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**Multi-criteria analysis in Territorial Impact Assessment: An application
of the TEQUILA model to the European transport policies case**

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Abstract

This paper aims at providing an in-depth assessment of the territorial and regional effects of EU transport policies.

Definition and operationalisation of territorial impacts are related to the concept of territorial cohesion, which we define as “the territorial dimension of sustainability”. Therefore, Territorial Impact Assessment encompasses impacts on the economy and competitiveness, on environment and climate change, on society and on landscape.

In order to attain a synthetic assessment of different impacts, impacts are defined not only as Single-dimension impacts but also as Summative impacts on the three macro-components of territorial cohesion - Territorial Efficiency, Territorial Quality and Territorial Identity - as well as on a generalized Summative Territorial Impact.

Impacts are assessed and computed at NUTS3 level through quantitative modelling by running the econometric simulation model Transtool built by DG Tren.

Results indicate that aggregate impacts on Territorial Efficiency and Identity are negative at the EU level whereas impact on Territorial Quality is generally positive throughout the EU regions. Finally, as to summative impact, all Old Member countries are negatively affected by the policy scenario considered, while all New Member countries are positively affected mainly thanks to both a positive impact on Territorial Efficiency and on Territorial Quality.

JEL codes: R15, R48

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1. Introduction: Territorial Impact Assessment and territorial Cohesion

The necessity of an in-depth assessment of the territorial and regional effects of EU sectoral policies and directives had already entered the European policy debate during the preparation of the European Spatial Development Perspective (1995-1999). Given the inherently multi-dimensional nature of the possible, intentional and unintentional, effects of the Union's policies, often going well beyond the single goals for which policies were conceived, the need for an integrated assessment came into full view. Furthermore, it was realized in that time that any integrated assessment should address multiple dimensions – the economic, the social, the environmental, the cultural – all of which represent distinct but interconnected aspects of what was increasingly considered as the 'territorial realm'.

In time, this mission became even more central in the EU policy debate. *The Third Report on Economic and Social Cohesion "A New Partnership for Cohesion"* (February 2004) introduced the general goal of "territorial cohesion", afterwards confirmed and institutionally strengthened through its inclusion among the main new goals of the Union in the Draft Constitution and the New Treaty. More recently, the *Territorial Agenda* of the Union (May 2007) and the First Action Programme (November 2007), as well as the *Green Paper on Territorial Cohesion* (October 2008), focussed explicitly on the issue of regional diversity, and emphasized the relevance of territorial and regional "uniqueness" for devising appropriate and diversified development strategies. These must be based on local specificities, knowledge and identity.

This last point is particularly relevant for the impact assessment debate: regional diversities imply, in fact, a different sensitivity to EU policy, justifying the increasing attention paid to this precise issue.

Very recently, the Commission itself produced a thorough and consistent document, taking a further step in the development and refinement of a growing tradition of impact studies of EU policies and directives (since 2002): the *Impact Assessment Guidelines* (January 2009) (SEC(2009)92). The general objectives of these guidelines are as follows:

- "to ensure that Commission initiatives and EU legislation are prepared on the basis of transparent, comprehensive and balanced evidence",
- to prepare "evidence for political decision makers on the advantages and disadvantages of possible policy options by assessing their potential impacts" through "the likely economic, social and environmental impacts of those options" (p. 4), both "intentional", i.e. referring to the very objectives of the policies, and "unintended"(p. 31);
- to improve "the quality of policy proposals by providing transparency on the benefits and costs of different policy alternatives" (p. 6).

The impact assessment in this case refers to the Union in aggregate terms, but a reference is explicitly made to the case in which impacts would "have a specific impact on certain regions" or "on single Member States" (p. 33).

Of course, the interest on regional differentiated impacts is central: impact assessment has to be made truly territorial, in order to activate counter-actions (or policy refinements) at all policy making levels, from the local to the EU one, in cases regional sensitivity and potential impacts are estimated to be too high.

In this paper, following Camagni (2006a, 2006b, 2009), we directly relate the relevance of and the application of TIA exercises to the concept of territorial cohesion, defined as the territorial dimension of sustainability. On elaborating this point further, we can envisage three main components/objective of territorial cohesion, namely:

- *Territorial efficiency*: resource-efficiency with respect to energy, land and natural resources; competitiveness of the economic fabric and attractiveness of the local territory; internal and external accessibility;
- *Territorial quality*: the quality of the living and working environment; comparable living standards across territories; similar access to services of general interest and to knowledge;
- *Territorial identity*: presence of "social capital"; capability of developing shared visions of the future; local know-how and specificities, productive "vocations" and competitive advantage of each territory.

From a positive point of view, these three dimensions constitute the pillar of territorial cohesion and may be reached through an integrated policy. From the normative point of view, they can represent the building blocks upon which a TIA methodology can be developed. In the remainder of the paper, we will firstly introduce, in Section 2, a renovated and advanced methodology for TIA, namely an augmented version of the original TEQUILA model developed by Camagni (2006a, 2006b, 2009). We will next describe the policy measure to be assessed (i.e. European Transport Policies) and introduce the criteria and indicators used in the assessment exercise (Section 3). In Section 4 and 5, we will comment on the findings coming out the application of the TEQUILA model to the policy measures under study and, in Section 6, we will extend our analysis by embedding the indications of the FLAG model into the TEQUILA model. In Section 7, we will draw the conclusions of the paper and advance further extension and use of the TEQUILA model.

2. Advances on the TEQUILA model and its operational package

To this end, we build upon and extend the TEQUILA1 model developed by Camagni (2006b, 2009). TEQUILA is an operational model aimed at assessing the territorial impacts of various policies. TEQUILA embraces an integrated approach to the assessment of territorial effects of (sectoral) policies. Relevantly, it directly links to the definition of Territorial Cohesion advanced in section 1, whose three main components, i.e. Territorial Efficiency, Territorial Quality and Territorial Identity, define the basic criteria of the assessment strategy.

