5 Impacts of TEN-T implementation during 2017-2030

While in the Baseline Scenario no TEN-T core network projects are assumed to be implemented beyond 2016, the implementation of the core network continues in the Reference Scenario until 2030. In 2030 the TEN-T core network will then be fully implemented and operational. Thus, the impact of the implementation of the TEN-T core network over the period 2017-2030 is assessed by comparing the Reference Scenario with the Baseline Scenario.

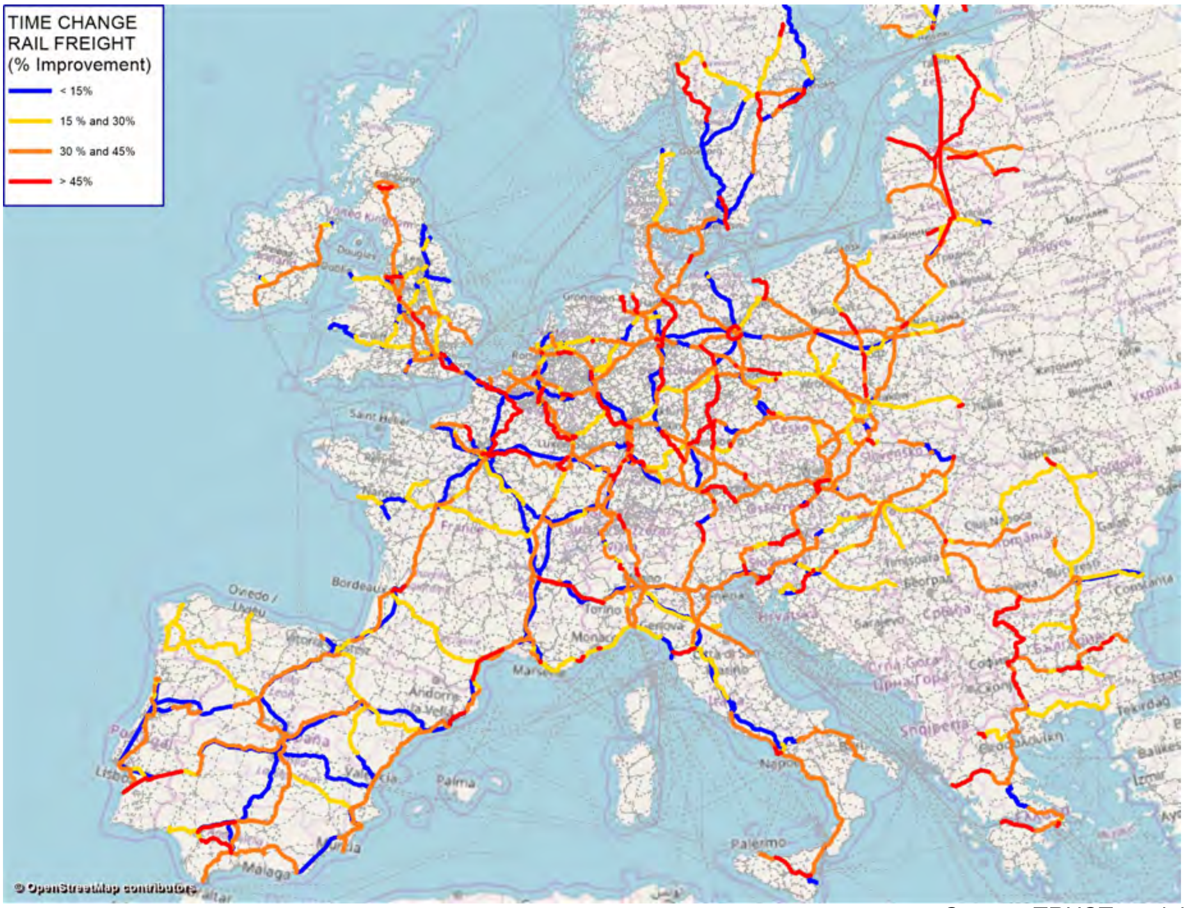
5.1 TEN-T impact at the network level

Network level results from TRUST are provided in terms of maps showing the changes in travel time along the core network in 2030. More detailed results in terms of changes in travel time and costs along the CNCs are provided in section 6.1.

Maps in Figure 26 and Figure 27 show the change of travel time in the TEN-T core rail network, respectively for freight and passengers, in the Reference scenario relative to Baseline in 2030.

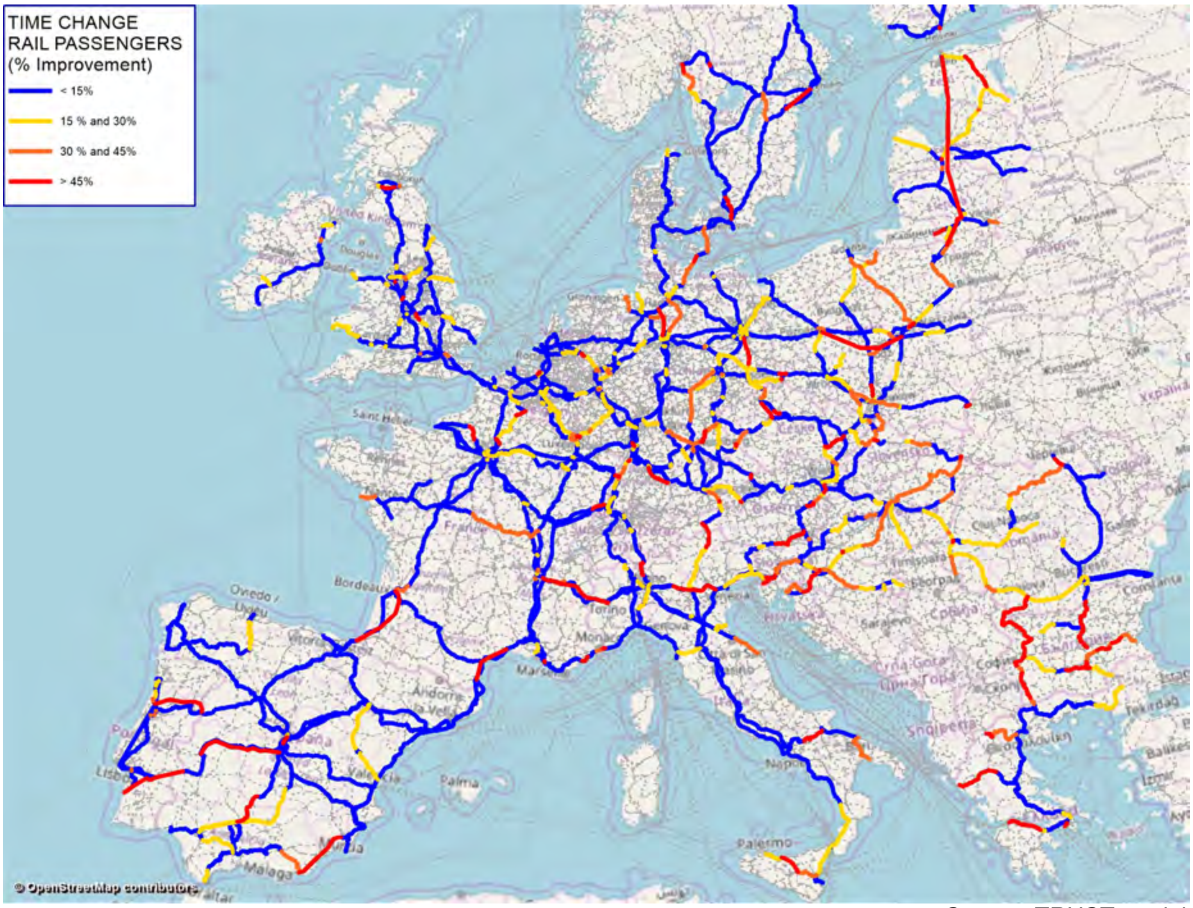
The comparison between the maps for passengers and freight clearly shows that the investments planned on the core network are expected to benefit more rail freight performance than passenger's one. Figure 26 shows indeed a high proportion of the freight network whose travel time gains are expected to be over 30%, in contrast to Figure 27 which shows that a high proportion of the passenger network whose expected time gains are lower than 15%. This result reflects the evidence that the most of investments in the rail sector aim to increase rail performance, where several improvements are still possible, while the performance of the rail passenger network is generally already of high level.

Higher reduction of travel time for rail freight is the outcome of a combination of different factors. On one side there are the impacts of infrastructure investments which will allow for higher operational speeds on the corridor(s); on the other side there are the impacts of a general improvement of the efficiency of the rail freight system following the removal of several barriers to freight trains circulation among which: increased time slots for freight trains; better integration with passenger trains traffic; reduction/elimination of bottlenecks; technical and operational improvements in cross-border transit.



