małaszewicze and in E20 railway are planned.

Therefore, looking through the prism of the desire to reduce CO_2 emissions, the railway, although it remains an attractive alternative, requires further investments. These investments will require time and financial expenditures. New undertakings, apart from carbon dioxide emissions, may also have an environmental impact in other ways (crossing animal migration routes, noise emission, pollution of areas that are still relatively unpolluted today, etc.). Therefore, it is necessary to conduct thorough research to determine whether the actual development of rail transport between the European Union and China will not only contribute to the reduction of CO_2, but will also have a generally positive impact on the preservation of nature. However, as it was emphasized at the beginning, the goal of protecting the environment must be in line with the basic task of transport systems, which is the transport of goods and people.

Summary and conclusions

1. The New Silk Road can be treated as an green alternative for maritime and air transport on China to European Union route when examining CO_2 emission. That is true both in case of Index1520 distance measure and for real distance between given reference infrastructural points. However study on the real distance measure showed that in case of TTW and WTW results for rail transport in comparison with maritime transport are better. Still in case of WTW actions are required to improve this parameter for rail transport and making in more competitive in that aspect.
2. It has to be consider that rail connection is relatively new in comparison to maritime and air solutions. Thus it may take some time to adjust and tune all New Silk Road elements to achieve even better (greener) results.
3. Taking into account not only environmental but also transport system potential rail transport may become a widely used transport solution for China – European Union transport only if extensive infrastructural program will be develop in near perspective. As official documents and press reports show, such programs are being implemented now and are being prepared both on the part of European Union countries, CIS countries and China.
4. Taking in mind further grow in China – European Union mutual trade exchange and some methodological shortcomings shown on the example of WTW, TTW and WTT, further studies should be carried out in the subject of green transport on that route. Strong effort should be put on comparison for direct and indirect environmental impact for same route (pair of sending and receiving point) served by various means of transport. Performing many similar tests will allow for a better comparison of existing transport solutions. Subsequent research should take into account not only the issue of CO_2 emissions, but also other substances and the impact of a given branch of transport on the environment in the general context (e.g. destruction of virgin lands, destruction of habitats and animal migration paths, noise) as well as on the every potential external costs and benefits related to functioning of current and planning of the future transport operations and investments.

Important notes

This study is a part of PhD research under prepared by author under the working title: "Economics effects of the functioning of New Silk Road rail infrastructure on Poland economy". The author invites interested readers to contact and cooperate

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