Cost-benefit analysis of the E40 waterway in Poland

Wouter Langhout
Langhout Ecologisch Advies
wouterlanghout@gmail.com

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www.eftec.co.uk

Public resources are limited and investments need to be well justified. This is especially the case for large infrastructure projects, which are a substantial part of government spending. Strong economic viability, as indicated by a cost-benefit analysis, is therefore essential before any investment can be considered.

The governments of Poland, Belarus and Ukraine are planning the construction of the E40 waterway, which will involve large scale engineering of 2,200 km of rivers including the Vistula, the Dnieper and the Pripyat[2]. There is a strong political commitment to this project, in spite of its environmental impacts and doubts on its feasibility, as the hydrology is very disadvantageous on large parts of the route and the E40 waterway cuts through difficult terrain, including the Chernobyl Exclusion Zone[3].

The present cost-benefit analysis covers the section Gdansk (Poland) to Brest (Belarus). The analysis is building on the feasibility conducted in 2015 by the Maritime Institute in Gdansk[4], which considered three variants (I-III), and the analysis of this study by the Belarussian Business Union of Entrepreneurs and Employers[5]. The main additions in this current analysis are the inclusion of external costs, an improved transport forecast and the inclusion of marginal costs for road and rail. All costs were also converted to 2019 prices[6]. At the time of writing, the preferred variant of the 150-200 km long channel between Warsaw and Brest is not known, but it is very likely that this will be a subvariant of variant III[7]. For the sake of completeness, variants I and II are also included in the analysis.

Economic viability

Table 1 gives an overview of the economic performance of the E40 for the section Gdansk to Brest. The Net Present Value (NPV) under the default scenario is strongly negative. The Economic Internal Rate of Return (EIRR) is below 0 for all three variants. For economic viability an EIRR of 0,05 is required in Poland[8]. Real transport investment costs exceed original estimates frequently by as much as 50 or 100 %[9].

	Investment	NPV	EIRR
Variant I	€ 9.840.589.100	**- € 4.770.507.276**	0,008
Variant II	€ 11.202.032.800	**- € 5.803.025.730**	0,004
Variant III	€ 12.272.645.700	**- € 6.584.042.170**	0,001

Table 1 Economic performance of the proposed E40 waterway section from Gdansk to Brest (NPV=Net Present Value; EIRR=Economic Internal Rate of Return).

The cost-benefit analysis indicates that the E40 waterway section Gdansk to Brest is not economically viable. These results are robust as indicated by the sensitivity analysis. Alternative investments therefore need to be identified, for example investment aiming at reducing the direct and external costs of railway freight transport between Gdansk and Brest.