Source: TRUST model

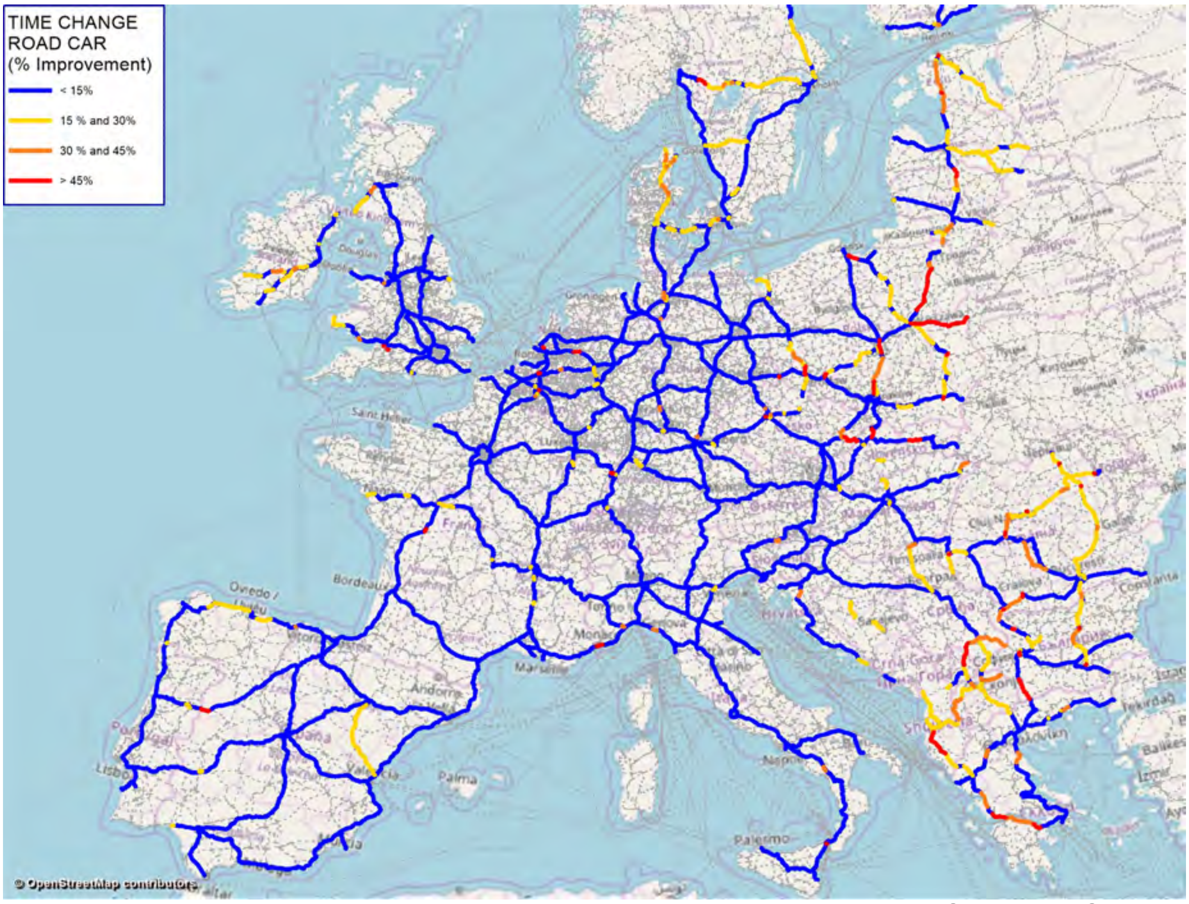
Figure 26: Changes of travel time for freight rail in the Reference Scenario relative to Baseline in 2030 (% change)



Source: TRUST model

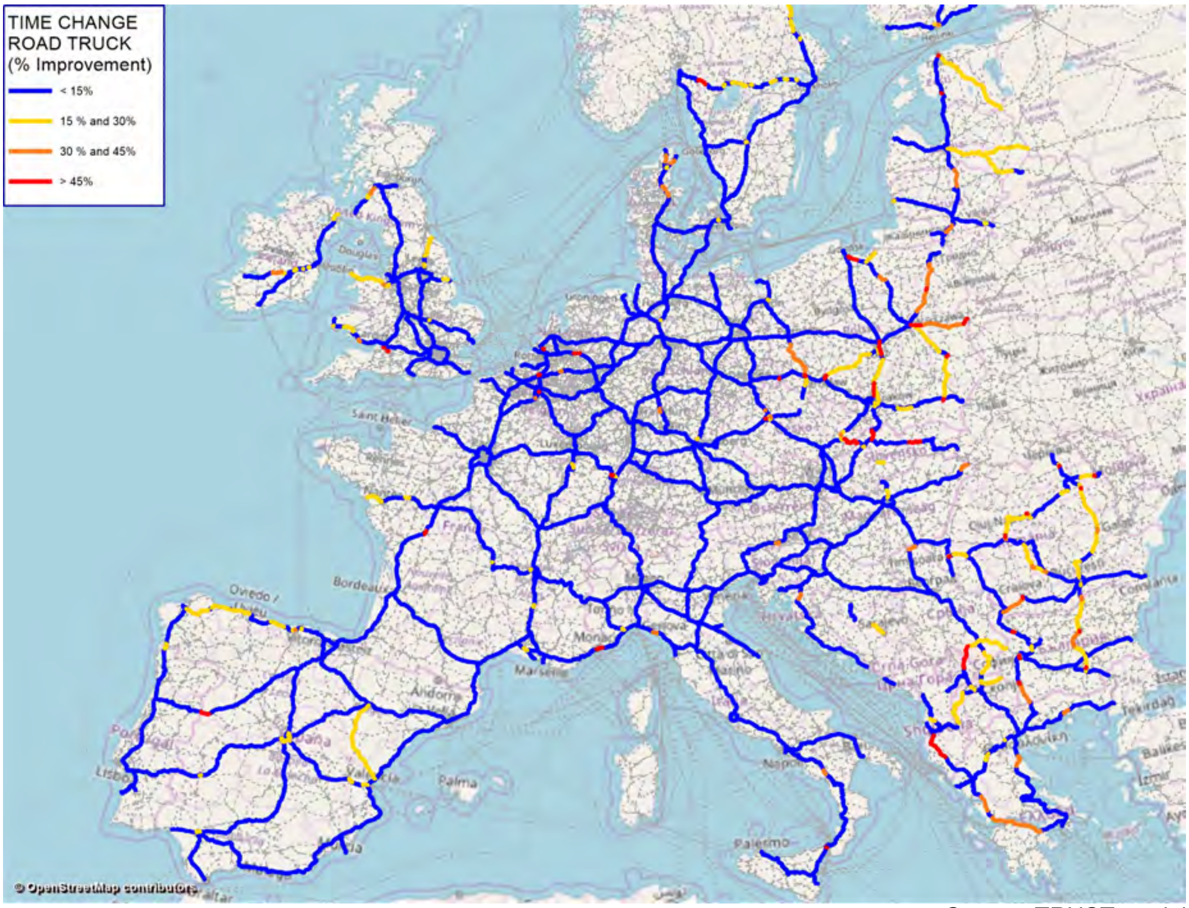
Figure 27: **Changes of travel time for passenger rail in the Reference Scenario relative to Baseline in 2030 (% change)**

Figure 28 and Figure 29 show the changes of travel time by road in the Reference Scenario relative to Baseline in 2030 respectively for cars and trucks. Not surprisingly, the changes are lower than those observed for the rail network, reflecting the implementation of the rail network development projects in the EU TEN-T. Indeed, on most of the network, time gains are below 15%. More detailed results at corridor level reported in section 8 show that the time gains on the road CNCs are mostly below 7%, partially also related to the already high performance of the road network.



Source: TRUST model

Figure 28: **Changes of travel time by road for passengers in the Reference Scenario relative to Baseline in 2030 (% change)**



Source: TRUST model

Figure 29: **Changes of travel time by road for freight in the Reference Scenario relative to Baseline in 2030 (% change)**

5.2 TEN-T impact on transport demand

Transport impacts at aggregate level are provided by the ASTRA model[9]. Passenger (car, bus, rail) and freight (road, rail and inland waterways) transport activity is computed according to the territoriality approach[10] and cover distance bands (i.e. including short distance demand). The territoriality approach considers all the traffic on the territory of a country. Results for air transport are provided in Table 19. Maritime transport is not considered in the current study; a detailed analysis on 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..

9 ASTRA is not a network model and, at most detailed level, it works with a NUTS1 zoning system. It deals therefore with transport demand at NUTS 1 level and not at corridor level.

10 The territoriality approach (e.g. also used in the Transport in Figures statistical pocket book) considers all the traffic on the territory of a country, regardless of its origin and destination.

5.2.1 Passenger demand

By 2030 the overall passenger transport activity slightly increases (0.2%) in the Reference scenario relative to the Baseline (see Table 16). Passenger activity by transport modes shows an increase of rail activity by 8.4% at the EU28 level (+8.9% at the EU15 level and 6.0% at the EU13 level). Road transport activity decreases by 0.7% at the EU28 level.

