European
Commission

The impact of TEN-T completion on growth, jobs and the environment

SYNTHESIS

Final Report

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30 November 2018

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About the project consortium

M-Five GmbH Mobility, Futures, Innovation, Economics (Karlsruhe) is a scientific consultancy providing systemic advice in the fields of mobility and economics. Their expertise covers the fields of emerging new mobility services and technologies, transport policy, economics and innovations. M-Five advises public and private entities, the former receiving sound policy advice and the latter strategic guidance for their business in the mobility domain and its deepening linkages with energy and ICT domains in a world of strong climate mitigation ambitions.

TRT Trasporti e Territorio srl (Milan) is an independent consultancy specialised in transport economics, transport planning and modelling. Established in 1992, TRT combines its expertise in research projects with professional studies supporting public and private players in the transport sector. TRT experts have a long record of experience in strategic planning, transport modelling, sustainable urban mobility, feasibility studies, project assessment, transport demand analysis and forecast, logistics and freight transport, planning and regulating of public transport, energy and environment.

Ricardo Energy & Environment is an energy and environmental consultancy with over 40 years' experience working with clients across the globe. Ricardo Energy & Environment is experienced in high-level strategic policy development and research for the European Commission and national governments, as well as analysis and modelling for major businesses, with their expertise covering a wide range of analytical tools and techniques. These skills and knowledge are used to provide strategic and specialist support to develop and evaluate transport policy both at home and internationally.

Table of contents

List of Abbreviations

ATL	Atlantic core network corridor
BAC	Baltic-Adriatic core network corridor
Bn	Billion
CGE	Computable general equilibrium model
CNC	Core network corridors on the TEN-T
CNoCNC	TEN-T core network not part of any CNC
CO$_2$	Carbon dioxide
CTP	Common transport policy
EC	European Commission
ERDF	European Regional Development Fund
ERTMS	European rail traffic management system
EU	European Union
EU 13	Bulgaria, Croatia, Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovak Republic, Slovenia
EU 15	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden, United Kingdom
FTE	Full-time equivalent employment
GDP	Gross domestic product
GHG	Greenhous gas emissions
IWW	Inland Waterway transport
MED	Mediterranean core network corridor
MoS	Motorways of the sea
MS	Member States
Mt	Megatonne, million tonnes
NEC	National emissions ceiling
NEDC	New European Driving Cycle – road vehicle test cycle

NSB	North-Sea-Baltic core network corridor
NSM	North-Sea-Mediterranean core network corridor
OEM	Orient-East-Med core network corridor
RALP	Rhine-Alpine core network corridor
RHD	Rhine-Danube core network corridor
SCM	Scandinavian-Mediterranean core network corridor
SDM	System dynamics model
TEN	Trans-European Network
TEN-T	Trans-European-transport-network
Tkm	Tonne kilometre – 1 tonne of goods transported over 1 km
WLTP	Worldwide harmonized Light-vehicles Test Procedure

1   Introduction and key numbers

Infrastructure development has always been important as a basis for the Common European Transport Policy (CTP) which dates back to the Treaty of Rome (1957). The development of Trans-European Networks (TENs) in the fields of transport, energy and telecommunications was included in the Treaty of Maastricht (1992). It serves the goals of economic development, competitiveness, environmental sustainability and regional and social cohesion. The EU Treaty requires the European Union to establish guidelines for the development of TEN. The first guidelines for the development of a trans-European network in the transport sector (TEN-T) were published in 1996. This was followed by several revisions, with the most important ones having been adopted in 2004 and 2013 (notably to reflect EU enlargement and strengthen the network approach).

European funding was first made available for certain transport infrastructure projects in 1982 through a specific line of the EU budget dedicated to transport infrastructure of European interest. Since the adoption of the first TEN-T Guidelines, successive EU Regulations were adopted for the granting of financial support to TEN-T projects of common interest. Available EU budgets for TEN-T policy have been steadily increasing over time, with a 24 billion Euro budget under the Connecting Europe Facility 2014 – 2020 (CEF). Besides the CEF as the main EU funding instrument for the TEN-T in all parts of the European Union, the TEN-T Guidelines are also the basis for EU funding under the Cohesion Fund.

TEN-T policy contributes to three principal objectives of EU policy-making: fostering growth, creating jobs and mitigating climate change. After more than 20 years of Trans-European transport network (TEN-T) policy, the European Commission is interested to assess the potential impacts of completing the core TEN-T in relation to these political priorities.

Thus this study has been carried out by M-Five, TRT and Ricardo with the objective to assess the growth, jobs and greenhouse gas (GHG) emissions impacts arising from the completion of the TEN-T core network. It builds on the projects along the core network corridors which remain to be implemented between 2017 and 2030 in order to achieve full completion of the core network. These projects, complemented by an estimation of investment needs for core network development outside the corridors, represent a total investment of 556 billion Euro in 2005 prices. The projects have been identified in relation to the 3rd work plans of the eleven European Coordinators who are facilitating cooperation along these corridors.

The study comes to the following key results:

- An **additional 800 000 European people will be employed in 2030** through the completion of the TEN-T core network,

- **7.5 million person-years of jobs will be generated** cumulatively during the period 2017 - 2030,

- Additional **GDP growth of 1.6 %** will be realised **in 2030**,

- **26 million tons of carbon dioxide emissions will be saved** between 2017 and 2030 in the transport sector. This is expected to be complemented by noticeable additional savings of carbon dioxide emission which will be enabled by further roll out of alternative fuel infrastructure (electricity, natural gas, hydrogen) and their use by cleaner vehicles.
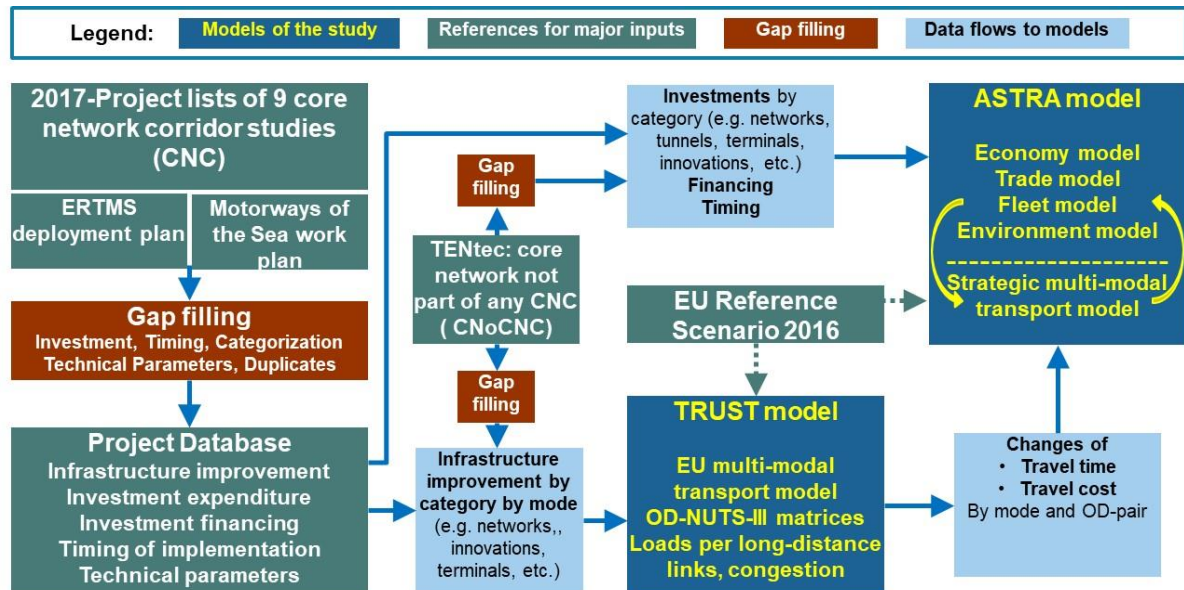
2 Methodology and input data

The analysis builds on three major pillars:

- A European multi-modal transport network model called TRUST, enabling the modelling of the travel impacts from implementation of the core network.