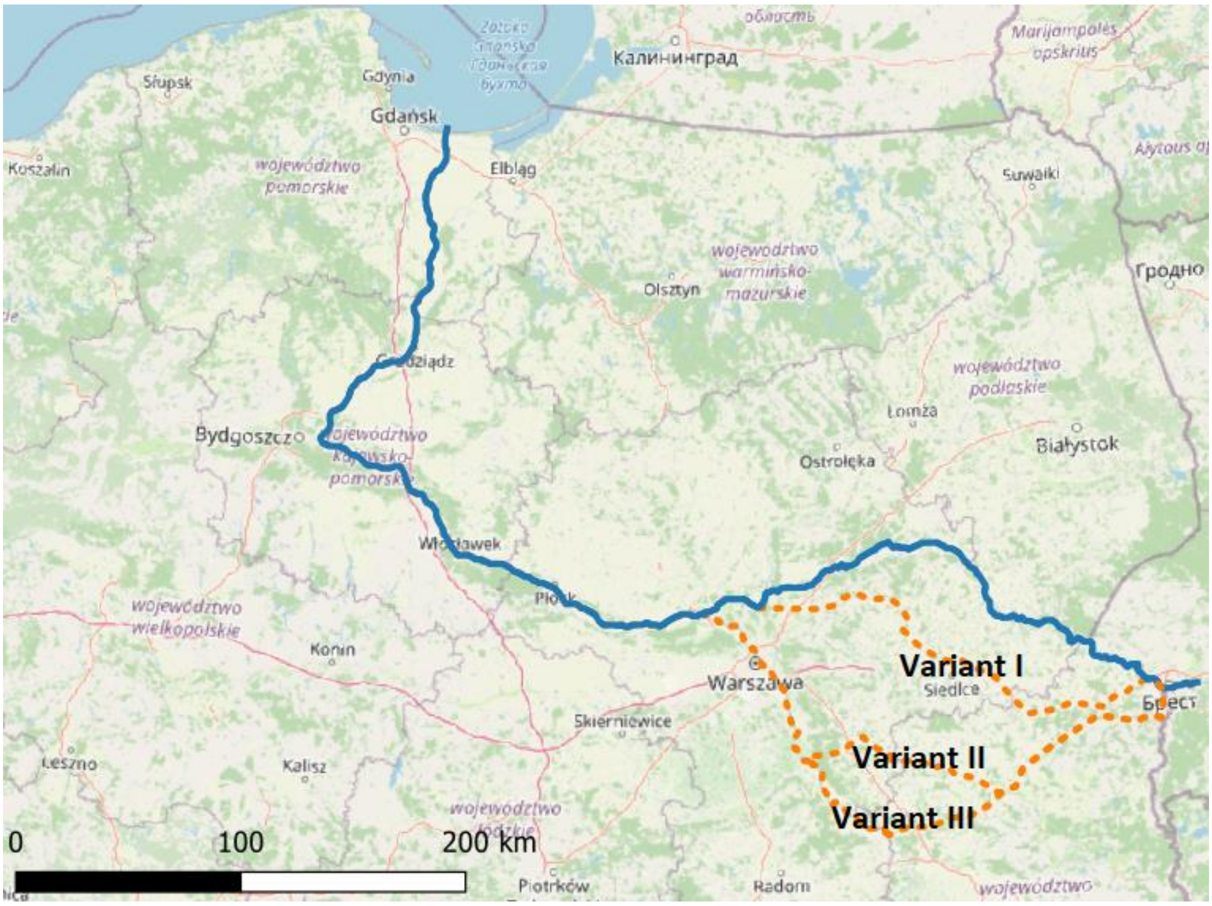

Figure 1: Overview of the E40 waterway from Gdansk to Brest and Variants I-III. ©OpenStreetMap.

Methods

Unless indicated otherwise the methods follow the Maritime institute in Gdansk[4]. Costs and benefits were calculated using the standard formula below. B_t is the benefits and avoided costs in year *t*, C_t is the costs in year *t* and *r* is the social discount rate. *NPV* is the Net Present Value.

$$NPV(r) = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+r)^t}$$

The EIRR is then obtained by solving the following equation for *NPV = 0* (± € 1.000):

$$NPV(EIRR) = \sum_{t=1}^{T} \frac{B_t - C_t}{(1+EIRR)^t}$$

The project is evaluated at a time horizon *T* of 40 years, with the first 10 years for constructing the E40, followed by 30 years of operation. To calculate the NPV, $r = 0{,}050$ ($0 > t \geq 30$) and $r = 0{,}045$ ($30 > t \geq 40$) are used[10].

Physical parameters

There are three variants identified by the Maritime institute in Gdansk[4]. Variant I connects Gdansk Deep Container Terminal (DCT) to Brest via Nieporęt and a channel of 208 km. Variant II connects Gdansk DCT to Brest via Góra Kalwaria and a channel of 196 km. Variant III connects Gdansk DCT to Brest via Deblin and a channel of 160 km. The parameters of the three variants for the E40 section Gdansk to Brest and the comparable route by rail and road are shown in Table 2.
It is worth noting the physical parameters of road and rail are more favourable than all three variants of the E40. The distance by rail and road is shorter than by inland waterway. Transport by rail and road from Gdansk DCT to Brest can be completed within 19 hours and 13 hours respectively, while shipping takes at least 61 hours. The full electrification of the railway between Gdansk DCT and Brest result in low external costs (see below).

