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Group of Experts on Benchmarking Transport Infrastructure Construction Costs

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Discussion on the structure of the final report of the Group of Experts

Findings, conclusions, and recommendations of the Group of Experts on Benchmarking Transport Infrastructure Construction Costs

Submitted by the Group of Experts on Benchmarking of Transport Infrastructure Construction Costs

I. Introduction

1. This document lists main findings, conclusions and recommendations identified by the Group of Experts on Benchmarking of Transport Infrastructure Construction Costs. It also provides an overview of some of the challenges experienced by the Group in the implementation of its mandate and suggestions for the way forward.

II. General

2. The Group of Experts on Benchmarking of Transport Infrastructure Construction Costs was established in the framework of the Working Party on Transport Trends and Economics following a workshop held in Geneva from 8–10 September 2014 on "Good practices and new tools for Financing Transport Infrastructure". During the workshop it was agreed by the participants that the benchmarking of transport infrastructure construction costs is significant for having realistic construction cost estimates and a stable investment program without unforeseen cost increases.

3. The first session of the Group was held in Geneva on 31 October–1 November 2016. During its first session the Group decided that its study report should focus on three main parts:

(a) Identify models, methodologies, tools and good practices for evaluating, calculating and analyzing inland transport infrastructure construction costs;

(b) Identify and list terminologies used in the ECE region for construction costs of inland transport infrastructure; if possible, create a glossary of agreed terminologies and related explanations;

(c) Collect and analyze data in order to prepare a benchmarking of transport infrastructure construction costs in the ECE region for each inland transport mode – road, rail, inland waterways – including intermodal terminals, freight/logistics centers and ports; analyze and describe the conditions/ parameters under which these costs have been calculated.

4. For the road sector Turkey, for the rail sector Poland and for inland waterways sector Croatia were designated as lead countries. Ten sessions of the Group were held in Geneva, the eleventh session was cancelled because of COVID-19 pandemic. Instead, two informal virtual meetings of the Group were organized by the secretariat.

5. Even though transport infrastructure costs include costs for construction, rehabilitation, upgrade, renewal, maintenance, and operation, only the first four categories of costs were considered, and it was suggested that the maintenance and operation costs could potentially be addressed in the format of a different Group.

6. All definitions are included in a consolidated list of terminologies on benchmarking of road, rail, inland waterway, ports, and intermodal terminals construction costs prepared by the Group.

7. Lead countries Turkey and Poland prepared the road and rail questionnaires which were disseminated by the secretariat for data collection purposes. A set of four open questions was also prepared and distributed in order to collect information on national benchmarking methodologies and approaches.

8. The Group observed that some ECE member States were reluctant to share their data for benchmarking purposes. Even though benchmarking is used in the public sector starting from the 1990s it is a relatively new tool for public sector in the field of infrastructure development.

9. The biggest challenge the Group faced in conducting the study was to create a sense of mutual understanding. Each country has its own standards to construct infrastructure and collect and structure cost data. For benchmarking of different countries or organizations, it is always to be expected that data may not be directly comparable.

10. Another challenge faced by the Group was the limited data availability.

11. A possible follow-up study may focus on maintenance and operation cost of transport infrastructures. This type of data is easier to find and access.

12. On the other hand, list of terminologies for maintenance and operation costs of roads, rails and IW were prepared by lead countries and agreed by the group.

13. The questionnaire forms to collect data on maintenance and operation costs by lead countries were also prepared and agreed by the group.

III. Road sector specifics

14. The Group conducted its work as follows:

(a) Identifying the parameters that affect the costs of a project is of critical importance. Superstructures such as tunnels and viaducts tend to have a major impact on the overall cost level of a project. The lead country for roads, Turkey, suggested that for analytical purposes, costs should be designated through descriptive analysis instead of regression analysis because cost data does not follow normal distribution.

(b) Road infrastructure was defined as including High-Capacity Roads (Motorways-Expressways), Medium Capacity Roads/Primary Roads and Medium Capacity Roads/ Secondary Roads.