- A European integrated assessment model called ASTRA, which integrates transport demand, vehicle fleet and economic models.

- An extensive database of projects along the core network corridors (CNC). These projects have notably been identified in the framework of the corridor analysis carried out by external consultants on behalf of the European Commission as well as in a study on ERTMS. Member States and other stakeholders / project promoters have been closely involved (in particular through the 'Core Network Corridor Fora').

Figure 1 presents the interactions between the TRUST and the ASTRA models, as well as the major inputs required by the current study. Both models are calibrated to an updated version of the **EU Reference Scenario 2016**[1] in terms of the expected development in demographics, economic growth, energy and the transport sector. This scenario is compared against a **Baseline Scenario** that assumes that no further core TEN-T network investments are implemented beyond 2016.

Regarding the inputs, "gap filling" has been necessary for projects whose preparatory process was not yet sufficiently advanced and the database therefore included "gaps". They have been filled on the basis of certain assumptions and comparable Unit cost. For projects outside the core network corridors, estimations on projects / investments have been made on the basis of alignments included in the Commission's geographical information system TENtec on the one hand and required TEN-T standards in accordance with the TEN-T Guidelines on the other.

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[1] The updated EU Reference scenario 2016 includes some updates in the technology costs assumptions (i.e. for light duty vehicles) and several policy measures adopted after its cut-off date (end of 2014) such as the Directive on Weights and Dimensions, the 4th Railways Package, the NAIADES II Package, the Ports Package, the replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonised Light-vehicles Test Procedure (WLTP). It has been developed with the PRIMES-TREMOVE model (i.e. the same model used for the EU Reference scenario 2016) by ICCS-E3MLab (Capros et al. 2016). A detailed description of this scenario is available in the Impact Assessment accompanying the Proposal for a Directive amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, SWD (2017) 180

Source: M-Five

Figure 1: **Major elements of the project methodology**

The TRUST and ASTRA models

Combining the TRUST and ASTRA models allows transport to be analysed on two levels:

1. The network level: covered by the TRUST model, which includes the links and nodes of the European transport system, and
2. The strategic level: covered by the ASTRA model, which includes intra-zonal demand split into different distance bands and inter-zonal demand provided at the level of origin-destination pairs between European regions.

With such a combined modelling approach it is possible to capture both the direct effects of the new infrastructure in the transport sector, as well as the indirect effects on supplying industries and the wider economic impacts induced by mechanisms such as higher productivity diffusing to other economic agents and into future years. (for more details on economic terminology, see chapter 3 of the report "Methodology and Results).

The project data base

The major data input to both models are parameters on the implementation of the TEN-T core network over time. Relevant assumptions are derived from a **Project Database** that was specifically developed by the project team, building upon sources including: the project list of the nine CNC, the deployment plan of the European Rail Traffic Management System (ERTMS), and the first work plan of Motorways of the Sea (see Figure 1). The final database contained 3,037 projects. These projects (including the results of the "gap filling"

exercise represent a total investment sum of 438 billion Euro[2]. Table 1 shows the breakdown of these projects in terms of investment types

Table 1: **TEN-T investments on the CNC by investment type (in millions of euros, 2005 prices)**

Investment type	2017-2020	2021-2026	2027-2030	2017-2030
ERTMS on board	8 853	7 023	1 388	17 263
ERTMS track side	1 499	1 190	235	2 924
Study*	4 106	2 230	310	6 646
Construction**	143 510	203 400	61 970	408 880
Rolling Stock***	12	198	0	210
Clean Fuel	1 318	492	34	1 844
Total CNC	159 298	214 533	63 937	437 767

Study: includes feasibility studies, market studies, technology demonstrations, etc.
*** Construction refers to implementation of networks i.e. rail tracks, roads, tunnels, bridges, canals, etc.*
**** Rolling stock refers to investments into locomotives and rail waggons*
Source: EC, M-Five analysis

Additional assumptions had to be formulated on the development of the core network sections that are not part of any CNC. The investment costs of these were estimated at 118 billion Euro, of which around 97 billion Euro were accounted for by railway projects and 21 billion Euro by road projects.

This leads to the estimated total investment need for the TEN-T core network of 556 billion Euro during the period 2017 – 2030. It has to be provided essentially from public sources at national level as well as, where appropriate, from private sources. EU contributions, mainly from the Connecting Europe Facility and from the Cohesion Fund, are part of this investment volume. They shall be used in a way to mobilise the necessary public and private investment in the most effective way.

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[2] The work plans and the corridor studies of each CNC including the horizontal priorities can be downloaded from this website (please click on the link of the CNC that you are interested in): https://ec.europa.eu/transport/themes/infrastructure/downloads_en

3 Transport impacts of TEN-T implementation

This section examines the transport impacts of TEN-T core network implementation until 2030, focussing on indicators related to the travel times, transport performance (tkm / pkm) as well as on emissions of CO_2 and air pollutants.

3.1 Impacts on European freight transport

Figure 2 shows the modelled impacts of the TEN-T core network implementation on rail freight travel times relative to the Baseline. On some links, time savings are anticipated to be more than 45%.
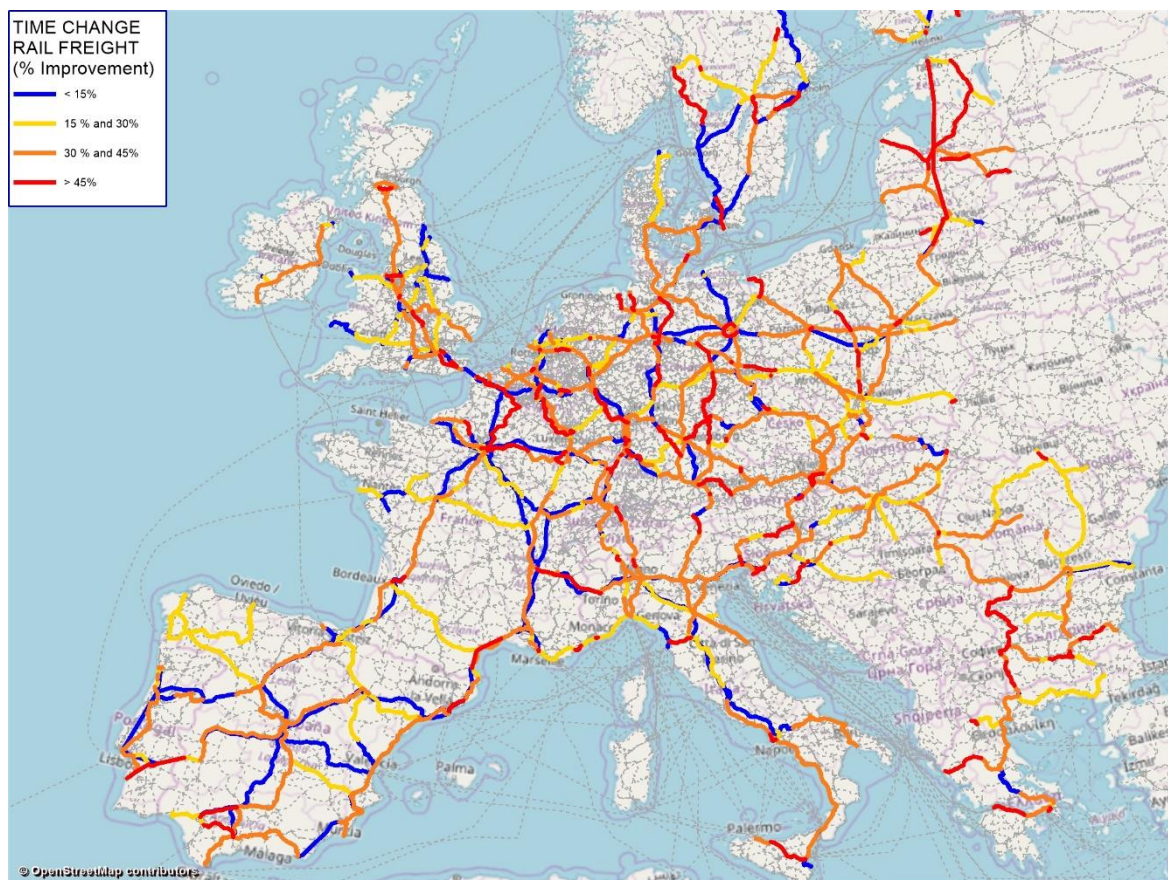
Source: TRUST model