Table 16: Changes in passenger transport activity (territoriality approach) for the Reference scenario relative to Baseline in 2030 (difference in million passenger-kilometres and % changes)

	CAR		BUS		RAIL		TOTAL	
	Delta	% Change	Delta	% Change	Delta	% Change	Delta	% Change
EU15	-37 095	**-0.8%**	-1 061	**-0.2%**	53 168	**8.9%**	15 012	**0.2%**
EU13	-3 390	**-0.4%**	-498	**-0.4%**	6 561	**6.0%**	2 673	**0.2%**
EU28	-40 485	**-0.7%**	-1 559	**-0.3%**	59 729	**8.4%**	17 685	**0.2%**

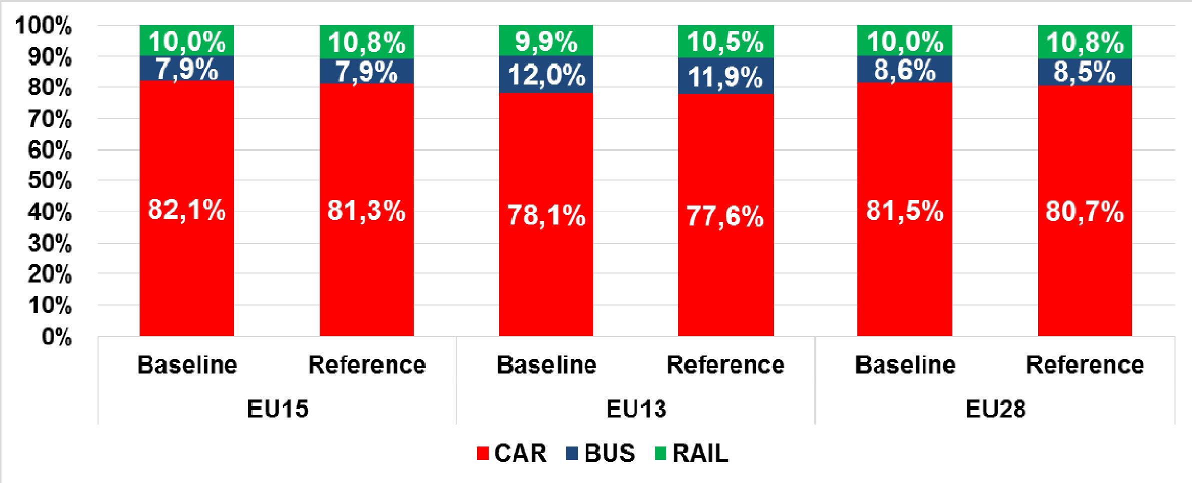
Source: ASTRA model; Note: Delta stands for the difference in tonne-kilometre per year while % change stands for the % difference between the Reference scenario and the Baseline scenario.

Passenger modal split in the Reference and Baseline scenarios in 2030 is shown in Table 17 and Figure 30. The modal share of rail is projected to increase by 0.8 percentage points (p.p.) in the Reference scenario in comparison with the Baseline at the EU28 level.

Table 17: Passenger Modal Split (territoriality approach) in the Reference scenario relative to Baseline in 2030

	Scenario	CAR	BUS	RAIL
EU15	**Baseline**	82.1%	7.9%	10.0%
	Reference	81.3%	7.9%	10.8%
	Variation	**-0.8%**	**0.0%**	**0.9%**
EU13	**Baseline**	78.1%	12.0%	9.9%
	Reference	77.6%	11.9%	10.5%
	Variation	**-0.5%**	**-0.1%**	**0.6%**
EU28	**Baseline**	81.5%	8.6%	10.0%
	Reference	80.7%	8.5%	10.8%
	Variation	**-0.8%**	**0.1%**	**0.8%**

Source: ASTRA model



Source: ASTRA model

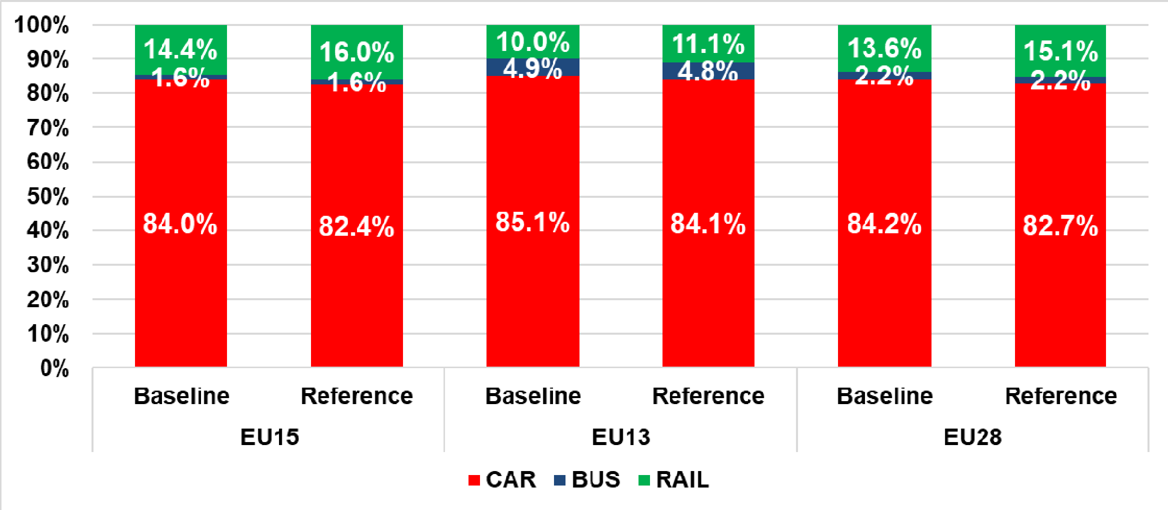
Figure 30: Passenger modal split (territoriality approach) in the Reference and the Baseline scenarios at 2030

More relevant changes can be observed for modal split of long distance passenger demand as reported in Table 18 and Figure 31. In this case rail modal share increases by 1.5 p.p. in the Reference scenario in comparison with the Baseline at the EU28 level.

Table 18: Long distance passenger Modal Split (territoriality approach) in the Reference scenario relative to Baseline in 2030

	Scenario	CAR	BUS	RAIL
EU15	Baseline	84.0%	1.6%	14.4%
	Reference	82.4%	1.6%	16.0%
	Variation	**-1.6%**	**0.0%**	**1.6%**
EU13	Baseline	85.1%	4.9%	10.0%
	Reference	84.1%	4.8%	11.1%
	Variation	**-1.0%**	**-0.1%**	**1.1%**
EU28	Baseline	84.2%	2.2%	13.6%
	Reference	82.7%	2.2%	15.1%
	Variation	**-1.5%**	**0.0%**	**1.5%**

Source: ASTRA model



Source: ASTRA model

Figure 31: **Long distance passenger modal split (territoriality approach) in the Reference and the Baseline scenarios at 2030**

The changes in air passenger transport activity for the Reference scenario relative to Baseline in 2030 are given in Table 19. At EU15 level a slight reduction of 0.5% is observed as consequence of the increased rail performance. A different trend is shown at the EU13 level, where a slight increase of 0.2% is observed. Overall the impact at the EU28 level is a slight reduction of 0.4%.

Table 19: **Changes in air passenger transport activity for the Reference scenario relative to Baseline in 2030**

	AIR	
	Delta	% Change
EU15	-3 514	-0.5%
EU13	151	0.2%
EU28	-3 363	-0.4%

Source: ASTRA model; Note: Delta stands for the difference in million pkm/year while % change stands for the % difference between the Reference scenario and the Baseline scenario

5.2.1 Freight demand

Freight performance projections are shown in Table 20 and Figure 32. Total freight activity increases by about 0.6% at the EU28 level in the Reference scenario relative to Baseline in 2030. Looking at the changes by mode it can be noted that freight activity by rail increases by 4.7% at the EU28 level, with an increase of 2.7% for EU13 countries and of 5.8% for EU15. Road freight transport decreases in EU15 countries by about 0.4% and by 0.3% in EU13 countries. Activity by inland waterways shows an increase of 0.6% at the EU28 level. These changes result in shifts towards more sustainable transport modes like rail and inland waterways - as shown respectively in Table 21 and Figure 32 for total transport activity and in Table 22 and Figure 33 for long distance traffic. Overall, rail freight activity increases its share by 0.7 p.p. at EU level. For long distance traffic, this means increasing the rail modal share by 0.9 p.p..