	Variant I	Variant II	Variant III
E40 Gdansk-Warsaw			
Length Dams with locks Travel time	431 km 8 dams 3 days	440 km 10 dams 3 days	440 km 12 dams 3 days
E40 Warsaw-Brest			
Length Channel length Locks Travel time	219 km 208 km 11 locks 2 days	255 km 196 km 9 locks 2 days	249 km 160 km 7 locks 2 days
Shipping parameters			
Tonnage per ship Average speed Working day	1125 tonnes 10,5 km/h 16 hours		
Rail			
Length Gdansk-Warsaw Length Warsaw-Brest Electrification	313 km 211 km Full		
Road			
Length Gdansk-Warsaw Length Warsaw-Brest	333 km 220 km		

Table 2 Physical parameters of the three variants for the E40 section Gdansk to Brest and the comparable route by rail and by road.

	Inland waterways	Modal shift from road	Modal shift from rail
First year of operation (t = 11)			
Gdansk-Warsaw	8.645.355 tonnes (7.687 ships)	6.380.272 tonnes	2.265.083 tonnes
Warsaw-Brest	1.729.071 tonnes (1.537 ships)	319.878 tonnes	1.409.193 tonnes

Table 3 Physical flows according to the transport forecast.

Transport forecast

The hinterland of the Vistula between Gdansk and Brest has about 22 million inhabitants[11]. The countries Austria, Hungary and Slovakia along the Danube are chosen as a model for the future market along the E40, as these countries have together approximately a comparable population and GDP[12]. The length of the Danube in these countries (748 km) is comparable to this section of the E40 waterway[13]. Furthermore, the Danube is in these countries a class VI waterway and therefore is a fully operational inland waterway for ships with a load of more than 4.000 tonnes. The total inland waterway transport of 4.800 million tonne-km of these three countries is projected on the E40 waterway in Poland using the shortest variant (Variant I).

The E40 route in Poland consists of two major sections: Gdansk to Warsaw and Warsaw to Brest. There are likely to be significant differences in the volumes of goods that will be transported on these sections. In 2019 34.853.210 tonnes of goods were turned over at the Port of Gdansk excluding transit[14]. Even the overall turnover of goods between Poland and Belarus is already significantly smaller than this turnover. In 2019 7.021.000 tonnes of goods were transported between Belarus and Poland[14]. The forecast therefore adopts a ratio 5:1 in terms of volume between the first and the second section.

To estimate the modal shift to inland waterway transport, the current modal shares along these sections are estimated. The goods from the Port of Gdansk are transported into the hinterland by rail (35 %) and by road (65 %)[15]. A high estimate of the share of goods that is currently destined for Warsaw, Bydgoszcz and other cities along the E40 is 33 % of the freight transported by rail freight transport and 50 % of the freight by transported by road. It is therefore assumed that 26,2 % of the shifted goods would have been transported by rail and 73,8% by road transport.
For the section of Warsaw to Brest it assumed that 81,5 % of the shifted goods would have been transported by rail, and 18,5 % by road, based on the goods transported between Belarus to Poland in 2019[14].

The volume of goods is assumed to increase with a rate equal to the discount rate. The default scenario assumes that 50 % of the above transport volume is realised in the first year of operation, including an increase in volume over 10 years to account for the economic growth during construction time. It is worth pointing out that there may be several difficulties for the interception of goods by an entirely new inland waterway in the first years, in particular a shortage of ships and staff, adverse weather and hydrology conditions, fluctuations in the demand for transport, tariff systems and other transport policy aspects, and logistics challenges such as seasonal restrictions on navigation and a lack of intermodal connections.