More in details, the model relies upon a multi-criteria framework and is based on weighted summation of the three main components of territorial cohesion defined above. In fact, territorial impacts are so widely differentiated and touch so many different dimensions (economic, social, physical, environmental, cultural, ...), that a unique expression in monetary terms (such as in Cost-Benefit Analysis) looks impossible. This is also consistent with a large body of literature and practices, namely in strategic environmental assessment.

As in the previous version of the model (Camagni 2006a, 2006b, 2009) but going more in depth, the renovated and augmented TEQUILA2 currently provides impact assessment at two different levels:

- As *single-dimension impact* (SDI), that is on single impact indicators of the policy examined, ranging from economic growth to environment to social elements;
- As *summative impact* (SI), that is on three above-defined macro-components of territorial cohesion - Territorial Efficiency, Territorial Quality and Territorial Identity - as well as on a generalized Summative Territorial Impact. This assessment implies comparison, averaging and compensation among different impacts.

Similarly to the previous version of the model, territorialisation of potential impacts is produced by considering the following regional specificities:

- the *intensity* of the policy application may be different on different regions;
- the relevance of the different fields or "criteria" is likely to be different for different regions, according to their *utility function* (e.g. the same impact on employment may have a completely different meaning in an advanced and in a lagging region),
- the *vulnerability* of the different regions to similar "potential" negative impacts is likely to be different (e.g. an urbanised region is more vulnerable to a chemical catastrophe than a desert region)
- the *desiderability* of the different regions to similar "potential" positive impacts is likely to be different (e.g. an entrepreneurial region is likely to benefit more from public incentives to R&D than a "dependent" region),

The rationale for the "territorialisation" of potential impacts lies on a symmetry with the risk assessment procedure. As in risk assessment, where $risk = hazard$ (potential risk) \times *vulnerability*, here the territorial impact is the product of a *potential impact* (PIM) times a *sensitivity* indicator linked to the specificities of each territory.

For each SDI, Territorial impact (TIM) on each region r is defined as follows:

$$TIM_r = S_{r,c} \cdot PIM_{r,c}$$

Where:

TIM = territorial impact

PIM = potential impact of policy
 r = region considered
 c = criterion
 $S_{r,c} = D_{r,c} \times V_{r,c}$ sensitivity of region r to criterion c
 $D_{r,c}$ = desirability of region r to criterion c
 $V_{r,c}$ = vulnerability of region r to criterion c

For each Single-dimension impact, Territorial impact (TIM) on each region *r* is defined as the product of a Potential Impact - PIM (defined for each region using statistical indicators or a simulation model) times an indicator of Desirability - D (in order to take into account the fact that, for example, the same employment growth has a different priority in advanced and lagging regions) and an indicator of Vulnerability - V (in order to take into consideration, for example, the higher vulnerability of urban areas to pollution or of natural areas to landscape fragmentation).

In fact, the actual impact of a policy can differ across European regions, according to their internal characteristics (i.e. regions perceive differently single impacts). TEQUILA takes these differences in impacts into consideration by means of $S_{r,c}$ which is a vector of regional characteristics defining:

- the vulnerability of a region to single types of impacts ($V_{r,c}$);
- the desirability of the impacts for a region ($D_{r,c}$)

$S_{r,c}$ can then be specified as: $S_{r,c} = D_{r,c} \cdot V_{r,c}$. $D_{r,c}$ times $V_{r,c}$ together represent the *sensitivity* of the single regions to each typology of impacts. In particular, the greater the value of $S_{r,c}$, the greater the sensitivity (i.e. absorptive capacity) of region *r* to policy measures impacting on criterion *c*. Vulnerability refers to negative impacts and desirability to positive impacts¹.

In case of Summative Impacts, the TIMs are averaged through a weighted sum of impacts on different criteria *c* (e.g.: impacts on regional GDP, jobs, accessibility). This procedure is carried out in two steps: SDIs are summarized into the three macro-dimensions (TIM-Efficiency, TIM-Quality and TIM-Identity) which are in turn summed up into the general Summative Impact.

For each SI, Territorial impact (TIM) on each region *r* is defined as follows:

$$SI_r = \sum c \theta c \cdot TIM_{r,c}$$

where

θc are the weights of the single impact criteria

Various criteria (*c*) are included in the model to measure the impact of a policy on *Territorial efficiency*, *Territorial quality* and *Territorial identity*. Each category consists of three or four criteria and their definition and measurement units are specified in next sections. It is worth mentioning that the scores on these criteria, measured in different units, are integrated into the TEQUILA model by means of weights and normalisation processes by computing a region-specific value function that transforms the values of $PIM_{r,c}$ in a 0-1 interval.

The different components of TEQUILA 2 have been assessed by means of experts judgements. This applies especially to the value functions and the weight values of each criterion, as well as the $D_{r,c}$, and $V_{r,c}$ components of the model, in order to understand differentiated regional impacts (for example, advanced vs developing regions, eastern/ western/ southern/northern regions, urbanised vs rural regions).

Finally, the basic structure of the previous version of the model has been renovated in multiple directions.

In particular, two methodological aspects have been explored in depth and represent operational and methodological improvements with respect to the previous TEQUILA1 model:

¹ As a matter of example, let's think about a policy measure aimed at promoting education and occupation in S&T. This is highly desirable per se in all types of regions, however remote rural ones will benefit little of the returns to this investment (i.e. they are not vulnerable, receptive to this measure). On the other side, let's think about a policy measure entailing a cut in transfers from national or European funds. In this case, all types of regions will be highly vulnerable (i.e. receptive) but the measure considered is far less desirable for advancing regions than for developed ones because of their more limited financial autonomy.

1. the weighting system, which captures preferences on different policy priorities and goals. It represents a crucial part of any multi-criteria analysis as refers to values and political priorities felt by the concerned populations. It was built addressing both policy makers and sectoral policy experts².
2. value functions, which translate impacts (PIMs) expressed in their own units into values ranging between 0 and 1, according to the form of the value function. Sectoral policy experts have been consulted also to gather this specific knowledge.