Table 20: Changes in freight transport activity (territoriality approach) for the Reference scenario relative to Baseline in 2030

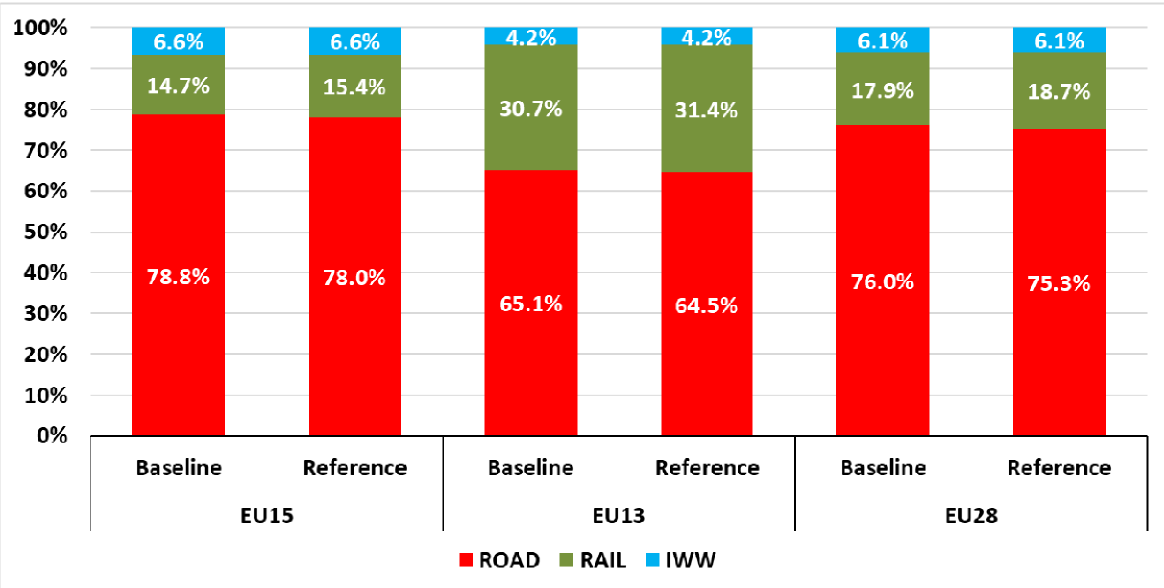
	ROAD		RAIL		IWW		TOTAL	
	Delta	% Change	Delta	% Change	Delta	% Change	Delta	% Change
EU15	-7 903	**-0.4%**	21 311	**5.8%**	1 108	**0.7%**	14 517	**0.6%**
EU13	-1 388	**-0.3%**	5 344	**2.7%**	70	**0.3%**	4 026	**0.6%**
EU28	-9 291	**-0.4%**	26 655	**4.7%**	1 178	**0.6%**	18 543	**0.6%**

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.

Table 21: Change of freight modal split of total demand (territoriality approach) in the Reference scenario relative to Baseline in 2030

	Scenario	ROAD	RAIL	IWW
EU15	**Baseline**	78.8%	14.7%	6.6%
	Reference	78.0%	15.5%	6.5%
	Variation	**-0.7%**	**0.8%**	**0.1%**
EU13	**Baseline**	65.1%	30.7%	4.2%
	Reference	64.5%	31.4%	4.2%
	Variation	**-0.6%**	**0.6%**	**0.0%**
EU28	**Baseline**	76.0%	17.9%	6.1%
	Reference	75.3%	18.7%	6.1%
	Variation	**-0.7%**	**0.7%**	**0.0%**

Source: ASTRA model



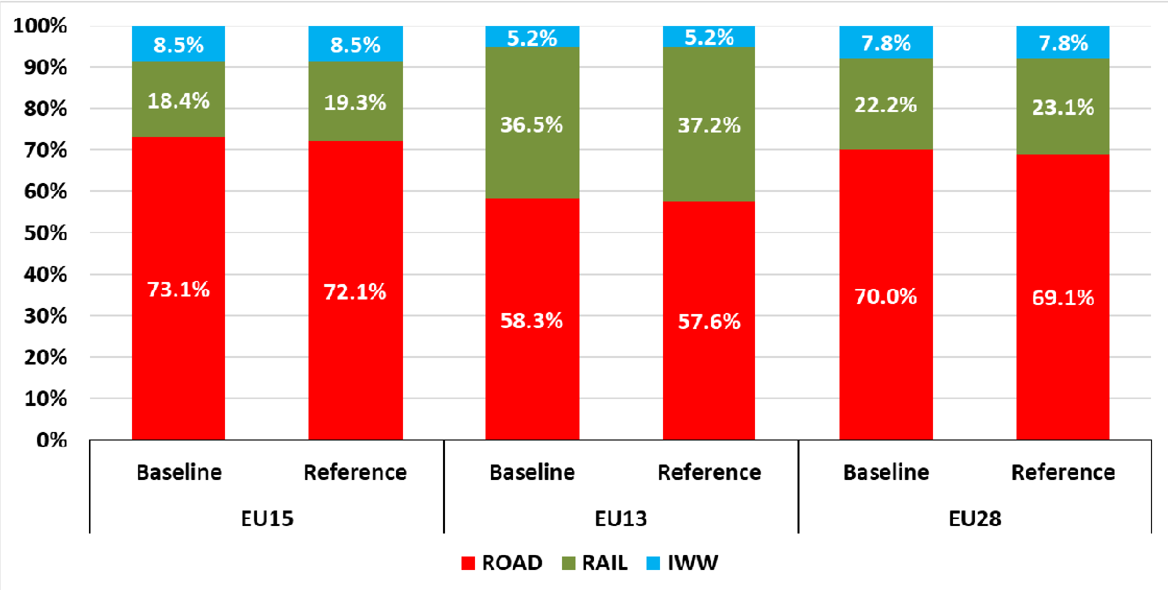
Source: ASTRA model

Figure 32: Freight modal split of total activity in tkm in the Reference and Baseline scenarios in 2030

Table 22: Change of freight modal split of long distance demand (territoriality approach) in the Reference scenario relative to Baseline in 2030

	Scenario	ROAD	RAIL	IWW
EU15	Baseline	73.1%	18.4%	8.5%
	Reference	72.1%	19.3%	8.5%
	Variation	-1.0%	1.0%	0.0%
EU13	Baseline	58.3%	36.5%	5.2%
	Reference	57.6%	37.2%	5.2%
	Variation	-0.7%	0.8%	0.0%
EU28	Baseline	70.0%	22.2%	7.8%
	Reference	69.1%	23.1%	7.8%
	Variation	-0.9%	0.9%	0.0%

Source: ASTRA model



Source: ASTRA model

Figure 33: Freight modal split of long distance traffic in the Reference and the Baseline scenarios in 2030

5.2.1 CO_2 emissions and transport external costs

The impacts on CO_2 emissions in the Reference scenario relative to the Baseline in 2030 are given in Table 23. Overall EU CO_2 emissions are expected to decrease by about 12.5 million tonnes in 2030 (1.4% decrease) relative to the Baseline). This impact is driven both by (i) shifts from road to more sustainable transport modes (i.e. rail and inland waterways) (ii) changes in the vehicle fleet composition in the Reference scenario in comparison with the Baseline scenario enabled by the refuelling/recharging infrastructure for alternative fuels and electro-mobility as described in section 3.6.

Table 23: Change of CO_2 emissions from total transport sector in the Reference scenario relative to Baseline at 2030

	CO_2	
	Delta	% Change
EU15	-10 797	**-1.4%**
EU13	-1 756	**-1.2%**
EU28	-12 553	**-1.4%**

Source: ASTRA model. Note: Delta stands for the difference in 1000 t/year while % change stands for the % difference between the Reference scenario and the Baseline scenario

This is expected to lead to a cumulative reduction of CO_2 emissions from the transport sector of about 71.6 million tonnes between 2017 and 2030, out of which 26 million tonnes are expected deriving 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. Changes of CO_2 external transport costs given in Table 24 show a reduction of about 436.2 million euro in 2030 (-1.4%) in the Reference scenario relative to Baseline in 2030. Changes of CO, NOx, VOC and PM yearly emissions from total transport sector in the Reference scenario relative to Baseline in 2030 are given in Table 25.

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 CO2 emissions savings on the core TEN-T network.

Table 24: Changes of CO_2 external transport costs from total transport sector in the Reference scenario relative to Baseline in 2030

	Delta	% Change
EU15	-375.6	**-1.4%**
EU13	-60.7	**-1.2%**
EU28	-436.3	**-1.4%**

Source: ASTRA model; Note: Delta stands for the difference in 1000 t/year while % change stands for the % difference between the Reference scenario and the Baseline scenario

Table 25: Changes of CO, NOx, VOC and PM from total transport sector in the Reference scenario relative to Baseline in 2030

	CO		NOx		VOC		PM	
	Delta	% Change	Delta	% Change	Delta	% Change	Delta	% Change
EU15	-18.3	**-0.2%**	-9.3	**-0.7%**	-11.2	**-0.2%**	-0.4	**-0.7%**
EU13	4.2	**0.3%**	-1.7	**-0.7%**	1.8	**0.2%**	-0.1	**-0.5%**
EU28	-14.1	**-0.1%**	-10.9	**-0.7%**	-9.4	**-0.2%**	-0.5	**-0.7%**

Source: ASTRA model; Note: Delta stands for the difference in 1000 t/year while % change stands for the % difference between the Reference scenario and the Baseline scenario

Changes of external costs of noise from inter-urban road traffic are given in Table 26. Reduction of external costs is due to both the upgrading of roads along the core TEN-T road network (roads with higher technical standard have lower cost for noise) and to the shift of traffic from other secondary roads to the core TEN-T roads. Table 27 shows the changes of external costs of congestion from inter-urban road traffic at 2030. Benefits from reduced inter-urban congestion are expected to be higher in EU13 (-9.3%) than in EU15 (-4.7%). Overall, EU28 congestion costs are expected to be reduced by 5.3%.