Figure 2:   **Changes of travel time by rail freight in the Reference Scenario relative to Baseline in 2030 (% change to the Baseline)**

The improvements in travel time on rail links and inland waterways are expected to lead to modal shift, resulting in growing importance of these modes over time. As Table 2 shows, at EU28 level rail activity increases by 4.7% in 2030 relative to the Baseline scenario. This is more pronounced in the EU15[3] (+5.8%), compared to the EU13[4] (+2.7%). These strong

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[3] EU15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Portugal, Spain, Sweden, the Netherlands, United Kingdom.

[4] EU13: Bulgaria, Czech Republic, Croatia, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, Slovakia, Slovenia.

improvements in rail freight transport performance reflect the impact of projects that aim to make long distance rail freight transport more competitive with road freight. Rail investments include substantial funding to remove bottlenecks (e.g. to implement 740-metre-long sidings) and to implement additional and/or more efficient freight transhipments facilities from road to rail.

Inland waterway activity in the EU28 increases by 0.6% in 2030 relative to the Baseline scenario. It should be noted that the focus of the current study is on the implementation of the projects on the core network corridors (CNC). The maritime sector is covered only in so far as projects in ports as well as impacts on ports' hinterland connections are concerned. A detailed analysis of the growth potential of inland waterways and maritime transport is undertaken in the forthcoming "Study on support measures for the implementation of the TEN-T core network related to sea ports, inland ports and inland waterway transport" by EY et al.

Total freight transport performance increases by 0.6% at EU28 level, driven by the positive impacts of the core TEN-T network investments on economic growth. At the same time, modal shift leads to an overall reduction in road transport activity (in tkm), which decreases by around 0.4% at EU28 level relative to the Baseline scenario. The figures in Table 2 refer to the *territoriality approach* which considers all the traffic on the territory of a country, regardless of its origin and destination."

Table 2:   **Changes in inland freight transport activity (territoriality approach) in the Reference scenario relative to Baseline in 2030 – difference in millions of tonne-kilometres and % changes**

	ROAD		RAIL		IWW		TOTAL	
	Delta	% Change	Delta	% Change	Delta	% Change	Delta	% Change
EU15	-7 903	**-0.4%**	21 311	**5.8%**	1 108	**0.7%**	14 517	**0.6%**
EU13	-1 388	**-0.3%**	5 344	**2.7%**	70	**0.3%**	4 026	**0.6%**
EU28	-9 291	**-0.4%**	26 655	**4.7%**	1 178	**0.6%**	18 543	**0.6%**

Source: ASTRA model;
Note: Delta stands for the difference in tonne-kilometre per year while % change stands for the % difference between the Reference scenario and the Baseline scenario.

3.2 Impacts on European passenger transport

Figure 3 shows that there are also improvements in rail passenger travel time taking place, although these are slightly lower than those for rail freight. For Western-Central Europe (Benelux, Germany, France) the improvements are typically less than 15% in 2030 relative to the Baseline scenario. In Eastern Europe, the improvements reach more than 45% in certain cases.
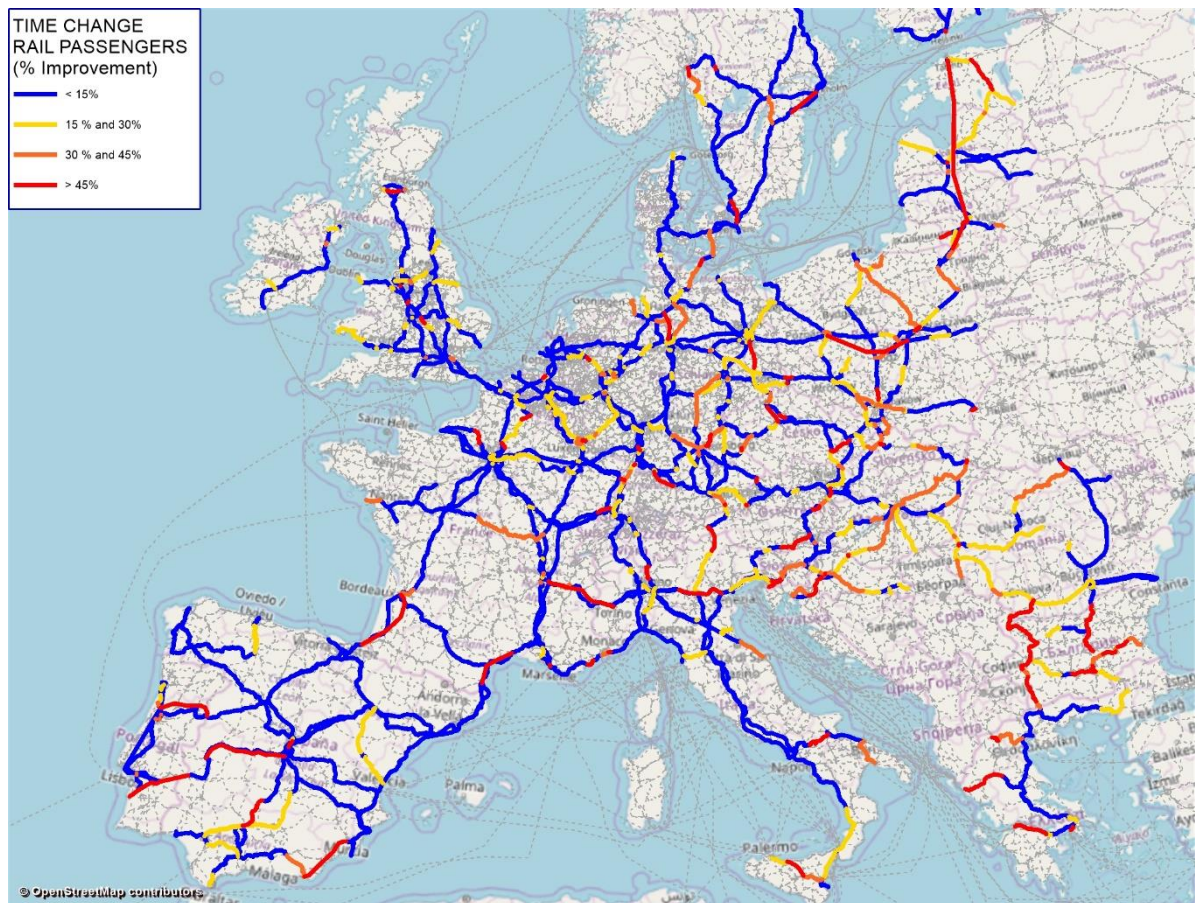
Source: TRUST model

Figure 3: **Changes of travel time by passenger rail in the Reference Scenario relative to Baseline in 2030 (% change to the Baseline)**

Passenger rail transport activity at the EU28 level increases significantly (+8.4%) relative to the Baseline scenario in 2030 (see Table 3). Higher increases are observed for the EU15 (+8.9%) compared to EU13 (+6.0%). On the other hand, road transport activity falls by around 0.7% at EU28 level in 2030 relative to the Baseline.