A last very important innovation was included in the new model. In order to take into consideration the fact that some negative impacts (e.g. on environment), exceeding certain thresholds, cannot be compensated by some other positive impacts, for example on economy, an appropriate model was used, the FLAG model, and applied to two different kinds of impacts of transport policies (emissions and congestion). In this case, for the regions in which an excessive impact is shown, compensation and weighted summation with other impacts is not allowed and the map describing the impact will show a “flag”.

The TEQUILA model is implemented through an Interactive Simulation Package (SIP) that presents the following characteristics (Camagni, 2006a and 2009):

1. interactive, and therefore directly usable during a public presentation and discussion;
2. easy to built and to be applied;
3. transparent in its basic assumptions;
4. flexible in the definition of basic parameters and in the form of the algebraic functions;
5. potentially useful for the assessment of different European policies.

Also the previous TEQUILA SIP has been reconsidered and enlarged in TEQUILA 2, specifically in two main directions:

1. it considers both impacts on single dimensions (economy, society, environment and climate change) and summative impacts (on territorial efficiency, quality and identity);
2. it integrates mapping procedures directly inside the computational machine, in order to avoid transfer procedure from a statistical elaboration tool to the mapping tool. Results of the assessment procedure are fully automated and integrated into a unique software package, allowing instant simulations and mapping in a way that could be useful for direct interaction with scientists and policy makers.
3. it enables to change the weighting system (i.e. the relative importance of the single impacts) and to explore changes arising from different preferences concerning the relevance of policy goals.

The test-bed of the newly augmented TEQUILA model is the European transport policy as updated by the decisions of the Commission (2006, 2007) with respect to those of the Van Miert Report (2003) taken into consideration by the previous TEQUILA exercise (Camagni, 2009) with a specific focus on two types of measures: infrastructure and regulatory policies (i.e. “transport pricing”).

The next section describes the policies to be assessed and the criteria and related indicators used in the TIA test.

² Weights to be attributed to each impact criterion and macro-criterion can be interpreted as relative preferences and priorities. Sectoral experts have been consulted in specific meetings and policy-makers through a questionnaire delivered at the ESPON Prague Conference in June 2009.

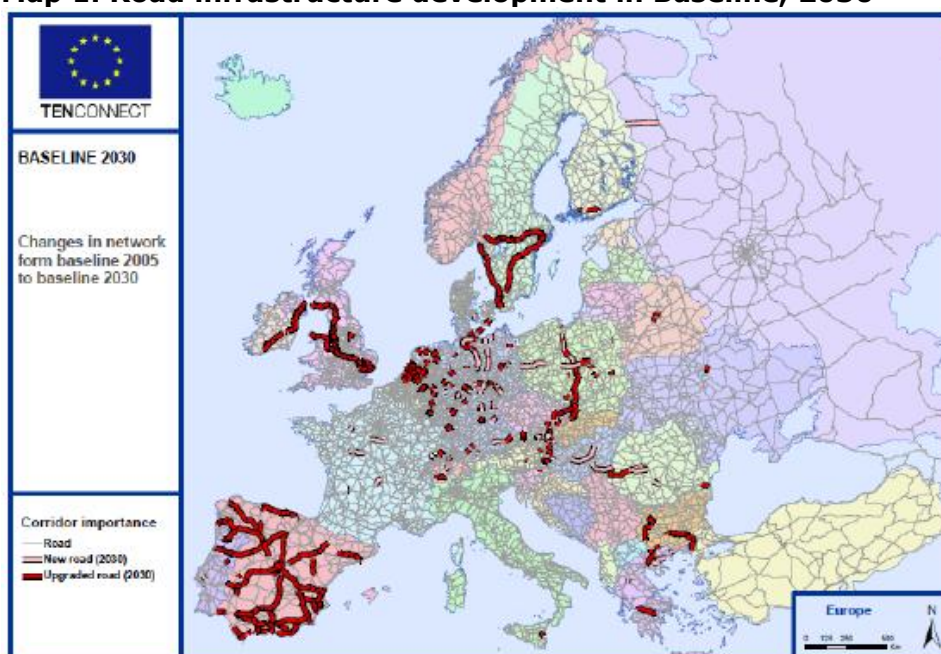
3. EU Transport Policy: scenarios, impact criteria and related indicators

Infrastructure networks to be assessed include the new priority project road network, railways dedicated to freight traffic, railways dedicated to passenger traffic, airports and ports. Networks cover EU-27 plus Norway, Switzerland, Liechtenstein, and Iceland.

The first policy scenario to be assessed is the *Baseline 2030* as defined in TRANSVisions study (DGTREN, March 2009)³. The Baseline scenario assumes as policy framework the Revision of Transport White Book 2010-2030. This means that the Priority projects already defined are supposed to be completed in the horizon year 2030. Internalisation of external transport costs is applied according to PO2C scheme (congestion, noise and air pollution for trucks). Transport costs change differently according to each mode, with a significant reduction for rail freight as liberalisation continues and costs for selected corridors are taken down.

In the *Baseline Scenario* (scenario a in maps), links which have been constructed between 2005 and 2008 and links, which are currently under construction or already planned for construction are considered. Therefore, the baseline is a conservative estimate of what could be accomplished. The roads indicated on the maps are road projects improving the main road network. Two different types of road works are foreseen, namely new construction and changes of existing infrastructure. Most of the changes are related to roads changing class or speed.

Map 1. Road infrastructure development in Baseline, 2030



The second scenario is an *Infrastructure Enhancement* one (scenario b in maps), where policies are oriented towards new infrastructure provision. It is based on a High Growth 2030 scenario as defined in TRANSVisions study. In this case, a more comprehensive infrastructure development than foreseen in the baseline is assumed. The 30 priority projects defined in 2003 by the Van Miert Report are assumed to be completed as well as a number of other projects of relevance to European cohesion. These developments are mainly located in Eastern Countries. The main objectives of this policy are improving cohesion, accessibility and reducing congestion by completing all the TEN networks and pan-european corridors that are not included in the priority projects, many of them in Eastern Europe and including axes for Peace

³ The baseline scenario refers to year 2030; it is developed by exploiting the TRANSTOOLS model within the policy framework of the Revision of Transport White Book 2010-2020 and the Green Book on TENs revision.

and Development. However, as this policy has the effect of increasing total traffic, it is assumed that a higher renewal of the car fleet will be enforced so that average emission ratios are lower. This target can be achieved by banning the presence in roads of old vehicles and by enforcing legal limits of emission ratios in newly manufactured vehicles. No other changes are introduced compared to the Baseline.