Table 26: Changes of external costs of noise from inter-urban road traffic in the Reference scenario relative to Baseline in 2030

	CARS		TRUCKS		TOTAL (CARS + TRUCKS)	
	Delta	% Change	Delta	% Change	Delta	% Change
EU15	-40	**-2.0%**	-56	**-4.5%**	-96	**-3.0%**
EU13	-32	**-6.9%**	-42	**-9.8%**	-75	**-8.2%**
EU28	-72	**-2.9%**	-98	**-5.8%**	-170	**-4.1%**

Source: TRUST model; Note: Delta stands for the difference in million Euro/year while % change stands for the % difference between the Reference scenario and the Baseline scenario

Table 27: Changes of external costs of congestion from inter-urban road traffic in the Reference scenario relative to Baseline in 2030

	CARS		TRUCKS		TOTAL (CARS + TRUCKS)	
	Delta	% Change	Delta	% Change	Delta	% Change
EU15	-2 280	**-4.7%**	-504	**-4.6%**	-2 784	**-4.7%**
EU13	-595	**-8.4%**	-223	**-13.1%**	-818	**-9.3%**
EU28	-2 875	**-5.2%**	-727	**-5.7%**	-3 602	**-5.3%**

Source: TRUST model; Note: Delta stands for the difference in million Euro/year while % change stands for the % difference between the Reference scenario and the Baseline scenario

5.3 TEN-T growth and jobs impacts

The economic impact of the completion of the TEN-T core network is explained by the interaction of the factors shown in Figure 13 above. On the one hand, the ASTRA model shows the transport network effects (time and cost improvements) as well as changes in operations and maintenance, in trade, intermediate inputs, total factor productivity, etc. On the other hand, there are additional 'pure' economic impacts from the completion of the network represented in ASTRA (i.e. investments from the project database and the various financing options, which have been discussed in section 3.6.3).

One can distinguish three types of impacts arising from the various economic and transport impulses:

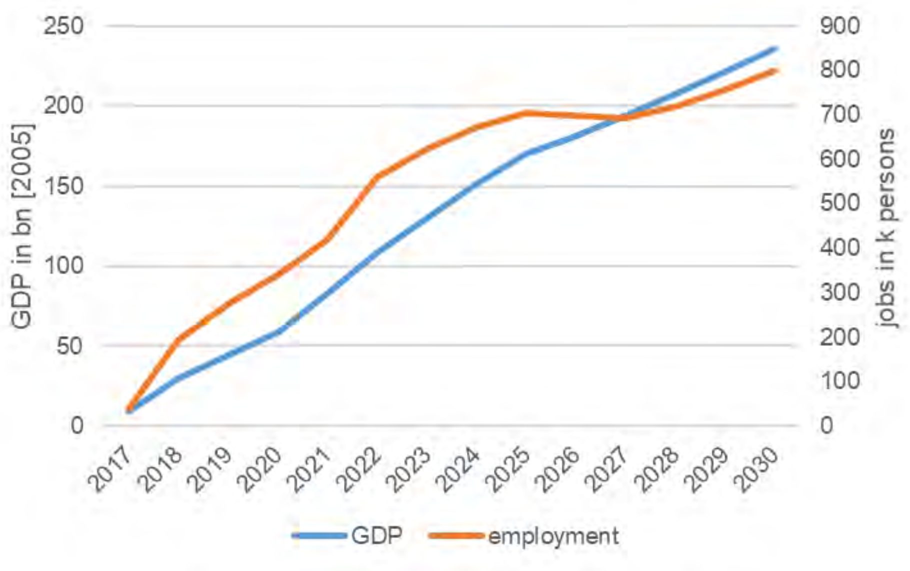
1. A transitional growth impact due to the demand shock associated with the direct demand impulses (additional investment in infrastructure), including the changes in demand by other sectors. Considering the discussion on terminology in the Annex

(section 10) this would represent the direct and indirect effects of the TEN-T investment.

2. A permanent increase in the level of GDP. This arises from the increase in the capital stock and the improved technology via higher investments. This is part of the second-round effects fostered by productivity growth as discussed in the Annex (see section 10).
3. A permanent impact on the rate of growth of GDP. This effect results from the gains in total factor productivity as well as induced effects from the changed consumption and business outlook from 1 and 2. Changes of consumption also occur from increased income as element of the second-round effects as discussed in the Annex (see section 10).

The time path of these three types of impacts is different. The bulk of the transitional growth impact due to the demand shock associated with the direct demand impulses occur primarily until 2025; but such impacts also take place post-2025. The second and third types of impacts occur gradually, at a later stage. Especially the permanent impact on the rate of growth of GDP mainly takes place post-2025 and continues to have an impact after 2030. Hence, it is not possible to split the impacts according to the three categories but it is usually possible to provide an indication on the main source of effects.

The completion of the TEN-T core network has positive economic impacts at EU28 level. Figure 34 displays the changes in GDP and employment in the Reference scenario relative to the Baseline scenario. While the difference in GDP between the Reference and Baseline scenarios is steadily rising from 2017 to 2030, employment shows more significant transition growth impacts.



Source: ASTRA model

Figure 34: **Impact of TEN-T core network implementation on GDP and jobs between 2017 and 2030**

Although GDP in Figure 34 grows steadily, the annual increase of GDP compared with the Baseline is higher during 2017-2025 relative to 2026-2030.

Table 28 shows the difference in GDP and employment between the Reference and the Baseline scenario for the years 2020 and 2030 for the EU15, EU13 and EU28.

In 2020 GDP for the EU13 is 1.9% higher in the reference scenario than in the baseline scenario. For the EU15 this difference is only 0.32% and for the whole EU28 thus 0.43%, as can be seen from Table 28.

The difference in employment in absolute numbers is reversed in 2020: As Table 28 shows for the EU13 that there are around 155 000 more full-time equivalent jobs in the reference scenario compared to the baseline scenario. This difference, however, translates in 0.4% more employment for the EU13 in 2020.

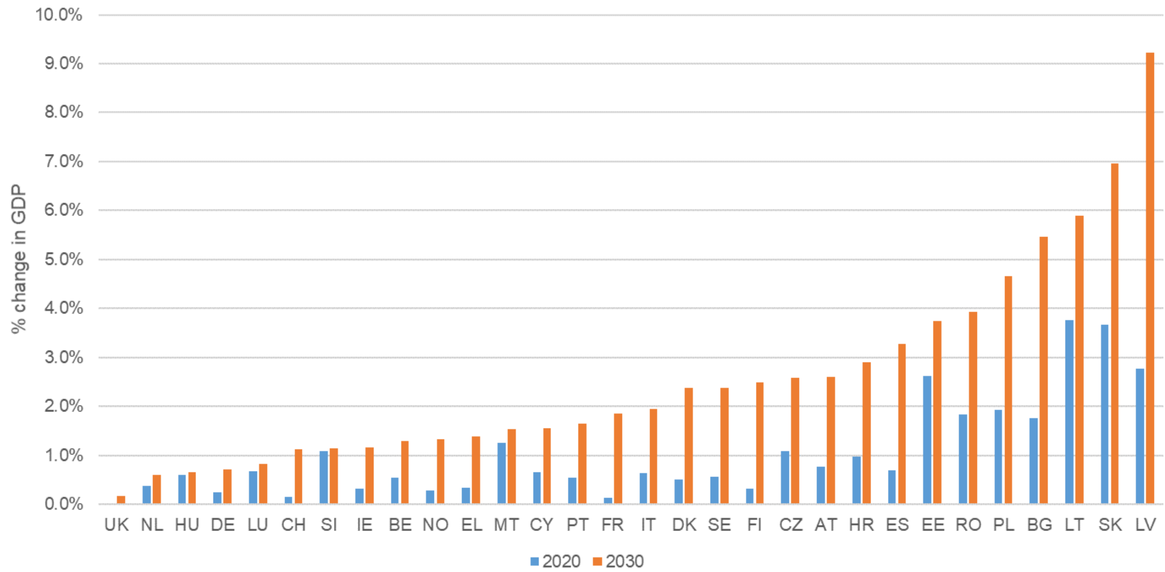
The EU15 in the reference scenario has around 185 000 more full-time equivalent jobs in 2020 than in the baseline scenario. In relative terms, this means 0.1% more employment for the EU15 in the reference scenario in 2020.

Table 28: Changes in the Reference scenario relative to the Baseline scenario for employment and GDP for EU15, EU13 and EU28

Changes in the Reference to the Baseline scenario	GDP		Employment	
	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

While in 2030 the difference in GDP for EU13 is 4.2% for the reference scenario compared to the baseline scenario and 1.4% for the EU15 (see Table 28), the growth path difference between the EU13 and the EU15 becomes smaller. That is to say, the MS of the EU15 seem to profit more from the impact types (2) and (3). Apparently, there is some convergence between the EU as a whole.



Source: ASTRA model

Figure 35: Changes in GDP due to additional TEN-T investments for each EU28 country

To reinforce this argument, one can draw on the breakdown of the country results as shown in Figure 35. The blue bars in the figure indicate the percentage changes in 2020 in the reference scenario compared to the baseline scenario and the orange bars show the changes for 2030. One can see that for many countries of the EU13 like Latvia, Slovakia, Lithuania, Bulgaria and Poland there are already significant GDP differences for 2020. For many of the EU15 like Italy, Denmark, Finland or Greece the changes in GDP from 2020 to 2030 are more substantial.

Latvia has 3.0% TEN-T investments relative to GDP in the period from 2017 to 2020, which is the highest share of TEN-T investments per MS. The share decreases for the next periods, but remains overall relatively high with an average of 2.0% for the whole period from 2017 to 2030. The data from this can be derived from Table 10.