Table 3: **Changes in inland passenger transport activity (territoriality approach) in the Reference scenario relative to Baseline in 2030 – difference in million passenger-kilometres and % changes**

	ROAD		RAIL		TOTAL	
	Delta	**% Change**	**Delta**	**% Change**	**Delta**	**% Change**
EU15	-38 156	**-0.7%**	52 646	**8.9%**	14 753	**0.2%**
EU13	-3 888	**-0.4%**	6 561	**6.0%**	2 673	**0.2%**
EU28	-42 044	**-0.7%**	59 207	**8.4%**	17 426	**0.2%**

Source: ASTRA model; Note: Delta stands for the difference in passenger-kilometre per year while % change stands for the % difference between the Reference scenario and the Baseline scenario.

Overall, the modelling results show that the investment in the TEN-T core network over the period from 2017 until 2030 improves the efficiency of the transport system, and boosts the competitive position of rail and inland waterway transport.

## 3.3 Transport impacts of individual core network corridors

Analysis at the corridor level shows that travel time improvements for passenger rail (left hand side in Figure 4) and freight rail (right hand side in Figure 4) are substantial. Passenger rail time savings along the corridors range between 6.8% for the Atlantic CNC and 30% for the Mediterranean CNC in 2030 relative to the Baseline. For rail freight, the time savings range between 23.3% for the North-Sea Baltic CNC and 44.4% for the Mediterranean CNC in 2030 relative to the Baseline. Apart from North-Sea Baltic CNC, the time savings for rail freight are generally higher than those for passenger rail.
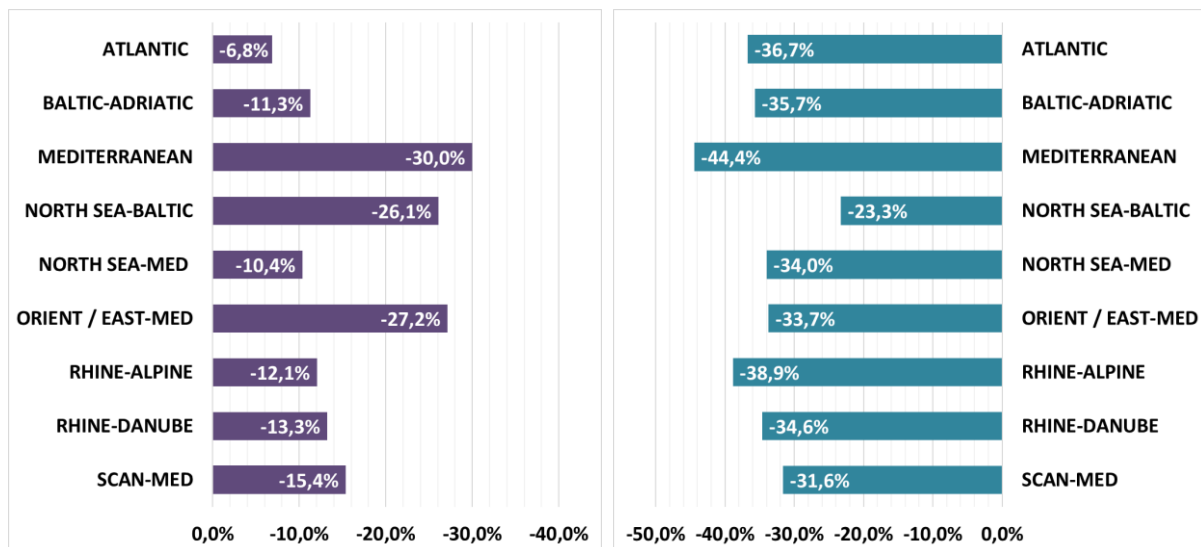
Source: TRUST model

Figure 4: **Changes in travel time by rail for passengers (left hand side) and freight (right hand side) by CNC relative to the Baseline in 2030 (% change)**

The completion of the TEN-T core network leads to a substantial increase in passenger rail transport activity (left hand side of Figure 5) and a small reduction in passenger road transport activity (right hand side of Figure 5) along the corridors in 2030 relative to the Baseline. The largest changes are observed for the Mediterranean and the Scandinavian-Mediterranean CNCs, which also constitute the two CNC with the largest investments. It should be emphasised that the results show modal-shift within the NUTS-zones crossed by the CNC, and not just on the links of the CNC.
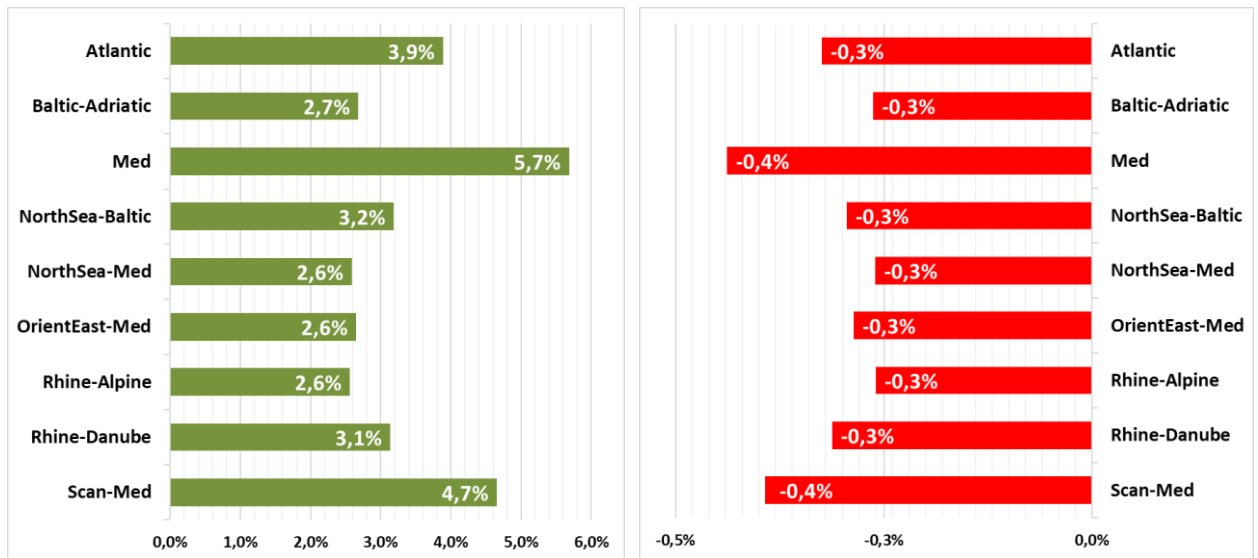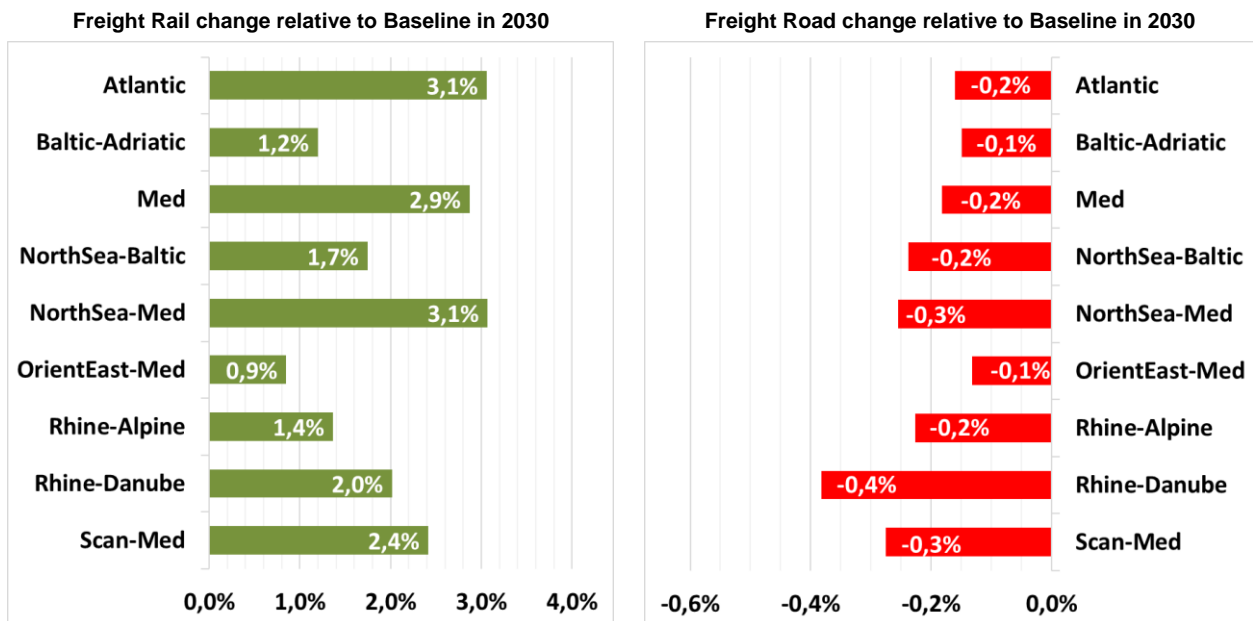
Source: ASTRA model