(c) The Group decided that for analytical purposes data infrastructure rehabilitation projects may also be considered since, in many countries, they are funded from capital budget. It was agreed to clearly define the distinction between investment and maintenance not to compare apples and peaches. Accordingly, road infrastructures work types were classified as follows: resurfacing, resurfacing by strengthening, pavement replacement, reconditioning, reconstruction, capacity improvement and new construction.

(d) The Group decided to focus its analysis on realized costs of construction projects for the period 2007–2016. The Group also decided that overall costs should exclude design costs, land acquisition costs, value added costs and costs of superstructures like tunnels, viaducts and bridges. Once the errors were removed and the costs were standardized to 2016, all construction cost data was turned into 2016 USD prices by using GDP Deflators. The GDP price deflator was used as it presents a more accurate picture of economies where currency values may be in flux.

(e) As agreed by the Group terrain type is also an important parameter in calculating construction costs. It was decided however not to consider this parameter because of a lack of a sufficient number of projects. The Group decided to separate superstructure construction costs like tunnels, viaducts and bridges from overall road construction costs.

(f) In order to benchmark road infrastructure construction costs, the cost unit was determined as US $ per km for single carriageway roads and US $ per lane x km for double carriageway roads and for tunnels US $ per m and for bridges US $ per m^2.

(g) For road tunnels, they are classified as single tube tunnel, twin tube tunnel, under water tunnels and for road bridges, they are classified as precasted and pre-stressed simple beam, balanced cantilever bridge, cable stayed bridge, suspension bridge and pedestrian bridge.

(h) The Group decided to also include benchmarking parameters such as surface area, population, population density, GNP, GNP per capita, annual budget, annual operating and investment budget rates, total road network, the length of annually completed road network, length of tunnels and bridges, etc.

15. 14 countries namely Austria, Bulgaria, Croatia, Cyprus, Estonia, Finland, Germany, Iceland, Italy, Latvia, Republic of Moldova, Sweden, Russian Federation and Turkey shared their road infrastructure construction cost data. However, in some cases data was missing or may have been misrepresented or inaccurate which complicated the actual data analysis. For instance, some countries may not have excluded some cost as superstructures such as tunnels, bridges.

16. The findings of the benchmarking analysis of road data of the Group are listed below:

(a) For Single Carriageway Roads:

(i) The highest observed cost for new construction of a primary single carriageway roads is 4.5 million US $ per km and the lowest one is 475,697 US $ per km. The highest one is nine times higher than the lowest one. The average of single carriageway primary roads new construction cost from nine ECE member States (Bulgaria, Croatia, Cyprus, Finland, Iceland, Italy, Russian Federation, Sweden, and Turkey) is 1,484,989 US $ per km.

(ii) The highest observed cost of new construction for secondary single carriageway roads is 2 million US $ per km, while the lowest one is 14,769 US $ per km. The highest one is thus 135 times higher than the lowest one. Such a difference was not anticipated by the Group. The average of single carriageway of secondary roads new construction cost from 6 ECE member States (Cyprus, Finland, Italy, Russian Federation, Sweden, and Turkey) is 682,949 US $ per km.

(iii) Regarding all road work types, it is also observed that the lowest cost for primary roads is 323 US $ per km for reconditioning and the highest one is 4,507,840 US $ per km for new construction.

(iv) Regarding all work types, it is also observed that the lowest cost for secondary roads is as 40 US $ per km for pavement replacement and the highest one is 2 million US $ per km for new construction.

(v) Average construction cost of primary single carriageway roads by work types gradually increases as for resurfacing 101,158 US $ per km, resurfacing by strengthening 291,627 US $ per km, pavement replacement 392,432 US $ per km, reconditioning 337,432 US $ per km, reconstruction 1,023,430 US $ per km and new construction 1,484,989 US $ per km. There is only one unexpected result which is reconditioning costs.