Also, Slovakia has a high initial share of TEN-T investments of 2.4%, relative to GDP, for the period from 2017 to 2020. The share for the whole period from 2017 to 2030 for this country is as high as 1.2%.

Lithuania has an initial share of 1.6%, but the overall share for the whole period is 0.7%, meaning that second-round effects (or the impact types (2) and (3)) play a significant role for explaining the GDP difference in 2030.

The same statement can be repeated for Poland: The share of TEN-T investments in relation to GDP for the period from 2017 to 2020 is 1.0%. The GDP difference in 2020 is thus also steered by the indirect effects of the investment, which have a small time-lag compared to the induced effects and can still be captured by the impact type (1).

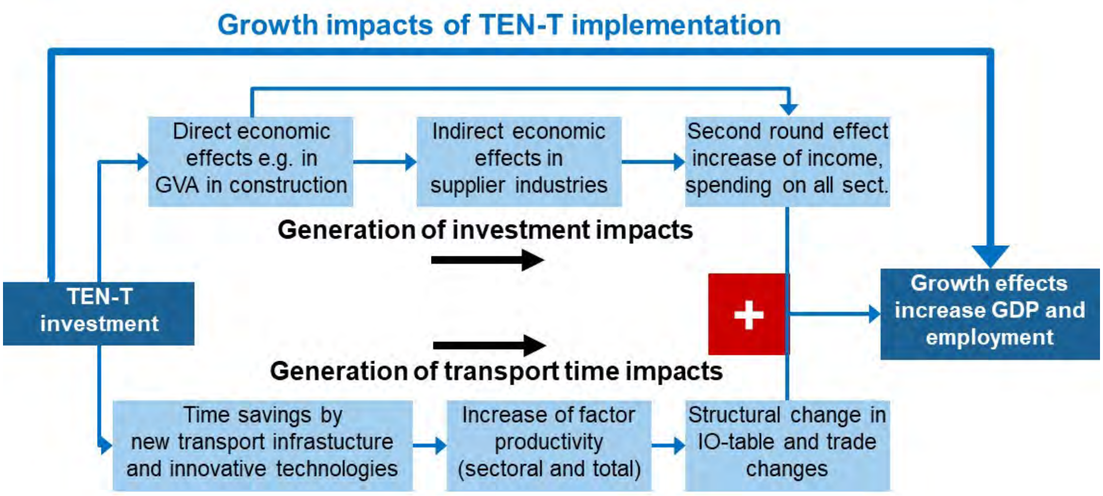
For two reasons it is important to report also the cumulated impacts of the TEN-T core network implementation over the period 2017 to 2030. First, the impacts of the TEN-T implementation occur over such a long period starting from the first additional investment in 2017 and ending at the time horizon of our analysis in 2030. In fact, the impacts even go beyond 2030, as is shown in section 5.4. Second, also the investment amount is quantified over the whole period and though it is distributed over 14 years the focus often is put on the total investment budget such that it is also strongly recommended to compare like-with-like to consider the total impacts of the investment. These are the cumulated impact of GDP and employment over 2017 to 2030. Table 29 present the cumulated impacts. In 2030 the cumulated increase of job-years amounts to 7,5 million additional job-years by the TEN-T investment out of which 4,5 million job-years accrue in the EU15 and 3 million job-years in the EU13.

Table 29: Cumulated impacts of TEN-T implementation on employment and GDP for EU15, EU13 and EU28

Changes from baseline to reference scenario	Cumulated GDP		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

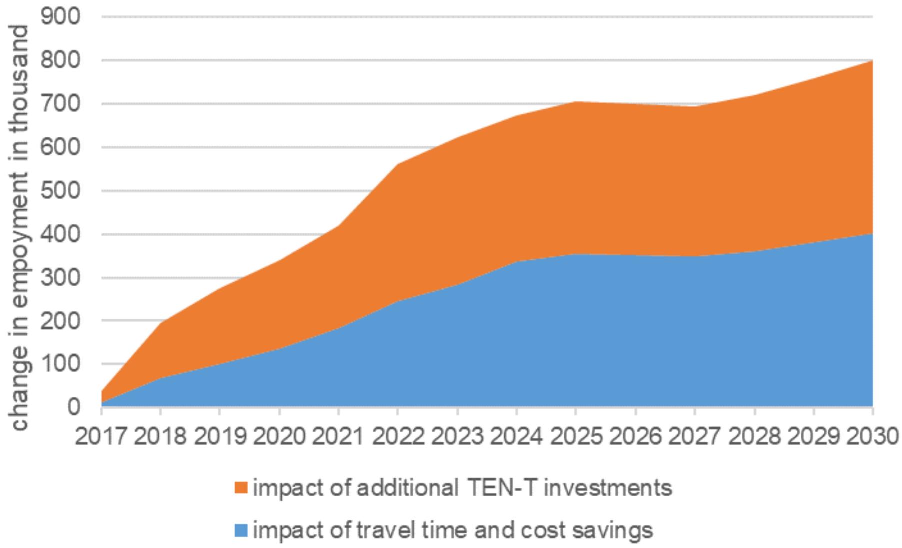
The analysis of economic impacts can be extended to capture impacts closer linked to the transport sector impacts. The impacts discussed so far comprise classical economic analyses of demand shocks, capital stock enhancement and total factor productivity growth (impact type 1, 2, 3 from above). The major impact of transport infrastructure improvement usually is reduction of travel times i.e. time savings. These travel time savings can be converted into (generalized) cost that affect the structure of the IO-table and the trade relationships. They can also be converted into average transport times that constitute one element of factor productivity in the different countries. This way of analysing separately the classical economic impacts of investment and the specific transport impacts on economic development is presented in Figure 36. Together the growth impacts of investment expenditures (upper chain of impacts) and the transport economic impacts (lower chain of impacts) generate the total impacts on GDP growth and jobs.



Source: M-Five

Figure 36: **Decomposition of growth impacts into impacts of investments and impacts of transport time and productivity**

In the real world the two impact chains can not be differentiated for several reasons. First, the two mechanisms are dependent on each other (i.e. no transport improvement without the investment). Second, there will be no transport investment without transport flow improvement as otherwise the project-based CBA would become negative as travel time improvements constitute one of the major benefits of any transport CBA. Thus a decomposition of impacts could only be undertaken by using a model in which either the impact chains can be included or excluded separately from the model or the impulses entering the model can be switched on and off separately. The latter was implemented using the ASTRA model and the decomposition results are presented in Figure 37.



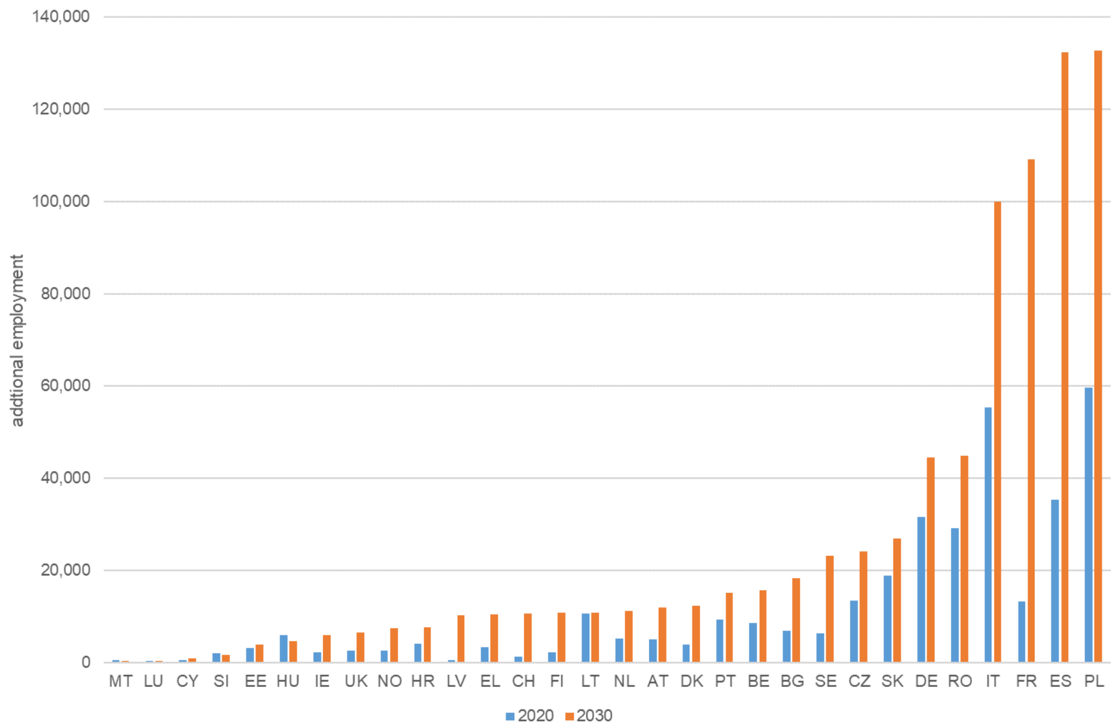
Source: ASTRA model

Figure 37: **Decomposition of investment and transport time/cost impacts on jobs in EU28**

Figure 37 shows the approximation of the investment expenditure impacts versus the transport impacts on jobs in ASTRA. Over time the balance between the impacts is shifting from the investment expenditures that in 2020 account for 60% of impacts towards the transport impacts, which increase from 40% of impacts in 2020 to more than 50% of impacts in 2030. It can reasonably be argued that this shift of impacts from an investment expenditure driven growth stimulus to a transport and productivity driven growth stimulus will continue such that in the longer run the transport side stimulus takes the lion share and the investment expenditure stimulus depreciates.