Costs
The costs are listed in Table 6Table 6.The costs consist of fixed costs, variable costs and the initial investment. Fixed costs are lock and channel maintenance costs and replacement costs based on the Maritime institute in Gdansk[4] converted to 2019 prices. This includes replacement investments, which are 0.1 % of the initial investment every year[4]. It is worth highlighting that the Maritime institute in Gdansk did not take into account climate change when estimating replacement investments, while significant investments could be needed to adapt the waterway to climate change, or to electrify the fleet.

Variable costs are the costs for inland waterway transport via the E40 and external costs. Transport costs are calculated on the basis of a flat daily rate, with an additional cost per tonne per km for fuel and lubricants. External costs consist mostly of air pollution, followed by climate change, accidents and well-to-tank costs[16]. External costs of inland waterway freight transport are lower than road freight transport, but higher than electrified rail freight transport. Habitat damage costs are excluded, as the estimation of these costs by CE Delft seems to have erroneously assumed full navigability of Polish rivers[16].

The investment costs calculated by the Maritime institute in Gdansk[4] were converted to 2019 prices. The investment costs depend on the number of dams, the length of the channel and the number of locks. It is worth highlighting that external costs for the investment are missing. It is expected that the investment will result in significant costs to society, for example major habitat damage and costs to water users, as well as climate change costs[4].

Benefits
The benefits are listed in Table 6.The benefits consist of revenues, savings, transfers and residual value. The revenues are lockage fees and channel usage fees. These are assumed to be transferred by the shippers to the customers for inland freight transport and flow back to the public, and are therefore not included as benefits.

The savings are due to the lower financial costs of inland freight transport, compared to the counterfactual which involves transporting the forecasted volume of goods by rail and road. The savings consist of lower transport costs, avoided marginal costs and avoided external costs. Marginal infrastructure costs are additional costs by an increase volume of transport on the existing network, covering maintenance and renewal expenditures.

External costs of rail consist of well-to-tank, noise and accidents. For road external costs consist mostly of congestion and accidents, followed by noise, air pollution, climate change and well-to-tank. Transfers[17] are excluded as these had not been treated consistently by Maritime institute in Gdansk[4]. The residual value is calculated using linear depreciation. The physical lifetime of the elements of transport infrastructure is assumed to be 60 years or less[9], hence an annual depreciation of 1,67 % is used.

Sensitivity analysis
A sensitivity analysis was carried out with the parameters listed in Table 4. It is worth noting that the resulting modal share of 22 % in the first year is already approaching the share of 30 % for inland waterway transport on the well-developed Rhine corridor[18]. As can be seen, this sensitivity analysis indicates that even for a high-performance scenario the E40 section Gdansk to Brest is not economically viable.

Conclusion
The cost-benefit analysis indicates that the E40 section Gdansk to Brest is not economically viable. These results are robust as indicated by the sensitivity analysis (see Table 5). This is even without considering the difficulties in intercepting goods that may arise in the first years of operation of an entirely new waterway (see above).

Alternative investments can easily be economically viable. The present analysis indicates the potential for electrified rail transport as a suitable alternative. With full electrification of existing railways along the route of the E40 waterway, reducing in particular the direct costs of rail freight transport, increasing the capacity as well as reducing the noise, is likely to be an economically viable investment. Other investments aiming at reducing external costs of roads, such as electrification and road safety, also should be explored.

Parameter	**Default scenario**	**High performance scenario**
Social discount rate (r)	0,050 (0 > t ≥ 30) 0,045 (30 > t ≥ 40)	0,050 (0 > t ≥ 30) 0,045 (30 > t ≥ 60) 0,040 (60 > t ≥ 65)
Time horizon (T)	40 years	65 years
Construction time	10 years	5 years
Transport volume in first year of operation	50 % of estimated volume of goods	75 % of estimated volume of goods
Tonnage per ship	1125 tonnes	1250 tonnes
Residual value	33,3 %	0 %

Table 4 Parameters for the sensitivity analysis.