The third scenario is a *Regulatory and Pricing Scenario* (scenario c in impact maps), based on Low Growth 2030 as defined in TRANSVisions study, characterised by a low economic development further emphasized by a negative population development. Low growth occurs because of increasing costs of energy, particularly oil. Europe's answer to the increasing energy costs is mobility reduction in terms of higher operating costs which reflects the high energy prices. Policies in this scenario are oriented towards taxation, internalisation of transport externalities, and putting incentives for a modal shift towards rail.

The Pricing scenario is focused on changes in the costs and prices of the different transport modes, taking the Baseline as a starting point. The main policy applied is a generalisation of internalisation costs to road passenger transport, while at the same time the PO2C scheme is expanded to incorporate an extra charge in motorways. Moreover the transport costs are increased in relation to baseline to encourage modal shift and a global reduction of mobility. As road modes are the most heavily charged by both costs and internalisation, a change towards rail and maritime modes is expected on this scenario.

Of what concerns transport pricing, in the Pricing Scenario research and development initiatives are in line with the baseline, but fuel cost for passenger cars is expected to be 20 % higher than in 2005, in constant 2005 prices. Also, distance based transport costs for heavy goods vehicles is assumed to increase 10% in constant 2005 prices.

Additionally, the network is assumed to be the same as in the baseline scenario. However, cost recovery for heavy goods vehicles is being anticipated in the Vignette countries. In the Pricing scenario the introduction of the cost recovery is assumed as a necessity in order to carry out necessary maintenance and reconstruction of the network under low growth conditions. Internalisation is anticipated at the slightly higher level than in the Baseline scenario (i.e. internalisation of noise, air pollution and congestion has the same values per km as indicated in the Baseline scenario plus an increase of 0,04euro/km). Passenger rail fares are expected to be the same as in the Baseline scenario. For rail freight the rail transport costs are assumed to increase mainly because the improvements in rail technology and cross border operations are not advancing as fast as in the Baseline scenario. An increase of rail transport costs of 6% has been assumed.

The air transport industry is supposed to be under strain because of high oil prices and a slow economic development. In order to ensure profitability of the business the 2005 air fares are assumed to increase 20% in real terms. The transport costs of freight transport by inland waterways are unchanged compared to the Baseline scenario. Also, maritime transport are supposed to develop along the same path as truck transport, i.e. maritime transport costs is assumed to increase 10% in real terms.

Policy intensity in each region (NUTS3) is defined considering the new infrastructure links passing through each region's territory, determining an increase in generalised accessibility. Intensity of pricing and regulations policy is attributed to regions with the intensity indicated in Table 1 in Annex I, determining transport costs and emissions proportional to the traffic which is forecasted.

TRANS-TOOLS, official DGTREN forecast model has been used to move from policy scenarios to the assessment indicators defined in Table 1 below⁴. The three components of territorial cohesion, namely territorial efficiency, territorial quality and territorial identity represent the main macro-criteria for SI, although each single sub-component has been inspected *per se* as SDI. Within each macro-criterion a number of criteria have been identified, and their relevance and their link to the policy measure being examined is explained below.

⁴ Logical chains from policy scenarios to impacts are incorporated into the general logics of the TRANS-TOOL model. For further details on TRANS-TOOL see AnnexII.

Table 1. Impact criteria and related indicators in territorial impact assessment⁵

Macro criteria	Variable	Criteria	Definition	Type	Measurement	Unit of measure
TE Territorial Efficiency	PIM_E1	Productivity of inland transport infrastructure	Productivity of inland infrastructure	Benefit	total traffic/km road and rail	passenger and tons / km
	PIM_E2	Productivity of airports	Productivity of airports	Benefit	pax noEU/ total pax	dimensionless
	PIM_E3	Economic growth	GDP per Capita	Benefit	GDP variation including the marginal increase due to new infrastructure	€/capita
	PIM_E4	Congestion costs	Congestion cost	Cost	time on congestion/total time	dimensionless
TQ Territorial Quality	PIM_Q1	Traffic passing through	Road freight crossing the region borders	Cost	non-intraNUTS2 road freight traffic/total freight traffic (no internal)	dimensionless
	PIM_Q2	Emissions	CO2 emissions per usable land	Cost	Road emissions for cars and trucks in MtonnesCO2 / usable land	million Tonnes CO2 / km2
	PIM_Q3	Safety	Traffic separation in different infrastructure levels	Benefit	traffic on motorways / (traffic 2-lane road + traffic on motorways)	dimensionless
	PIM_Q4	Market opportunities	Market potentially accessible	Benefit	GDP at less than 3 hours (multimodal)	million €
TI Territorial Identity	PIM_I1	Landscape fragmentation	Density of high capacity road and rail infrastructure	Cost	km of motorway + km of 2track rail / surface (km/km2)	km/km2
	PIM_I2	Exposure to external visitors	External passengers (outside the region) at more than 3h	Cost	All passengers reaching the NUTS3 at more than 3h	passengers
	PIM_I3	Regional integration	Regional road connectivity	Benefit	average time by road to other NUTS3 capitals in the same NUTS2 (inverted)	time in hours

With reference to the experience of the first version of the TEQUILA model (Camagni 2006a, 2006b, 2009), some changes were introduced in the present project concerning the impact criteria (see Table 1 above). The main differences refer to:

- The inclusion of productivity of infrastructure and airports in Territorial Efficiency;
- The inclusion of congestion costs in the Territorial Efficiency macro-criterion;
- The inclusion of freight traffic passing through regions, and of accidents/safety in Territorial Quality;
- The exclusion of an indicator of "Creativity" in the Territorial Identity criterion, judged too weak;
- The inclusion of an indicator of globalisation in Territorial Identity (I2: exposure to external visitors)⁶.