(vi) Average construction cost of secondary single carriageway roads by work types gradually increases as for resurfacing 68,378 US $ per km, resurfacing by strengthening 183,316 US $ per km, pavement replacement 315,973 US $ per km, reconditioning 203,163 US $ per km, reconstruction 449,025 US $ per km and new construction 682,949 US $ per km. There is only one confusing result which is reconditioning cost.

(b) For Double Carriageway Roads:

(i) The highest cost of new construction cost for motorways is 7.8 million US $ per lane x km and the lowest one is 371,013 US $ per lane x km. The highest one is 21 times higher than the lowest one. The average of double carriageway motorways new construction cost from nine ECE member countries (Austria, Bulgaria, Croatia, Cyprus, Finland, Italy, Russian Federation, Sweden, and Turkey) is 2,157,667 US $ per lane x km.

(ii) The highest cost for new construction of double carriageway primary roads is 3.96 million US $ per lane x km and the lowest one is 134,716 US $ per lane x km. The highest one is 29 times higher than the lowest one. The average of double carriageway primary roads new construction cost from four member countries (Croatia, Finland, Russian Federation, and Turkey) is 1,423,171 US $ per lane x km.

(iii) The highest cost of new construction cost for double carriageway secondary roads is 1.95 million US $ per lane x km and the lowest one is 160,557 US $ per lane x km. The highest one is 12 times higher than the lowest one. The average of double carriageway of secondary roads new construction cost from three ECE member States (Bulgaria, Russian Federation and Turkey) is 923,639 US $ per lane x km.

(iv) Regarding all work types, it is also observed that the lowest cost for motorways is as 15,684 US $ per lane x km for resurfacing and the highest one is 11,018,275 US $ per lane x km for expansion (capacity improvement).

(v) Regarding all work types, it is also observed that the lowest cost for double carriageway primary roads is as 4,231 US $ per lane x km for resurfacing and the highest one is 6,755,612 US $ per lane x km for expansion (capacity improvement).

(vi) Regarding all work types, it is also observed that the lowest cost for double carriageway secondary roads is as 3,385 US $ per lane x km for resurfacing and the highest one is 1,948,808 US $ per lane x km for new construction.

(vii) Average construction cost of motorways by work types gradually increases as for resurfacing 135,282 US $ per lane x km, resurfacing by strengthening 203,185 US $ per lane x km, pavement replacement 314,373 US $ per lane x km, reconditioning 493,218 US $ per lane x km, expansion 1,683,017 US $ per lane x km and new construction 2,157,667 US $ per lane x km.

(viii) Average construction cost of primary double carriageway roads by work types gradually increases as for resurfacing 11,807 US $ per lane x km, resurfacing by strengthening 76,814 US $ per lane x km, pavement replacement 167,925 US $ per lane x km, reconditioning 905,827 US $ per lane x km, reconstruction 211,809 US $ per lane x km and new construction 1,423,171 US $ per lane x km. There is only one confusing result which is for reconstruction.

(ix) Average construction cost of secondary double carriageway roads by work types gradually increases as for resurfacing 10,442 US $ per lane x km, resurfacing by strengthening 1,405,245 US $ per lane x km, pavement replacement 173,901 US $ per lane x km, reconditioning 597,085 US $ per lane x km, reconstruction 259,279 US $ per lane x km and new construction 923,639 US $ per lane x km. There are two confusing result one is for resurfacing by strengthening the other one is for reconditioning

(c) For Superstructures Bridges and Tunnels Construction Costs:

(i) Superstructures costs were analyzed as bridges and tunnels construction cost. Bridges cost unit is US $ per m2, tunnels cost unit is US $ per m.

(ii) For single tube tunnels six countries (Austria, Croatia, Iceland, Italy, Sweden, and Turkey), for twin tube tunnels five countries (Croatia, Cyrus, Italy, Sweden and Turkey) for underwater tunnels one country (Turkey) provided data.