Figure 5:   **Changes in passenger transport activity (territoriality approach) of the NUTS1 regions crossed by the core network corridors (CNC) relative to the Baseline in 2030 (% change) – rail on left hand side, road on right hand side**

The completion of the TEN-T core network leads to a substantial increase in freight rail transport activity (left hand side of Figure 6) and a small reduction in freight road transport activity (right hand side of Figure 6) along the corridors in 2030 relative to the Baseline.

Rail freight variations range from 3.1% for the NUTS1 regions crossed by the North Sea-Med and the Atlantic corridor to 0.9% for those crossed by the Orient-East-Med corridor. Road freight reductions following the increased rail performance range from 0.1% in the NUTS1 regions crossed by the Orient-East-Med and Baltic-Adriatic corridors to 0.4% in those crossed by the Rhine-Danube corridor.

Figure 6: Change of freight transport activity by road and rail (territoriality approach) in the NUTS1 regions crossed by the core network corridors (CNC) relative to the Baseline in 2030 (% change) – rail on left hand side, road on right hand side

3.4 Impacts on decarbonisation and environment

The implementation of the core TEN-T network leads to a reduction in CO_2 emissions from transport of 12.5 Mt CO_2 in 2030 relative to the Baseline (-1.4%), due to modal shift from road to rail and inland waterways. The expected cumulative reduction of CO_2 emissions from the transport sector is about 72 million tonnes between 2017 and 2030, of which 26 million tonnes are from TEN-T core network completion and the rest from measures to promote cleaner vehicle technologies enabled by the refuelling/recharging infrastructure for alternative fuels and electro-mobility. This adds to the savings already generated by the part of TEN-T network completed between 1996 and 2016.

The Reference scenario does not take into account the policies recently adopted at the EU level for 2030 (i.e. the recast of the Renewables Energy Directive, the revision of the Energy Efficiency Directive and the Effort Sharing Regulation), and those recently proposed by the Commission (i.e. the first "Europe on the Move" package in May 2017, the second Mobility Package in November 2017 and the third "Europe on the Move" package in May 2018). Taking these policies into account would lead to much higher CO_2 emissions savings on the core TEN-T network.

Modal shift to environmental friendly modes also reduces the emissions of air pollutants from transport. NO_x emissions decrease by 11,000 tons in 2030 (-0.7%) compared with the Baseline. Emissions of particulate matter (PM) reduce by 0.7% in 2030 compared to the Baseline.

4 Economic impacts of TEN-T implementation

The economic impacts of TEN-T implementation are analysed from four different angles:

- Impacts for the whole EU until 2030
- Impacts for different Member States
- Impacts of individual CNC,
- Longer-term impacts until 2040.

The impacts of investments in the core TEN-T network go beyond the transport system. The modelling exercise shows a wealth of economic impacts:

- Infrastructure investments have a positive impact on value-added and employment in the construction sector.
- Investments in technology such as locomotives or components of the European Rail Traffic Managements System (ERTMS) foster growth and employment in the railway and electronics industries.
- Supply industries to these sectors (i.e. construction, railway and electronics) provide intermediate goods and services, improving their own economic outcomes.
- Transport time savings increase the productivity of the supply chains and create new opportunities for business trips, which in turn improves productivity.
- Sectoral productivity gains due to higher sectoral investment in technology inputs increase total factor productivity of the European economy, with positive impacts on GDP.
- Increased GDP leads to second round impacts, with additional income spent by households on sectors producing consumer goods and services.

4.1 Economic impacts for the whole EU

The ASTRA model measures these macroeconomic impacts through key indicators including gross domestic product (GDP) and employment. Table 4 shows that GDP at EU28 level goes up by 1.6% in 2030 (0.4% in 2020) relative to the Baseline. The table also shows that the economic impacts are not evenly distributed over the European Union: GDP in EU13 Member States increases by 4.2% in 2030 (1.9% in 2020) relative to the Baseline, whereas for the EU15, the GDP increase is lower (0.3% in 2020 and 1.4% in 2030).

Since population and labour force are substantially larger in the EU15 than in EU13, the absolute increase in employment in the EU15 in 2030 (about 510,000 jobs) is higher than in the EU13 (around 288,000 jobs). In relative terms however, employment in the EU13 is 0.4% higher in 2030 with respect to the Baseline and 0.1% higher in the EU15. For the EU28, 797,000 additional jobs are created in 2030 thanks to the completion of the core TEN-T network. Employment numbers are provided as full-time equivalent (FTE), in other words equivalent employees working full-time.

Table 4: **Changes in GDP and employment in the Reference scenario relative to the Baseline due to the TEN-T core network implementation between 2017 and 2030**

Changes in the Reference scenario relative to the Baseline	GDP		Employment (FTE)	
	2020	2030	2020	2030
EU15	0.3%	1.4%	185 200	509 600
EU13	1.9%	4.2%	155 300	287 500
EU28	0.4%	1.6%	340 500	797 000

Source: ASTRA model

The economic impacts can also be measured as cumulative impacts over the whole time period from 2017 until 2030 by summing the difference between the Reference and the Baseline for each year. The resulting cumulative impacts are shown in Table 5.