Territorial Efficiency

Impact on Productivity of inland transport infrastructure (PIM_E1)

1. The road and rail infrastructure length (km) is calculated summing up all road and rail links in a region assumed in each scenario. TRANSTOOLS graphs cover major national and regional links.
2. The increase in road and rail infrastructure induces a reduction in transport costs, due to lower length and travel times between NUTS3 capitals.

⁵ The main source exploited to compute impact indicators is the TRANSTOOL model developed within the TRANSVISION study.

⁶ Impact indicators were firstly indicated by sectoral experts and next discussed by the research consortium in charge of carrying out the ESPON – TIPTAP project through extensive interactions and discussions. This differs from and represent an improvement upon the first version of TEQUILA indicators and model.

3. As a result of relative lower transport costs, trip distribution between NUTS3 capitals and modal split change, leading to new traffics on the networks.
4. Productivity of inland transport infrastructure in each NUTS3 region is defined as a ratio between total road and rail traffic (vehicle-km) and total length of road and rail infrastructure.
5. A higher productivity ratio indicates a better use of available infrastructure and thus is considered as a benefit for the region.

Impact on Productivity of airports (in relation to external trips) (PIM E2)

1. The total air passengers in each airport are calculated using TRANSTOOLS forecast model.
2. Variations on GDP and population in each region are obtained using the econometric submodel CGEurope.
3. The attractiveness of each region to external EU business and tourist trips changes according to GDP and population.
4. Productivity of airports is calculated in each NUTS3 region as a ratio between extraEU air passengers over total air passengers, by adding figures of all airports in the region.
5. A higher productivity ratio indicates more attractiveness of the region to external trips, encouraging more economic development and thus is considered as a benefit for the region.

Impact on Economic growth (PIM E3)

1. Impact on economic growth in each region is defined for each scenario. Economic growth is measured as GDP per capita.
2. CGEurope submodel calculates the marginal increases in GDP due to the presence of new transport infrastructure, including spill over effects from neighbouring regions.
3. Economic growth is considered as a benefit for the region.

Impact on Congestion cost (PIM E4)

1. New infrastructures change transport costs.
2. Variations in transport costs change locational choices, trip distribution, modal split and total traffic volumes.
3. Traffics on road network are used to compute congestion using flow-speed curves on each link.
4. Congestion cost is defined as the number of daily hours driving on congestion on one day in each link.
5. A higher congestion level is considered as a cost and has a negative impact on the region.

Territorial Quality

Impact on Freight traffic passing through (PIM Q1)

1. TRANSTOOLS model calculates freight matrices for a given scenario. The model works at NUTS2 level for freight.
2. Matrices are assigned on the networks.
3. Vehicle-km is computed for each NUTS2.
4. Traffic passing through is defined as the ratio between freight vehicle-km with origin or destination outside the NUTS2 over total freight traffic in the region.
5. Traffic passing through is considered as a cost.

Impact on Emissions (by road traffic) (PIM Q2)

1. Road passenger and freight matrices are assigned to the road network for each scenario.
2. According to the average speed in each link and the number of vehicle-km, the CO2 emissions are calculated using standard speed-emission curves, representative of the average EU27 fleet.
3. Total emissions inside each NUTS3 are summed up and divided by the surface of the region (usable land).
4. An increase in the density of CO2 emissions is considered as a cost.

Impact on Safety (PIM Q3)

1. New road infrastructures are introduced in the TRANSTOOLS graphs.

2. Road matrices are computed and assigned on the network.
3. All vehicle-km in the roads of each NUTS3 is summed-up.
4. Safety is defined as the ratio between traffic on roads with separate lanes over total traffic, given that roads with separate lanes have a much lower accident incidence.
5. An increase in Safety is considered as a regional benefit.

Impact on Market opportunities (PIM Q4)

1. TRANSTOOLS model computes the GDP in each NUTS3 region.
2. TRANSTOOLS graphs are used to compute travel times between NUTS3 capitals using different transport modes, taking into account congestion on road.
3. For each NUTS3 region, the GDP of other regions at less than 3 hours travel time is summed up (including the own GDP). 3 hours is the average maximum time limit to make a daily round trip.
4. More GDP at 3 hours implies more chances to boost the regional economy and thus it is considered as a benefit.

Territorial Identity

Impact on Landscape fragmentation (PIM I1)

1. Landscape fragmentation in each region is computed by dividing the total length of motorways and 2-track rails over total regional surface.
2. Only high capacity infrastructures are considered because they are the ones having the highest barrier effect on the environment.
3. Higher fragmentation is considered as a cost.

Impact on Exposure to external visitors (PIM I2)

1. TRANSTOOLS graphs are used to compute travel times between NUTS3 capitals using different transport modes, taking into account congestion on road.
2. All passengers arriving to a NUTS3 capital at more than 3 hours distance are summed up.
3. Visitors at more than 3 hours of travel time are considered as a cost.

Impact on Regional integration (PIM I3)

1. TRANSTOOLS road graph is used to compute travel times between NUTS3 capitals, taking into account congestion.
2. Average travel time between NUTS3 capitals inside the same NUTS2 is calculated.
3. A reduction on average time is considered as a benefit.

4.Key findings on Single Dimension Impacts

Impacts are first of all calculated on single dimensions (SDIs), giving answer to a series of general questions such as: a) Which impact on the economy and competitiveness? b) Which impact on society? c) Which impacts on environment? d) Which impacts on climate change? e) Which impacts on landscape and territorial identity? Accordingly, SDIs are presented under the form of:

- a. impacts on the economy
- b. impacts on competitiveness
- c. impacts on society
- d. impacts on environment and climate change
- e. impacts on landscape and local identities

Of course, single impacts may refer to multiple dimensions: for example congestion is both an element of territorial competitiveness and quality of life of the local society. We have allocated single impacts to their priority class according to our judgement, but of course impact measures are open to other interpretations.