	Investment	**NPV**	**ERR**
Variant I	€ 9.840.589.100	**- € 1.027.846.088**	0,044
Variant II	€ 11.202.032.800	**- € 2.333.246.351**	0,040
Variant III	€ 12.272.645.700	**- € 3.140.980.497**	0,038

Table 5 Results of the sensitivity analysis.

Cost type	**Cost**	**Benefit type**	**Value**
Fixed costs			
Lock operation costs	€ 76.238 per lock per year[4]		
Channel operation costs	€ 141.764 per year[4]		
Maintenance and replacement costs of variant I	€ 9.840.589 per year[4]		
Maintenance and replacement costs of variant II	€ 11.202.033 per year[4]		
Maintenance and replacement costs of variant III	€ 12.272.646 per year[4]		
Variable costs			
Direct costs of freight transport by the inland waterway	€ 3.284 per day[4]	Avoided direct costs of freight transport by road and rail	€ 0,0524 per tonne per km (road)[4] € 0,0494 per tonne per km (rail)[4]
		Avoided marginal infrastructure cost by road and electrified rail	€ 0,0112 per tonne per km (road)[19] € 0,0069 per tonne per km (rail)
Cost of fuel and lubricant	€ 0,0350 per tonne per hour[4]		
External cost of freight transport by the inland waterway	€ 0,0113 per tonne per km[9]	Avoided external costs of freight transport by road Avoided external costs of freight transport by rail	€ 0,0398 per tonne per km[9] € 0,0044 per tonne per km[9]
Investment costs		*Residual value*	
Constructing variant I	€ 9.840.589.100[4]	Residual value of infrastructure	€ 3.280.196.367
Constructing variant II	€ 11.202.032.800[4]	Residual value of infrastructure	€ 3.734.010.933
Constructing variant III	€ 12.272.645.700[4]	Residual value of infrastructure	€ 4.090.881.900

Table 6 Parameters for the cost-benefit analysis (default scenario).

[1] The cost-benefit analysis has been independently reviewed by economics for the environment consultancy (eftec; www.eftec.co.uk). eftec's review makes suggestions to improve elements of the analysis and presentation of results. However, these do not affect eftec's overall opinion, which is to support the conclusions of the cost-benefit analysis. Whilst eftec has endeavoured to provide accurate and reliable information, eftec is reliant on the accuracy of underlying data provided and those readily available in the public domain. eftec will not be responsible for any loss or damage caused by relying on its work.

[2] For more information see https://www.savepolesia.org.

[3] Grygoruk M, Jabłońska E, Osuch P, Trandziuk P (2018). Analysis of selected possible impacts of potential E40 International Waterway development in Poland on hydrological and environmental conditions of neighbouring rivers and wetlands- the section between Polish-Belarusian border and Vistula River. Warsaw, December 2018. https://savepolesia.org/wp-content/uploads/2020/04/Grygoruk-et-al_Possible-impacts-of-E40-waterway-in-Poland.pdf

Grygoruk M, Jabłońska E, Osuch P, Trandziuk P (2019). Analysis of selected possible impacts of potential E40 Inland Waterway development in Belarus and Ukraine on hydrological and environmental conditions of neighbouring rivers and wetlands. Warsaw, March 2019. https://savepolesia.org/wp-content/uploads/2020/04/Grygoruk-et-al_Possible-impacts-of-E40-waterway-in-Belarus-and-Ukraine.pdf.

[4] Maritime Institute in Gdansk (2015). Restoration of Inland Waterway E40 Dnieper –Vistula: from Strategy to Planning. Final Feasibility Study Report – Corrected Report (According to the remarks and requirements introduced by Willem Zondag, Legal and Technical Consultant). Gdansk, December 2015. Available from https://www.banktrack.org/download/restoration_of_inland_waterway_e40_dnieper_vistula_from_strategy_to_planning/190110_e40restoration_feasibility_study_enjune2015.pdf. See also the summary brochure https://czech.mfa.gov.by/docs/e40restoration_brochure_en.pdf

[5] Business Union of Entrepreneurs and Employers (2019) Economic Assessment of Reconstruction Plans for the Inland waterway E40. https://savepolesia.org/wp-content/uploads/2020/04/BUEE_E40-waterway_Economic-assessment.pdf.