Table 5: **Changes in cumulative GDP and cumulative jobs due to the TEN-T core network implementation between 2017 and 2030[5]**

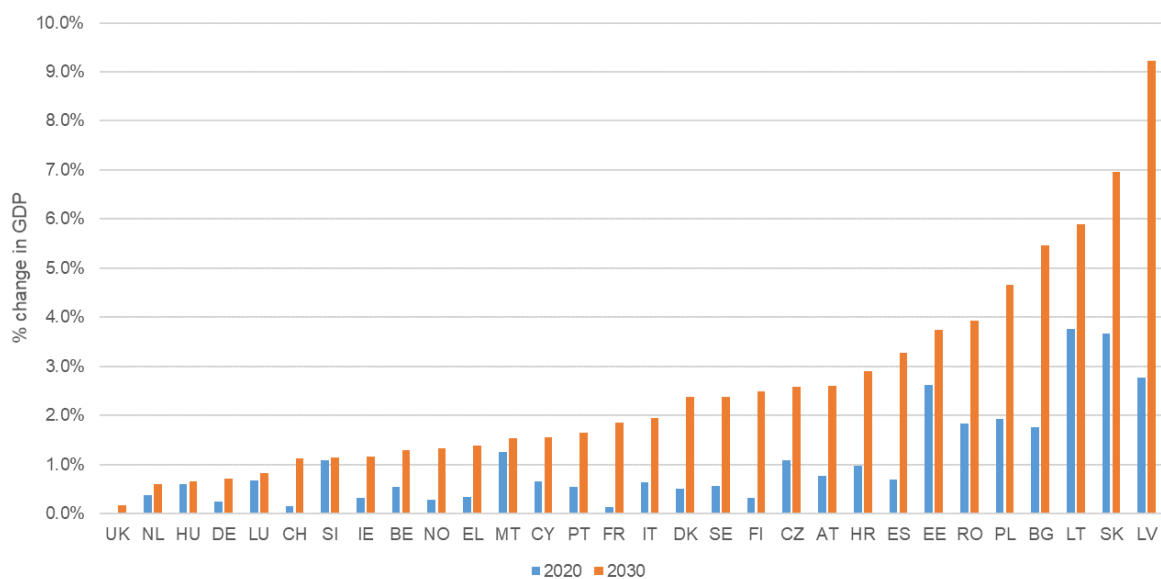| Changes in the Reference scenario relative to the Baseline	Cumulated GDP in billion Euro$_{2005}$		Cumulated job years	
	2017 to 2020	2017 to 2030	2017 to 2020	2017 to 2030
EU 15	95,000	1,400,000	457,000	4,537,000
EU 13	47,000	426,000	394,000	2,963,000
EU 28	143,000	1,826,000	851,000	7,501,000

Source: ASTRA model

4.2 Economic impacts on Member States

At Member State level, the impacts depend on factors such as: the size of TEN-T investment in relation to GDP or to their total investment; the sectoral structure of their economy; the specific improvements of transport performance; the dependency on trade and trade structure etc. The time profile of TEN-T investments and thus of improvements in travel time is also different between countries. As a consequence, the impacts on GDP vary country by country. Moderate increases in GDP of around 1% in 2030 relative to the Baseline are projected for several EU15 countries, while more substantial increases of more than 3% in GDP are shown for many EU13 countries. Comparing the impacts on GDP in 2020 and in 2030 allows a rough distinction between countries that benefit most

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[5] *Cumulated GDP* is the difference in the integral of the GDP in Reference scenario and the Baseline in billion Euro$_{2005}$. *Cumulated job years* are the difference in the integral of FTE for the Reference scenario and the Baseline scenario in person-years. One person-year is one person working on a full-time job over a period of 1 year. The integral is taken for both indicators over the period 2017 until 2020 and 2017 until 2030.

from direct impacts of investments (that appear relatively quickly) and those with more significant impacts due to second-round effects (that take longer to materialise). However, it is not possible to exactly divide the effects in the taken modelling approach and the two timings can be rather seen as a proxy for direct and indirect effects. For instance, countries like Luxembourg, Slovenia and Hungary have positive impacts on GDP that are similar in 2020 and in 2030 (respectively the blue bar and orange bar in Figure 7), showing that most of their benefits are from direct impacts of investments. Conversely, countries like Bulgaria, Denmark, Sweden and Latvia have GDP impacts in 2030 that are more than the threefold of the impacts in 2020, showing that they benefit significantly from second-round effects deriving from productivity growth and spillovers.
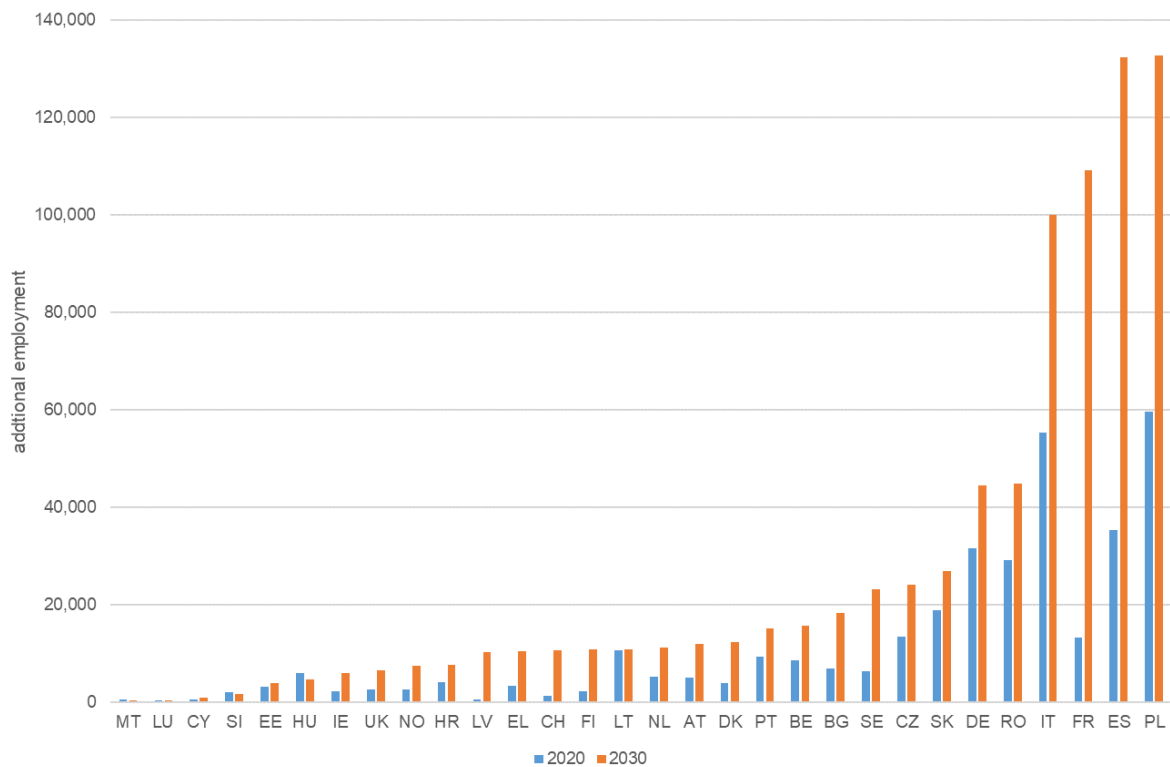

Source: ASTRA model

Figure 7:   **Changes in GDP in 2020 and 2030 in the Reference scenario relative to the Baseline, by country**

The impacts on employment by Member State in 2020 and 2030 are presented in Figure 8. Similarly to GDP, these vary by country. For employment, the labour productivity in the Baseline scenario (i.e. by country and at sectoral level) represents an additional important factor influencing the impacts across MS. This is obvious taking into account that the additional employment is derived from the ratio between investment and productivity such that high productivity levels generate lower additional direct employment from the same level of investment than low productivity levels.