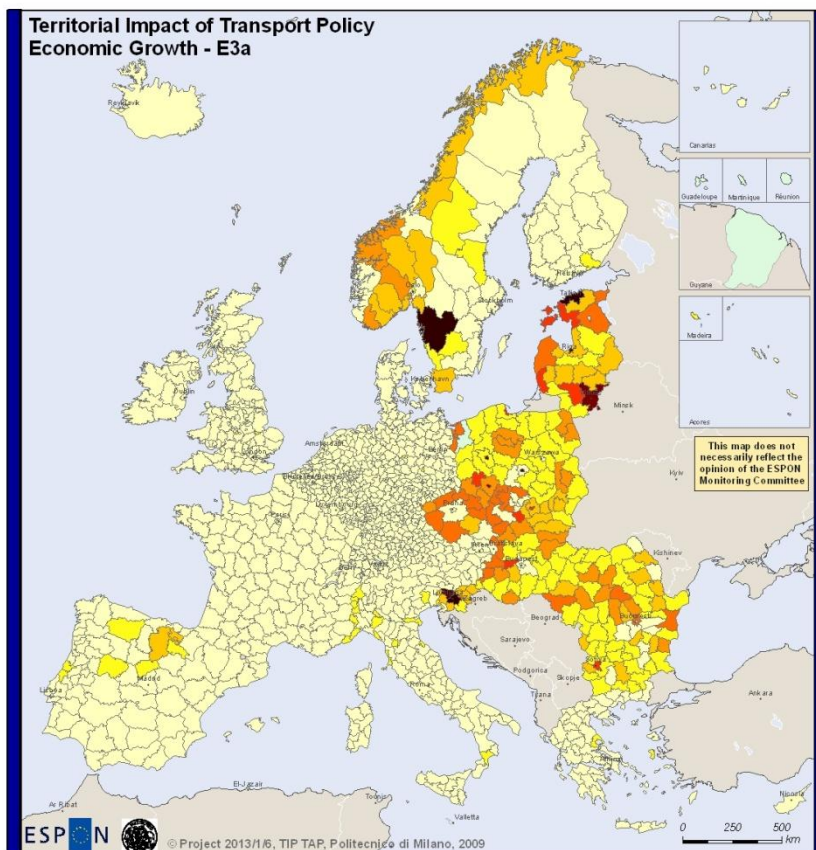
Comment and interpretation of results directly compare the outcomes of the three scenarios: Baseline (a), Infrastructure Enhancement (b), and Pricing (c).

Impacts on the economy

The first indicator in this case is impact on economic growth (E3a, Map 2). In the baseline scenario a generalized positive impact, though limited, is found throughout Europe, thanks to a sufficiently spread out new infrastructure provision and to processes of growth diffusion. An increase between 2005 and 2030 ranging around 25.000 euro per capita (see PIM_E3) will be relatively less appreciated in rich regions, while more important impacts will show up in eastern countries. Most relevant positive impacts will touch:

- capital city regions in central-eastern Europe: Vienna, Bratislava, Tallinn, Riga, Vilnius, Bucuresti, Sofiya,
- border regions, benefiting from lowering of international institutional barriers: the areas of Pécs, Nova Gorica, Stettin, Timisoara, Katowice-Krakov, the entire south-western Poland, the entire western border of Czechia,
- big and medium city regions at the crossroad of, or along the new important transportation axes: Poznan, Lodz, Ostrava, Brno, Linz and Graz,
- port and maritime areas: Dantzig, Umea, Trieste, Koper, Costanza, the entire coast of the three Baltic republics.

Map 2. Territorial Impact of Transport Policy on Economic Growth (E3a)



In most of these areas, new infrastructure provision will represent quantum jumps with respect to previous accessibility conditions; moreover, these increases will be highly desirable given the lagging conditions of these areas in economic terms. It looks relevant to highlight the emerging reality of a new central European macro-area, encompassing southern Poland, Czechia, eastern Austria and western Slovakia and Hungary, around the crossroad between a north-south axis (Dantzig – Vienna) and a east-west axis Munich – Vienna – Budapest – Costanza.

Passing to the Infrastructure Enhancement scenario (E3b), a more varied outcome emerges. Countries where new infrastructures are envisaged – like Spain, Italy, Greece and UK – still show an (extra) positive impact on GDP in almost all regions. In New Member states, important benefits will come to Czechia (thanks to both road and rail improvements), Hungary (mainly rail improvements), Bulgaria, Estonia and Lithuania (mainly road improvements). In aggregate, European terms, the improvements in GDP per capita will be modest. In the Pricing Scenario (E3c) more peripheral countries will lose (but also France apparently will) and more central countries will gain (but also UK, Greece and Finland will).

A second impact indicator concerning economic structure refers to (intra-)regional integration (I3a), an indicator that is also relevant for enhancing local identity. Increases are visible only in those countries in which present infrastructure engagement is higher, namely Spain and Germany. Other positive impacts are visible along the Tyrrhenian coast in Italy, along the Paris-Nantes-Bordeaux axis, interested by the new high speed train line, and the axis moving southward of Warszawa. Eastern countries in general show negative impacts, as a result of increasing congestion on main intra-regional links which are not sufficiently upgraded. On the other hand, this condition of New Member countries is due to change in the Enhanced Infrastructure scenario (I3b), where consistent positive impacts on internal integration show up, particularly in Romania and Bulgaria but also in the Baltic Republics, north-eastern Poland and Slovakia. Among Old Member Countries, Portugal, UK and south-western Sweden show some positive impacts.

Interestingly enough, the Pricing scenario appears very advantageous for most EU regions in terms of internal integration, with the highest positive impacts in eastern countries, Ireland and UK, but also in Spain, Portugal, Northern Italy, south-western France (I3c), probably thanks to reductions in congestion on roads.