It should be taken into account that the travel time improvements computed by the TRUST model in 5-year intervals are linearly interpolated between 2020 and 2025. This should overestimate the time improvements in the initial years of the 5-year interval as improvements in the networks enfold synergies when more links are improved following rather an exponential pattern than a linear pattern. This should then also hold for the impact curve of time&cost savings.

The same breakdown for the MS as in Figure 35 for GDP is done in Figure 38 for employment. Employment is derived from gross production (or value added) and sectoral labour productivity. Employment changes are the result of the direct, indirect and induced effects and a mixture of the three impact types.

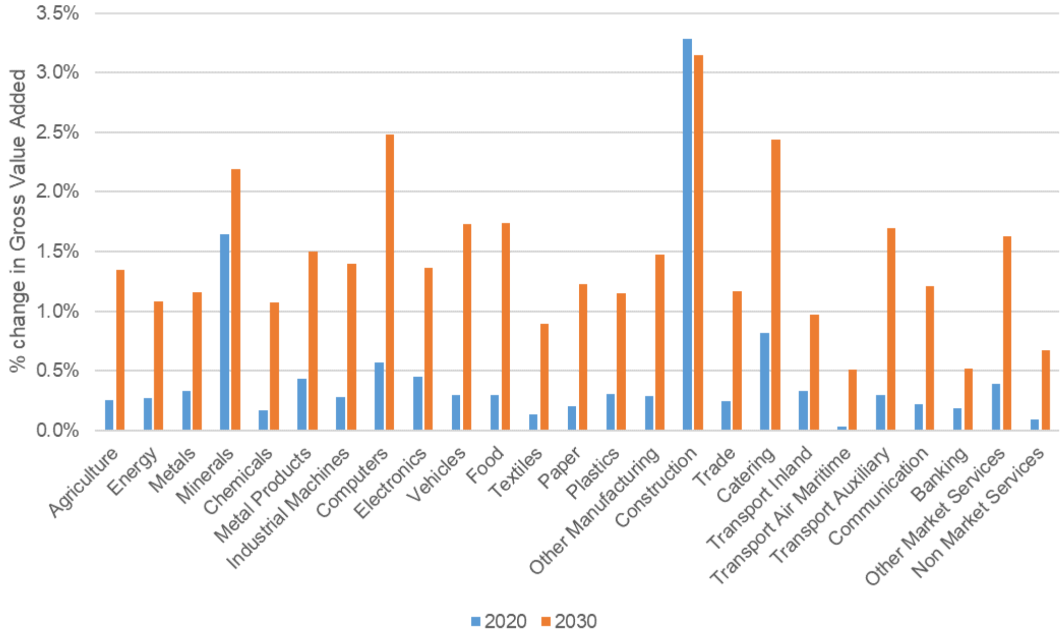


Source: ASTRA model

Figure 38: Jobs created due to additional TEN-T investments for each EU28 country

Figure 38 shows that in 2030 the bigger countries enjoy the largest employment gains. While the GDP difference with 4.7% in 2030 for Poland makes it the 5th biggest effect in this category, in absolute employment this translates to around 133 000 additional jobs in 2030. With GDP overall production rises and a larger country requires more employment in absolute terms than a smaller country.

The same argument holds true for Spain: In 2030 the country enjoys additional 3.3% GDP, which is the 8th biggest effect on relative GDP changes and this also results in around 133 000 additional jobs in 2030, which is due to the economy and working population in Spain being higher than that in Poland and that a larger number of jobs is needed to create GDP growth and a higher production.



Source: ASTRA model

Figure 39: Changes in Gross Value Added for EU28 due to additional TEN-T investments

Finally, Figure 39 shows the development of sectoral growth. While in the period up to 2020 construction is clearly the sector with the highest impact in Europe, the other sectors catch up in 2030 due to the impact types (2) and (3). While construction is also affected by the wider economic impacts, its relative importance in 2030 decreases.

5.4 TEN-T economic impacts beyond 2030

This paragraph focuses on the long term economic impacts until 2040 resulting from the additional TEN-T investments in the period 2017 to 2030. The documented results do not include additional investments over the period 2031 to 2040. Instead they project the longer-term effects of those scenario changes that happened over the period 2017 to 2030 for the subsequent 10 years period. The argument to carry out such an analysis is that by the TEN-T investment the economy is shifted on a higher long-term growth trajectory, which is actually confirmed by the following analysis.

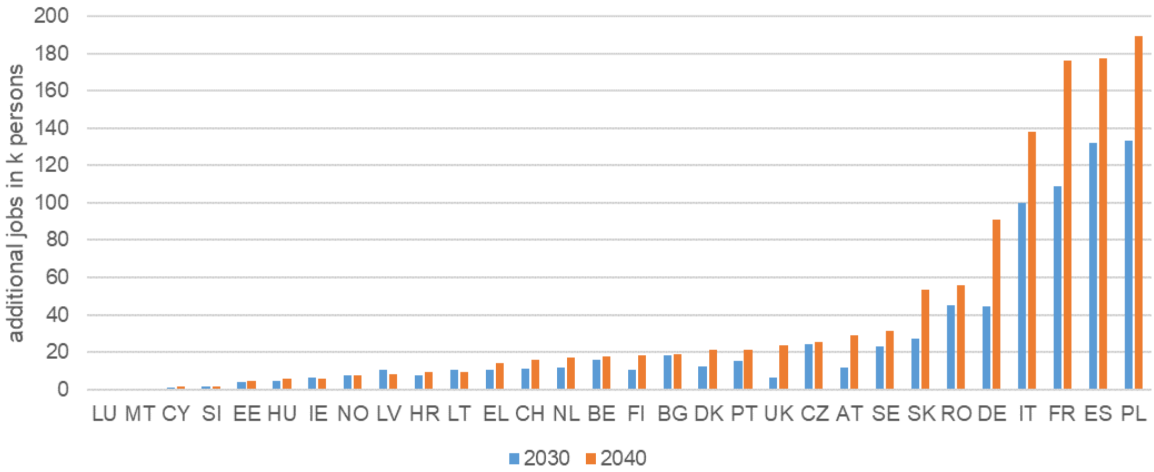
Table 30 provides an overview of the changes in employment and GDP in 2030 and 2040 in the EU13, EU15 and EU28. Overall GDP grows on average 2.6% in all MS by 2040. The relative GDP growth is in 2030 as well as in 2040 higher in the EU13 than the EU15. In the EU13 GDP is about 5.6% higher and in the EU15 2.3% higher in the reference scenario than in the baseline scenario in 2040. Due to the TEN-T investments there are close to 1.2 million additional jobs in the EU28 in 2040 of which 383 000 are located in the EU13 and 783 000 in the EU15.

Table 30: Overview of TEN-T core network impacts on GDP and employment for 2030 and 2040

	GDP		Employment	
	2030	2040	2030	2040
EU15	1.38%	2.27%	509 600	782 700
EU13	4.17%	5.61%	287 500	382 900
EU28	1.59%	2.56%	797 000	1 165 600

Source: ASTRA model

The analysis of the long-term growth trajectory can also be undertaken at the level of the MS. This is shown for the impact on employment. The impact of the TEN-T investments for the years 2030 and 2040 on employment for each MS are summarised in Figure 40. There are significant job increases in nearly all European countries in the period from 2030 to 2040. Especially in Germany, Italy, France, Spain and Poland there accrue large absolute employment effects in this period.



Source: ASTRA model

Figure 40: Impact of TEN-T investment on employment in 2030 and 2040

6 Findings on the core network corridors (CNC)

The corridor results are presented by the following three sections, describing first the transport results by CNC and the comparing the results across all CNC; then second with the same structure presenting the economic results by CNC and then across all CNC. The last section provides for a synthesis derived from the big picture of all single corridor analyses.

6.1 Transport impacts of CNC

The sections below provide transport results for the Core Network Corridor Scenarios. In these scenarios only the implementation of individual corridors are simulated, meaning that each scenario does not include the other 8 CNCs and the completion of the Core-Non-CNCs network.

Results are provided both at the network level from the TRUST model and at an aggregate level from ASTRA model. Network level results from TRUST are provided in terms of percentage change relative to a Baseline in 2030 of:

- Travel time by rail for passenger and freight.
- Travel time by road for passenger and freight.
- Operational cost by rail for passenger and freight.

Road operational costs remain basically unchanged across all scenarios. Travel time changes are provided as averages along some key corridors sections identified on the basis of representative Origin-Destinations (OD) pairs along the corridors covering the whole corridors length and connecting major network nodes and/or country borders.

TRUST model output in terms of variation of OD travel costs and time by road and rail modes were used as input for the ASTRA model to compute modal split changes determined by infrastructure improvement. ASTRA model works with a NUTS1 zoning system and therefore the most detailed results that can be provided by ASTRA are at NUTS 1 level.