(iii) For single tube tunnels the highest cost is 20,000 US $ per m and the lowest one is 19,827 US $ per m. The average cost for single tube tunnel is 27,024 US $ per m. The highest cost is two times higher than the lowest one.

(iv) For twin tube tunnels the highest cost is 40,000 US $ per m observed and the lowest one is 9,922 US $ per m. The average cost for single tube tunnel is 16,437 US $ per m. There is not significant difference between the highest cost and the lowest one.

(v) Bridges costs were analyzed as precasted and pre-stressed simple beam, balanced cantilever bridge, cable stayed bridge, suspension bridge and pedestrian bridge.

(vi) Eight countries namely Croatia, Cyprus, Estonia, Iceland, Italy, Republic of Moldova, Sweden, and Turkey provided data for precasted and pre-stressed simple beam construction costs. The average of eight countries is 1,801 US $ per m2. The highest one is observed in Iceland as 3,690 US $ per m2, on the other hand the lowest one is observed in Turkey as 698 US $ per m2. The highest cost is 5 times higher than the lowest one.

(vii) Four countries namely Cyprus, Estonia, Germany, and Turkey provided data for Balanced Cantilever Bridge Construction Costs. The average of four countries is 2,176 US $ per m2. The highest is 2,583 US $ per m2, and the lowest one is 1,416 US $ per m2. The highest cost is 1.8 times higher than the lowest one.

(viii) Two countries namely Germany and Turkey provided data for Cable Stayed Bridge Construction Costs. The average of two countries is 6,328 US $ per m2.

(ix) Only one country, Turkey provided data for suspension bridge construction costs which was at 9,644 3,006 US $ per m2.

(x) Five countries namely Iceland, Latvia, Republic of Moldova, Sweden, and Turkey. The average of five countries is 5,164 US $ per m2. The highest one that is observed is 16,542 US $ per m2 and the lowest one is 1,050 US $ per m2. The highest one is 15 times higher than the lowest one.

17. From the above analysis it can be concluded that some construction costs of road infrastructures are not comparable across ECE member States. This result shows that mutual understanding is still a challenge. Data and results need to be further calibrated.

18. Regarding other benchmarking parameters such as GNP per capita and population density a correlation between actual cost and the size of economies and of countries was not established. This may in part be due to limited data availability because of which the data boxplot analysis could not be applied.

19. The present study has however proven its value and it is therefore recommended to continue the data collection efforts of the Group. In doing so, efforts need to be made to make sure that there is a better understanding among ECE member States wishing to submit additional data regarding the exact requirements. Better and more data would allow an even better analysis and results.

IV. Rail sector specifics

20. The railway is a very complex system with many different elements – track and track bed, catenary system, signalling and telecommunication systems, turnouts, bridges, tunnels, culverts, passages, level crossings, eco-passages, terminals, stations etc.

21. Each railway line has its characteristics and technical parameters to be fulfilled. Furthermore, there are differences among ECE member States when it comes to track gauge, axle load, electrification system, signalling system etc.

22. Therefore, each line is different, and a different approach is adopted for its construction, upgrade or renewal. As a result, the costs are calculated individually and are difficult to be compared.

23. For the purpose of this report Azerbaijan, Bulgaria, Croatia, Finland, Kazakhstan, Poland, Serbia, Slovenia, Tajikistan, Turkey, and Turkmenistan kindly provided data on their investment projects in the railway sector. Some of this data was collected within the ECO-ECE-ISdB GIS project. Additionally, the data of the ECE Trans-European Railway (TER) project was acquired and analysed as well.

24. Data analysis was made for each country separately with the exception of Bulgaria, Slovenia, and Poland, where several infrastructure elements were to be compared. All countries provided information on the cost of upgrades for speeds between 120 and 160 km/h. The analysis revealed that some elements are more expensive in particular country, and others are comparable.