Impacts on competitiveness

Productivity increases on infrastructures, measured by increase in traffic/km, and reduction of congestion costs may be rightly interpreted as contributing to territorial competitiveness. Concerning the productivity indicator on inland traffic infrastructure (E1a), a generalized increase shows up, particularly intense along some major transportation axes in eastern countries (as the Warszawa-Krakow axis, and its continuation from Vienna to Gyor) and around some of their major urban areas (Dantzig, the Trieste-Koper integration area, Ljubljana, Bucuresti and Sofiya). Some productivity reductions also show up in some rare, scattered areas. Similar positive results are shown by the airport productivity indicator (E2a), where major increases concern French and British regions, but in particular main increases apparently concern second and third level airports.

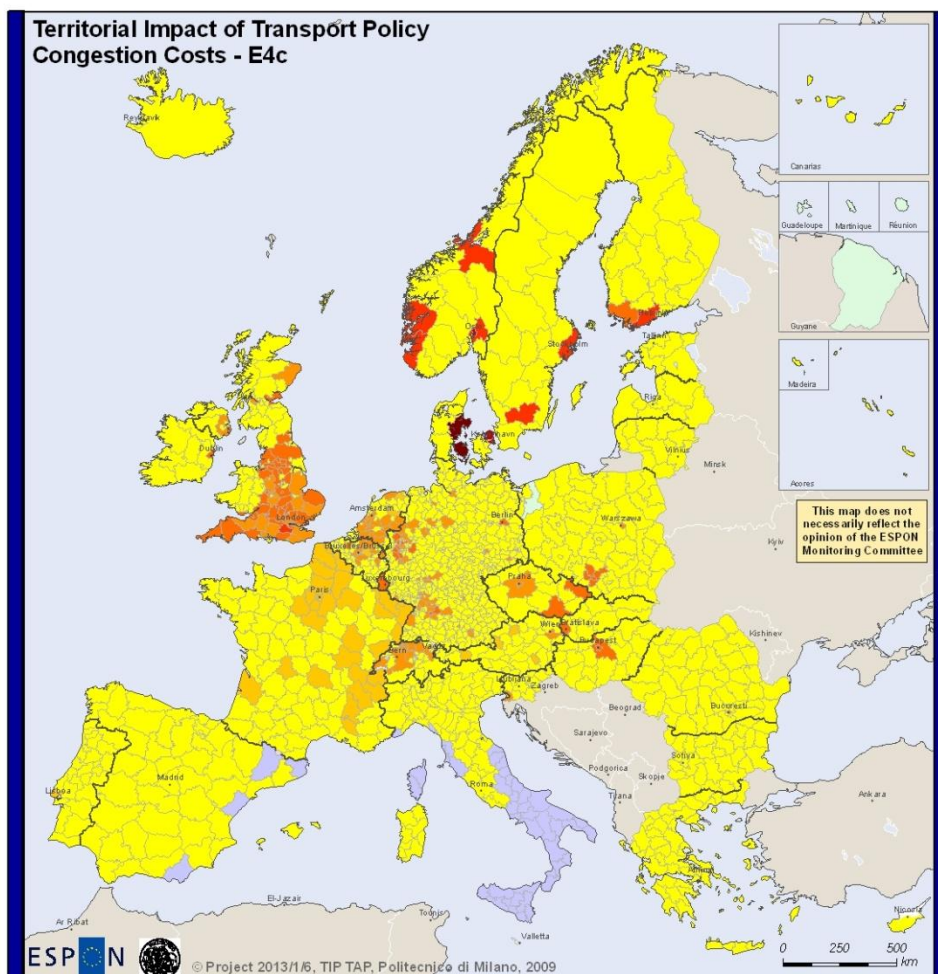
Opposite results are of course pointed out by the congestion indicator (E4a), where the negative sign is pervasive, in particular in many major northern metropolitan areas (the entire England and London in particular, København, Malmö, Stockholm, Helsinki, Amsterdam and Rotterdam, many areas in Westfalen, Berlin, Warszawa and Praha).

Considering the Infrastructure Scenario, an increase in network productivity with respect to the baseline scenario is confirmed (E1b), especially in main eastern corridors, while airport productivity (E2b) still concerns, in the positive sense, not really big airports but second and third level airports (e.g., Florence, Pisa, Brescia, Naples, Sassari and Brindisi in Italy), especially in countries like Germany and Portugal. Concerning congestion (E4b), this scenario

brings strong support to eastern countries, northern countries like Sweden, Germany, Denmark, and southern countries like Greece and Portugal.

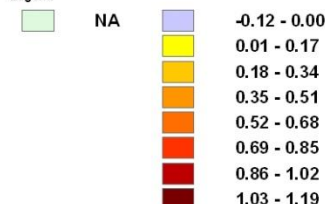
Interesting results come also from the Pricing scenario. Regulatory and pricing measures will overall reduce traffic per km on the entire network (E1c), increase air traffic (E2c) in areas characterized by congested transport networks (western German regions and Dutch regions, London, Milan, Rome) or by huge distances from the European barycentre (Lisbon, Ljubljana, Budapest, Praha, Bucuresti, Sofiya). Interestingly enough, pricing policies will reduce congestion overall and in particular in already heavily congested areas; exceptions regard mainly southern Italian and a few Spanish regions (E4c, Map3).

Map 3. Territorial Impact of Transport Policy on Congestion Costs – E4c



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Legend



Regional level: NUTS3 (2006)
Source: EUROSTAT, ESPON database
Origin of data: own calculation