Similarly to the GDP analysis above, MS can be differentiated between those who primarily benefit from direct effects of investments and those who mostly benefit from second-round effects (i.e. 2030 impacts being two to three times higher than in 2020). The results are presented in terms of additional jobs created, expressed as full-time equivalent (FTE). Hence, higher increases in absolute terms correspond to larger MS, with Italy,

France, Spain and Poland showing more than 100,000 additional jobs created in 2030 relative to the Baseline. The impact in these MS stems mainly from the second-round effects. The reasons for countries with significant direct impacts but limited second round impacts can be threefold: (1) high share of imports in the sector benefitting from the investment, and thus (2) low growth of income and thus consumption in the country, and (3) low stimulus of total factor productivity in that country. The reasons for countries with more significant second round effects can be fourfold: (1) high share of domestic input to construction sector, (2) significant exports of intermediate goods for the construction in other MS, (3) high growth of income and thus consumption in the country, and (4) high stimulus of total factor productivity. In particular the final two effects stimulate each other and enfold growth dynamics over time[6] such that the second round effects, when the dynamics are kicked off initially, increase over time and could become much larger than the direct effects.
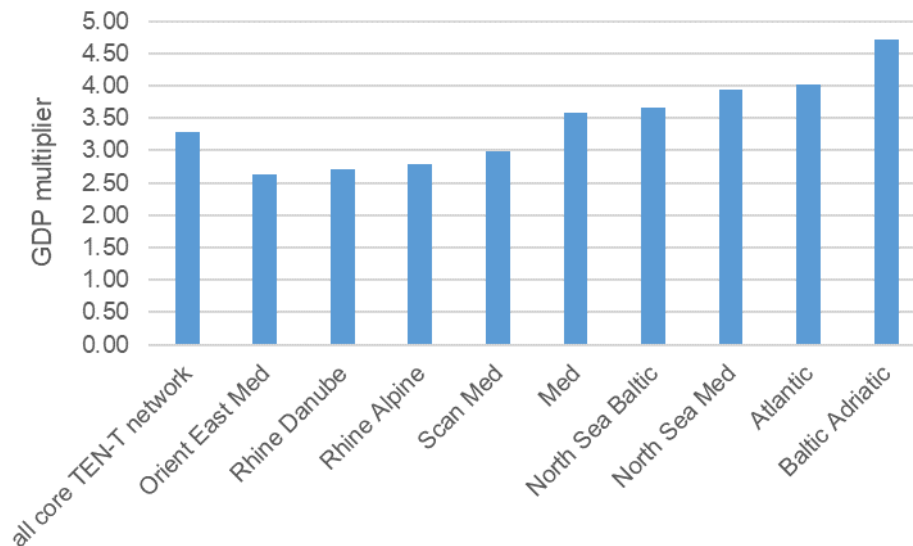

Source: ASTRA model

Figure 8:   **Additional jobs created in 2020 and 2030 in the Reference scenario relative to the Baseline, by country**

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[6] Higher income in year 1 – more spending in year 1 – more investment to satisfy consumption – higher productivity – higher income in year 2, etc.

4.3 Economic impacts from individual core network corridors

Economic multipliers are used as an indicator to understand the economic impact of TEN-T implementation. The multipliers establish a relation between the input of a policy, in our case the required investment, and the output, which can refer to different economic indicators, like GDP, income or employment.

Figure 9 shows GDP multipliers for individual corridors, that provide an indicator of the additional GDP created by each euro invested over the period 2017 to 2030. These range from 2.6 for the Orient-East-Med CNC to 4.7 for the Baltic-Adriatic CNC. The GDP multiplier for the whole TEN-T core network over the period 2017 to 2030 is 3.3, meaning that every euro invested in the TEN-T core network creates 3.3 euros of GDP on average.
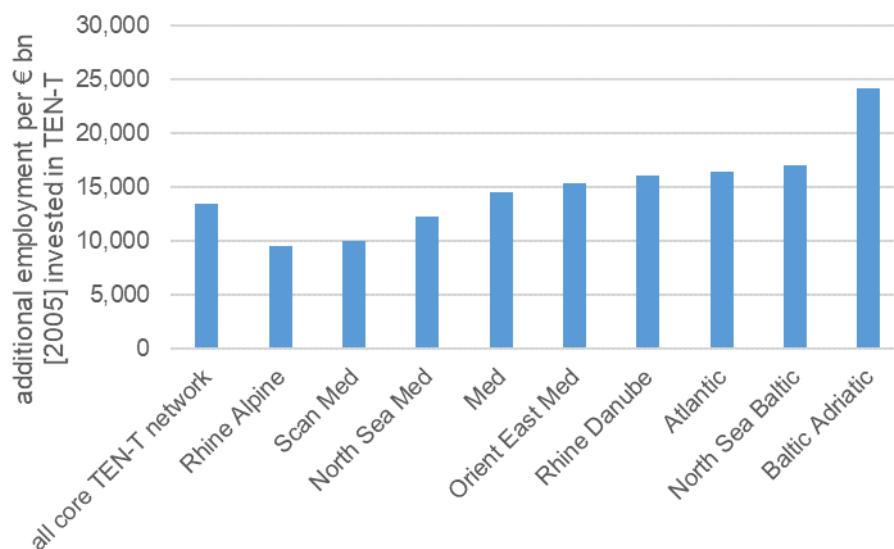

Source: ASTRA model

Figure 9:   **GDP multipliers for the TEN-T core network implementation between 2017 and 2030**

The GDP multipliers of the TEN-T network implementation can be compared with other sectors that receive European funding. Taking agriculture as an example, Monsalve et al. (2016) report that the multiplier of EU agricultural funds for value added for rural development is smaller than one. However, especially for low-skilled employment the multiplier is considerably higher. It must be noted, though, that the analysis used a multi-regional Input-Output model, such that induced effects are not considered, while these are part of our analysis based on the ASTRA model. Mary et al. (2013) used a computable general equilibrium (CGE) model to show a cumulative multiplier for rural development of 2.1 in an ex-post evaluation. For urban policies, the multiplier is considerably higher. However, the analysis is made only for one region (Cordoba in Spain) and most likely cannot be generalised for the whole EU. In general, it seems that the average GDP multiplier of TEN-T core network implementation of 3.3 is likely to be higher than the impacts of funds dedicated to agriculture.

The change in employment induced by the TEN-T core network implementation between 2017 and 2030 is presented in Figure 10. The Baltic-Adriatic corridor (BAC) shows the highest multiplier with about 24,000 additional job-years per billion Euro invested (expressed in 2005 prices) by 2030. The high employment multiplier of the BAC results from the large investments placed in Poland that shows a large impact due to its sectoral structure, as well as their labour productivity (see Figure 8). Low multipliers are projected for the Rhine-Alpine and the Scandinavian-Mediterranean corridors, below 10,000 additional job-years per billion Euro invested (expressed in 2005 prices). The reason is that these corridors pass through countries with comparably high labour productivity so the same increase in investments leading to growth in value-added would then translate into a significantly lower impact on employment.[7] The high labour productivity also causes salaries to be higher and thereby employment is often substituted for capital. The average multiplier for the whole TEN-T core network is above 13,000 additional job-years per billion Euro invested (in 2005 prices).

Source: ASTRA model

Figure 10:   **Employment multipliers for the TEN-T core network implementation between 2017 and 2030**

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[7] To derive employment from value-added the latter needs to be divided by the productivity in Euro/FTE. High values for productivity then lead to small numbers for employment.

4.4 Long-term economic outlook of TEN-T core network impacts

Transport infrastructure assets have long lifetimes. Therefore, it is reasonable to test the longer-term impacts of the full implementation of the TEN-T core network by 2030. This has been performed by running the ASTRA model until 2040 without adding further investments or other policy measures between 2030 and 2040. The results show the medium to long-term (until 2040) second-order effects of the TEN-T core network implementation taking place between 2017 and 2030. EU GDP is projected to increase by 2.6% in 2040 relative to the Baseline, compared to 1.6% in 2030. The additional jobs created amount to 1,166,000 in 2040, compared to 797,000 in 2030. Thus, the longer-term effects increase further. In other words, the economy is lifted on a higher growth path due to the investment through long-acting mechanisms such as increases in productivity enabled by the improved transport system.

5 Limitations

The objective of this study is to assess impacts on economic growth and employment at EU level following the completion of the TEN-T network.

The study is not a transport forecasting study, since the approach required that the projections of transport activity, GHG emissions and economic indicators were aligned to the updated EU Reference Scenario 2016[8]. It is also not intended to provide estimates of traffic volumes along the CNCs, nor to replace the CNCs transport market studies.