ASTRA model results for the CNCs scenarios are provided at three different levels of aggregation:

- EU level results, which show the impact of the scenario at the European level by summing up the results for all Member States (i.e. EU15, EU13 and EU28).
- CORRIDOR COUNTRIES level results, which show the impact of the scenario by summing up only the results for the countries crossed by the corridor.
- CORRIDOR NUTS 1 level results, which show the impact of the scenario by summing up only the results for the NUTS 1 zones crossed by the corridor.

This choice is driven by the need to allow for the comparability of the effects at different scale.

Passenger (car, bus, rail) and freight (road, rail and inland waterways) transport activities are computed according to the territoriality approach. As the territoriality approach considers all the traffic running on the territory of a country, results for air and maritime modes are not computable under this approach. Results for these modes are provided at the European level in the next Section.

6.1.1 Transport impacts at the network level

The tables and charts below provide the average variation of travel time and costs for road and rail modes (for both passengers and freight demand) along all the CNC corridors relative to Baseline for different time horizons.

Data on travel time variations reported in Table 31 show that in the investments planned on CNCs are expected to benefit more rail freight performance than passengers' one with the Mediterranean corridor (-44.4%) benefiting more than the others for the reduction of freight travel time at 2030 followed by the Rhine-Alpine (-38.9%) and Atlantic (-36.7%). Other CNCs show a reduction of travel time ranging from -35.7% (Baltic-Adriatic) to -23.3% (North Sea-Baltic). The improvement for passengers' train travel time shows significant reductions for the Mediterranean (-30.0%), the Orient-East-Med (-27.2%) and the North-Sea-Baltic (-26.1%) corridors. Lower time gains in the range of -15.4% (Scan-Med) to -6.8% (Atlantic) apply to the other corridors.

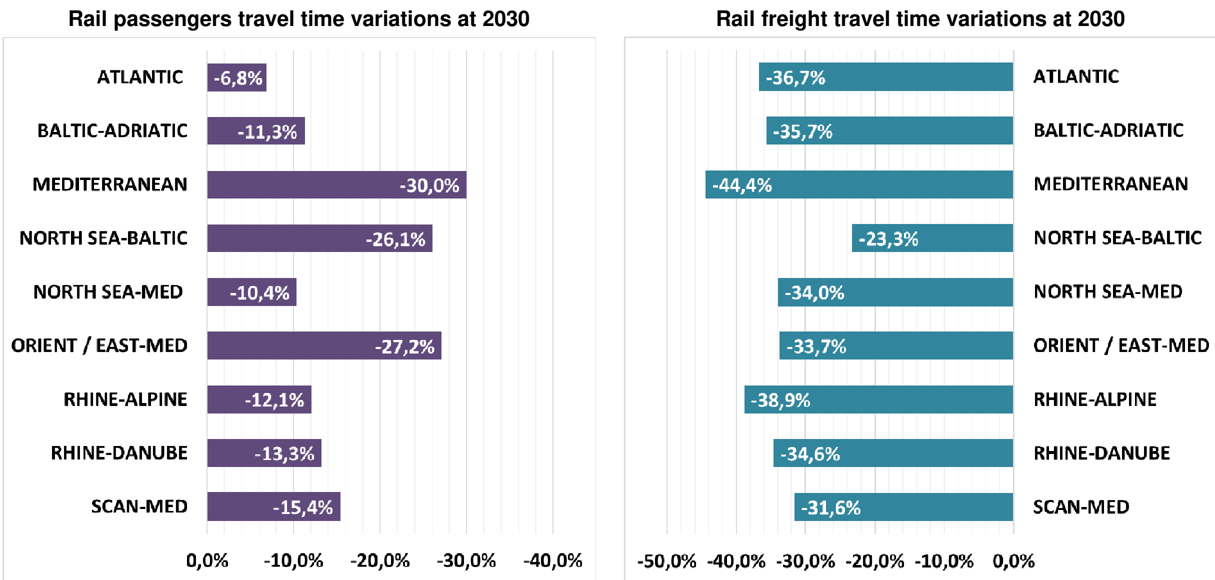
As already mentioned above, higher reduction of travel time for rail freight is the outcome of a combination of the impacts of infrastructure investments which increase operational speeds on the corridor(s) and of the impacts of a general improvement of the efficiency of the rail freight system following the removal of several barriers to freight trains circulation.

Table 31: Changes of travel time by rail for both passengers and freight in the CNCs scenarios relative to Baseline in 2030 – (% change to the Baseline)

	RAIL TRAVEL TIME % CHANGE	
CORRIDOR	Passengers	Freight
ATLANTIC	-6.8%	-36.7%
BALTIC-ADRIATIC	-11.3%	-35.7%
MEDITERRANEAN	-30.0%	-44.4%
NORTH SEA-BALTIC	-26.1%	-23.3%
NORTH SEA-MED	-10.4%	-34.0%
ORIENT-EAST-MED	-27.2%	-33.7%
RHINE-ALPINE	-12.1%	-38.9%
RHINE-DANUBE	-13.3%	-34.6%
SCAN-MED	-15.4%	-31.6%

Source: TRUST model

Variation on rail operational costs along the CNCs reported in Table 32 mirror the assumptions implemented for taking into account the ERTMS deployment over time.



Source: TRUST model

Figure 41: **Changes of travel time by rail for both passengers and freight in the CNCs scenarios relative to Baseline at 2030 – (% change to the Baseline)**

Table 32: **Change of rail costs for passengers and freight in the CNCs scenarios relative to Baseline – (% change to the Baseline)**

CORRIDOR	TYPE	RAIL COST % CHANGE		
		2020	2025	2030
ATLANTIC	Freight	-0.2%	-0.3%	-9.0%
	Passengers	-0.2%	-0.3%	-9.0%
BALTIC-ADRIATIC	Freight	-0.4%	-2.5%	-9.0%
	Passengers	-0.4%	-2.5%	-9.0%
MEDITERRANEAN	Freight	-1.3%	-2.1%	-9.0%
	Passengers	-1.3%	-2.1%	-9.0%
NORTH SEA-BALTIC	Freight	0.0%	-0.5%	-9.0%
	Passengers	0.0%	-0.5%	-9.0%
NORTH SEA-MED	Freight	-0.3%	-5.6%	-9.0%
	Passengers	-0.3%	-5.6%	-9.0%
ORIENT-EAST-MED	Freight	0.0%	-1.2%	-9.0%
	Passengers	0.0%	-1.2%	-9.0%
RHINE-ALPINE	Freight	-1.0%	-4.1%	-9.0%
	Passengers	-1.0%	-4.1%	-9.0%
RHINE-DANUBE	Freight	-0.1%	-1.1%	-9.0%
	Passengers	-0.1%	-1.1%	-9.0%
SCAN-MED	Freight	0.0%	-0.5%	-9.0%
	Passengers	0.0%	-0.5%	-9.0%

Source: TRUST model

Changes of travel time along the **road** CNCs for passengers and freight are presented in Table 33. It can be noted that road changes are less relevant than those observed for the rail network.

Table 33: Changes of travel time by road for passengers and freight in the CNCs scenarios relative to Baseline – (% change to the Baseline)

CORRIDOR	TYPE	ROAD TRAVEL TIME % CHANGE		
		2020	2025	2030
ATLANTIC	Freight	0.0%	-3.3%	-3.3%
	Passengers	0.0%	-4.7%	-4.7%
BALTIC-ADRIATIC	Freight	0.3%	0.6%	-2.7%
	Passengers	-2.4%	-2.7%	-4.1%
MEDITERRANEAN	Freight	-0.7%	-1.0%	-2.9%
	Passengers	-1.1%	-4.1%	-6.8%
NORTH SEA-BALTIC	Freight	-2.7%	-11.3%	-11.4%
	Passengers	-4.4%	-15.9%	-16.9%
NORTH SEA-MED	Freight	-0.2%	-0.2%	-0.3%
	Passengers	-0.4%	-0.4%	-0.5%
ORIENT-EAST-MED	Freight	-1.3%	-4.1%	-4.2%
	Passengers	-1.8%	-5.7%	-6.1%
RHINE-ALPINE	Freight	0.0%	0.0%	0.0%
	Passengers	-0.1%	0.0%	-0.4%
RHINE-DANUBE	Freight	-2.9%	-7.9%	-8.1%
	Passengers	-0.6%	-7.8%	-8.1%
SCAN-MED	Freight	0.0%	-0.1%	-0.1%
	Passengers	-1.8%	-1.9%	-2.1%

Source: TRUST model

The reduction of travel time at 2030 is higher on the North Sea – Baltic (-16.9% for passengers and -11.4% for freight, given the infrastructure investments on road connections between Warsaw and Baltic states capital cities) followed by the Rhine-Danube (-8.1% for passengers and freight) and the Orient-East-Med (-6.1% for passengers and -4.2% for freight). Other CNCs show smaller impact. Road operational costs remain substantially unchanged.

6.1.2 Transport impacts at the aggregate level

Change of passenger transport activity by car and rail (territoriality approach) in the NUTS1 regions crossed by the corridors for all CNCs scenarios relative to Baseline at 2030 are given in Table 34 and Figure 42.