[6] A correction of 1,03 is applied to account for the increase in prices. Statistics Poland (2021) Harmonized Indices of Consumer Prices (HICP). https://stat.gov.pl/en/topics/prices-trade/price-indices/harmonized-indices-of-consumer-prices-hicp,15,1.html#

[7] https://programwisla.pl (now defunct).

[8] European Commission (2014). Guide to Cost-Benefit Analysis of Investment Projects - Economic appraisal tool for Cohesion Policy 2014-2020.

[9] Jones, H., Moura, F., & Domingos, T. (2014). Transport infrastructure project evaluation using cost-benefit analysis. *Procedia-Social and Behavioral Sciences* 111, 400-409.

[10] r = 0,05 conforms with the European Commission recommendation for cohesion countries. See European Commission (2014). Guide to Cost-Benefit Analysis of Investment Projects. Economic appraisal tool for Cohesion Policy 2014-2020.

[11] Eurostat (2021) Population on 1 January 2019 by age, sex and NUTS 2 region [Wielkopolskie; Kujawsko-Pomorskie; Warminsko-Mazurskie; Pomorskie; Lódzkie; Swietokrzyskie; Lubelskie; Podlaskie; Warszawski stoleczny and Mazowiecki regionalny].

National Statistical Committee of the Republic of Belarus (2021). National Accounts of the Republic of Belarus. Minsk, 2021 [Brest region].

[12] Eurostat (2021) Gross domestic product (GDP) at current market prices by NUTS 2 regions in 2019 [Wielkopolskie; Kujawsko-Pomorskie; Warminsko-Mazurskie; Pomorskie; Lódzkie; Swietokrzyskie; Lubelskie; Podlaskie; Warszawski stoleczny and Mazowiecki regionalny].

National Statistical Committee of the Republic of Belarus (2021). National Accounts of the Republic of Belarus. Minsk, 2021 [Brest region].

[13] INDanube (2014) Fairway Rehabilitation and Maintenance Master Plan – Danube and its navigable tributaries. EU Strategy for the Danube Region, Priority Area 1a – To improve mobility and multimodality: inland waterways. Version 13 November 2014. See https://navigation.danube-region.eu/wp-content/uploads/sites/10/sites/10/2019/09/2014-11-13_FRMMP_final_document_clean.pdf

[14] Główny Urzad Statystyczny and Urzad Statystyczny w Szczecinie (2020) Transport – wyniki działalnosci w 2019 r. Warsaw and Szczeczin. https://stat.gov.pl/obszary-tematyczne/transport-i-lacznosc/transport/transport-wyniki-dzialalnosci-w-2019-roku,9,19.html.

[15] Pieriegud (2019) Analysis of the potential of the development of rail container transport market in Poland. Final Report Directorate-General for Regional and Urban Policy Contract No 2018CE16BAT079. Brussels, Belgium. https://ec.europa.eu/regional_policy/en/information/publications/reports/2019/analysis-of-the-potential-of-the-development-of-rail-container-transport-market-in-poland

[16] CE Delft (2019). Handbook on the external costs of transport. Version 2019 – 1.1. Delft, the Netherlands. Publication code: 18.4K83.131 https://cedelft.eu/publications/handbook-on-the-external-costs-of-transport-version-2019/.

[17] For publicly investments, part of the investments is returned to the state in the form of taxes (labour taxes, income taxes).

[18] Jonkeren O. et al. (2019). A shift-share based tool for assessing the contribution of a modal shift to the decarbonisation of inland freight transport. European Transport Research Review (2019) 11:8.

[19] CE Delft (2019) Overview of transport infrastructure expenditures and costs. Delft, the Netherlands. Publication code: 18.4K83.134.