25. In case of the Polish upgrade projects the infrastructure elements for different speed ranges ($V<120$ km/h, $120<V\leq160$ km/h, $160<V\leq200$ km/h) were compared. The interesting conclusion is that many of the elements are irrelevant to the speed. For Bulgaria, four infrastructure elements were compared for renewal and upgrade – three of them are more expensive for upgrade.

26. For Bulgaria, Croatia, Finland, Serbia, and Slovenia the allocation of costs of different categories was analysed on the example of the specific projects. In the example of Turkey, it is demonstrated that in the case of new construction, most of the infrastructure elements designed for higher speed are more expensive. Therefore, a different conclusion was reached than in the case of Poland. It needs to be emphasised that Turkey implemented new construction, whilst Poland undertook upgrading work.

27. Furthermore, in Turkey three projects were analysed in terms of their cost in relation to their length. The cost of one project was much higher than the length that was accounted for.

28. Kazakhstan provided information about specific projects putting the costs of rails, bridges, and tunnels in one group and stations in another. There was also demonstrated the coherence between the cost of the projects and their length.

29. For Tajikistan, the allocation of costs of three projects was analysed, alongside with the relevance between cost of the rail tracks and the project length.

30. The relevance between total costs of the projects and their length was analysed for Turkmenistan and Azerbaijan. In Turkmenistan cost of the projects was proportional to their lengths. In Azerbaijan the cost of particular projects were not proportional to their lengths. In addition, also the cost of tracks and tunnels in Azerbaijan were integrated in the analysis.

31. The data presented by TER has been collected since 2012, so it includes knowledge about projects that have been put into operation since 2011. It contains information about length and costs of the projects which was used in the analysis.

32. As it was mentioned, most of the data was difficult to compare due to the specific and complex character of railway systems. Nonetheless, the study provides a very good basis for extending the scope of the costs analysis and launch a more focused research on individual projects, requiring more detailed information presented in the form of the case studies.

V. Inland waterways sector specifics

33. Inland waterways transport is, in comparison to road or air transport, seen as more environmentally friendly and energy efficient, and can therefore greatly contribute to socio-economic development of EU.

34. Inland navigation offers opportunities to move, cargos firstly and passengers likewise, instead of roads, in an energy-efficient manner. With that being said, IWT can contribute to mitigating road congestion.

35. For purpose of this report Austria, Croatia, Czechia, Luxemburg, Poland and Slovakia provided data about inland waterways infrastructure and IWW ports infrastructure construction, updates and maintenance costs.

36. Regarding average maintenance costs of inland waterways infrastructure, we compared data from Austria and Luxemburg as the data from other countries wasn`t as complete and thus comparable. Austria invests larger sums in IW maintenance then Luxemburg but at more favourable prices.

37. As for construction costs of IW infrastructure, we compared the data received from Austria and Croatia. Similar to comparison above, prices for dredging, pilots building, operation towers including radar, VHF etc. are more favourable (lower) in Austria.

38. Regarding IW ports infrastructure construction, updates and maintenance costs, the differences among the data received were too large for quality comparison. For that reason we chose to analyse Croatian Port Authority data. We can conclude that average price of construction of container terminal ($/unit) (PA Slavonski Brod) is lower than the average price ($/unit) for construction of general cargo terminal (PA Osijek).

39. As mentioned before, most of the data was difficult to compare due to specifics of inland waterway navigation and rivers per se. Another dimension is incomparability of costs since IW projects involve many different and per location specific works and projects, which occur as needed and with provision of funds.

VI. Guidance by the Group of Experts

40. At its forthcoming final session, GE.4 is invited to consider, discuss, amend and possibly endorse this document for submission to the thirty-fifth session of the Working Party on Transport Trends and Economics (WP.5) and for inclusion in its final report.

41. In relation to this, the Group may also want to consider the sustainability proposals for the continuation of its work as laid out in document ECE/TRANS/WP.5/GE.4/2022/6, in particular relating to the possibility of integrating its data and analytical findings in the International Transport Infrastructure Observatory (ITIO).