The updated EU Reference Scenario 2016 also does not consider the policies recently adopted at the EU level for 2030 (i.e. the recast of the Renewables Energy Directive, the revision of the Energy Efficiency Directive and the Effort Sharing Regulation), and those recently proposed by the Commission (i.e. the first "Europe on the Move" package in May 2017, the second Mobility Package in November 2017 and the third "Europe on the Move" package in May 2018). It also does not consider the National Emissions Ceilings (NEC) Directive (2016/2284/EU). Taking these policies into account would lead to higher savings of CO_2 emissions and air pollutants on the core TEN-T network.

Since the Reference scenario does not consider the decarbonisation policies recently adopted by the EU and those currently in the pipeline, the modelled impacts on GHG

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[8] The updated EU Reference scenario 2016 includes some updates in the technology costs assumptions (i.e. for light duty vehicles) and several policy measures adopted after its cut-off date (end of 2014) such as the Directive on Weights and Dimensions, the 4th Railways Package, the NAIADES II Package, the Ports Package, the replacement of the New European Driving Cycle (NEDC) test cycle by the new Worldwide harmonised Light-vehicles Test Procedure (WLTP). It has been developed with the PRIMES-TREMOVE model (i.e. the same model used for the EU Reference scenario 2016) by ICCS-E3MLab (Capros et al. 2016). A detailed description of this scenario is available in the Impact Assessment accompanying the Proposal for a Directive amending Directive 1999/62/EC on the charging of heavy goods vehicles for the use of certain infrastructures, SWD (2017) 180

emissions presented in this study are conservative - reflecting the impact of infrastructure focussed policies but not the vehicle technology focussed policies.

The study considers different compositions of the vehicle fleet in the Baseline and in the Reference scenario as a result of the implementation of the TEN-T core network, since the investments are expected to stimulate higher penetration of alternatively fuelled and electric vehicles. More specifically, for passenger cars the share of battery electric vehicles in 2030 at the EU28 level is assumed to increase from 1.4% in the Baseline scenario to about 2% in the Reference scenario. Similarly, the share of fuel cell cars is assumed to go up from 0.1% in the Baseline to 0.3% in the Reference scenario. Similar increases are assumed for light commercial vehicles, while for heavy goods vehicles assumptions concern the uptake of LNG vehicles (their share going up from 2.1% in the Baseline to 2.6% in the Reference scenario).

This study does not consider changes in charges (i.e. rail access charges, road charges etc.), or assumptions on other policies in the transport sector except for those explicitly mentioned in the report. Assumptions on reductions in rail operational costs are only driven by the deployment of the European Railway Traffic Management System (ERTMS) over time.

The impact of Brexit is not analysed by the study.

The most detailed level of the economic analysis is at the Member State level. Regional analyses at more detailed levels may be undertaken by using the total national impact as a benchmark input and other methodologies to analyse the regional impacts at the level of NUTS-zones.

6   Conclusions and Recommendations

The study has analysed the full TEN-T core network implementation by 2030, which consists of the nine core network corridors (CNC) and the remaining part of the core network that is not part of any CNC. On the CNC, 3,037 projects were identified that will be completed between now and 2030, requiring an investment of 438 billion Euro in 2005 prices. Additional investments of 118 billion Euro are assumed to take place on the core network outside the CNC. In total the core network investment considered by the study amounts to 556 billion Euro until 2030.

Following the full implementation of the TEN-T core network in 2030, rail passenger activity is expected to increase by 8.4% in the Reference scenario relative to the Baseline (8.9% at the EU15 level and 6.0% at the EU13 level). Conversely, there are reductions in road (-0.7%) and air transport (-0.4%) activity taking place as a consequence of the increased rail performance. The completion of the core TEN-T network is also expected to lead to an increase in rail freight transport activity of 4.7% in 2030 relative to the Baseline (5.8% for the EU15 and 2.7% for the EU13); road freight transport activity would decrease by about 0.4% and the activity of inland waterways would go up by 0.6% in 2030 relative to the Baseline. The results thus show modal shift towards more sustainable transport modes like rail and inland waterways, due to their increased competitive position.

In terms of carbon dioxide (CO_2), savings of 12.5 million tonnes take place in 2030 relative to the Baseline as a result of the full TEN-T core network implementation. This is expected to lead to a cumulative reduction of CO_2 emissions from the transport sector of about 72 million tonnes between 2017 and 2030, of which 26 million tonnes are from TEN-T core network completion and the rest from measures to promote cleaner vehicle technologies enabled by the refuelling/recharging infrastructure for alternative fuels and electro-mobility. This adds to the savings already generated by the part of TEN-T network completed between 1990 and 2016.

Modal shift to environmental friendly modes also reduces the emissions of air pollutants from transport. NO_x emissions decrease by 11,000 tonnes (-0.7%) in 2030 compared with the Baseline. Emissions of particulate matter (PM) reduce by 0.7% in 2030 in the Reference Scenario versus the Baseline.

In terms of economic impacts, GDP would increase by 1.6% in 2030 relative to the Baseline and an additional 797,000 full-time equivalent jobs would be generated due to the completion of the core TEN-T network. The growth impact differs substantially between the EU13 (+4.2%) and the EU15 (+1.4%). These large differences between countries are linked to: (1) the share of TEN-T investments in the total investments undertaken in a country, and (2) country specific economic endowments (e.g. labour productivity in certain sectors).

The economic impact can also be shown in relation to the level of investments. The GDP multiplier of the TEN-T investments amounts to 3.3, which indicates that for every euro invested, 3.3 euros of additional GDP are created. In terms of employment, for every billion

euro invested into the TEN-T core network between 2017 and 2030 an average of 13,000 additional job-years are generated.

The full TEN-T impacts are larger than those already presented, since TEN-T implementation commenced during the 1990s and accelerated during the 2000s, gaining further momentum after 2010, in particular fostered by the increased funds provided by the EU to network elements delivering high EU added-value (e.g. cross-border projects).

CNC are the most important instrument to organise and drive the implementation of the TEN-T core network. The CNC benefit from a focussed effort to upgrade their developments to high quality standards as defined by the TEN-T regulation. In particular, rail networks are addressed by the CNC as well as inland waterway networks on selected corridors. Along the CNC, bottlenecks are eliminated, cross-border links are established or upgraded and the travel speeds are increased. The results at the level of CNC in terms of rail travel time savings and stimulating modal shift are very promising.

Looking at the whole transport system - of which the core network is an important element- and taking all rural and urban transport infrastructure into account, the impact on total modal split is of the order of one-digit percentage changes. This is still remarkable considering that many MS benefit from only one or two CNC. The economic impacts delivering an increase of 1.6% in European GDP reveals the benefit of the TEN-T policy to focus on a core network that better connects European regions. The concept of the core network corridors can be extended in a fruitful manner by connecting the CNC with regional networks, which can be done in several ways:

- via multi-modal terminals enabling the use of other modes for regional distribution.

- via upgrading selected links of the comprehensive network, thereby closing gaps in the regional distribution networks.

- via eliminating organisational barriers that still exist at borders even after the cross-border infrastructure has been upgraded for the more environmental friendly modes.

The next decade still requires a focus on the completion of the CNC to reap the benefits of a strong and integrated network covering Europe, which over time is becoming seamlessly integrated with the regional networks. Taking the two approaches of full implementation of regional networks and linking various national regional networks across the borders with each other fits best to the vision of a European integration that benefits both people and the economy..

Of equal importance is the objective of transport decarbonisation. TEN-T core network implementation contributes to decarbonisation by fostering modal shift towards more environmentally friendly modes. However, like other infrastructure programmes, it cannot solve the decarbonisation problem alone. It must be complemented by other policies to increase the efficiency of the transport system and to promote low-emission alternative

energy for transport, and low- and zero emission vehicles. This has been acknowledged in the 2016 EU strategy on low-emission mobility.

List of figures

List of tables

7 References

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