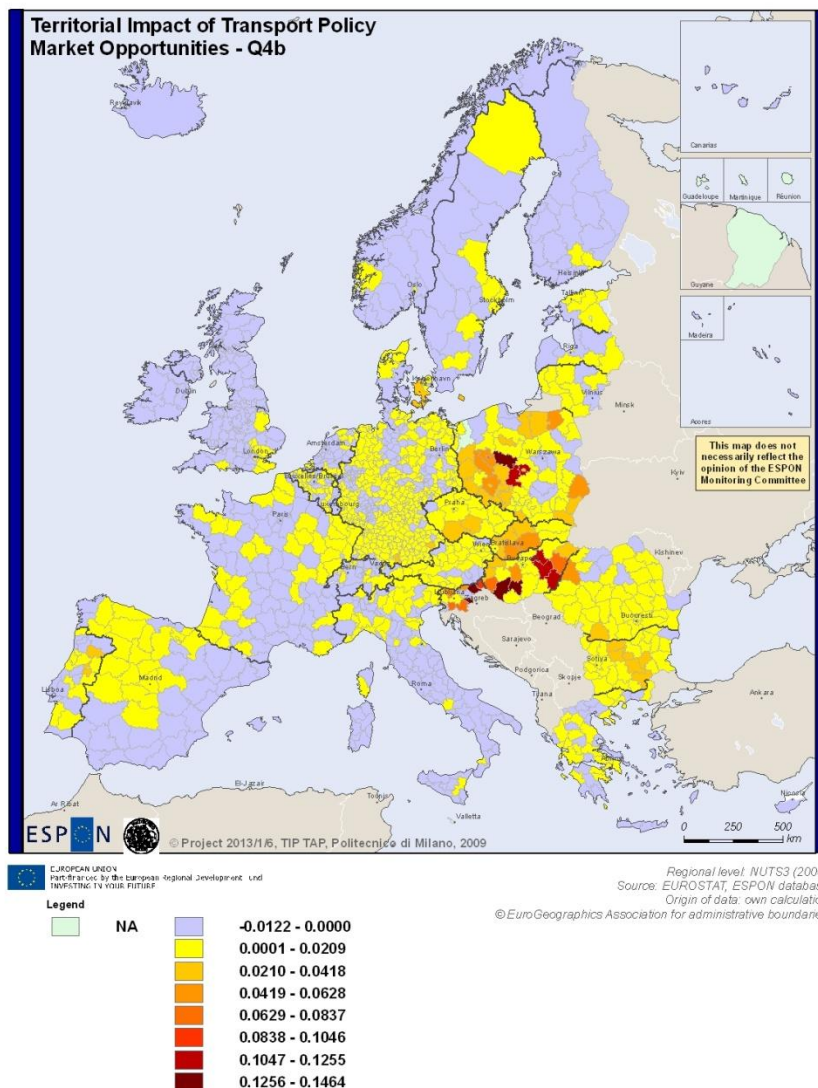
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Impacts on society

Impacts on safety and market opportunities (Q3 and Q4) refer to societal impacts. Safety will increase pervasively according to the baseline scenario (Q3a) and in eastern countries and Germany in the Infrastructure one (Q3b). Positive impacts from regulations (Q3c), contrary to expectations, do not regard the main metro areas, where road pricing will mainly apply, but concern scattered areas and, interestingly, the entire EU eastern border, from Finland to Greece.

New market opportunities, measured by the increased income potential thanks to new accessibilities, are pervasive in the Baseline Scenario (Q4a) and particularly intense in wide areas of southern and central Poland and in the greater Praha area. These opportunities would further increase in the case of the Enhanced Infrastructure Scenario (Q4b, Map 4) and expand towards the greater Budapest area; they would not be reduced in a Pricing Scenario (Q4c). Only some congested areas around large metropolitan areas could suffer from some reductions: the areas of London, Dublin, Amsterdam and Rotterdam, the Kiel-Hamburg axis, Berlin, Madrid, Milan, Rome, Naples and Côte d'Azur.

Map 4. Territorial Impact of Transport Policy on Market Opportunities – Q4b



Impacts on environment and climate change

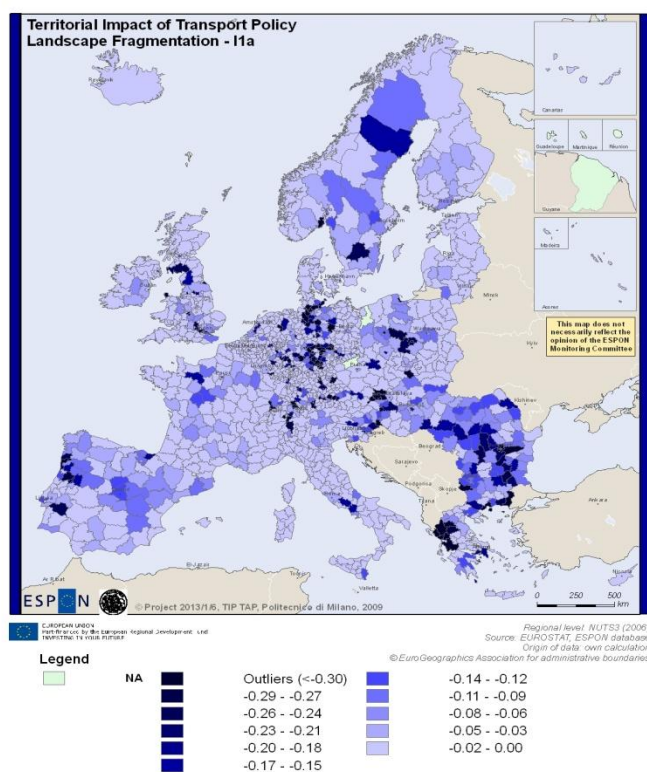
Traffic passing through the region generates negative externalities and no benefit (except for highway owners, gas stations and some highway restaurants); therefore they are considered as costs in the territorial impact assessment exercise. In the Baseline Scenario these costs are visible, though limited (Q1a); in some rare cases through traffic will be reduced thanks to re-assignment to other trunks. A stronger reduction would derive from pricing policies (Q1c): in many regions in Austria, Germany, Denmark, Ireland and UK and in some peripheral areas hit by rise in transport cost. But also new infrastructure provision could reduce the related externalities (Q1b): this is visible in many northern countries, in Germany and also in the Iberian peninsula.

Impacts on emissions are mapped in Q2a: they are not huge but pervasive in the Baseline Scenario, being positive (indicating reductions) only in many German and Dutch areas and in some regions in southern Italy. Enlargement of the network generates some even robust increases, especially in Spain and Poland. In the Enhanced Infrastructure Scenario (Q2b), some new benefits are forecasted, thanks to the hypothesis of trend improvements in fuel efficiency of vehicles, mainly in old Member States but rarely in eastern countries, while in the regulatory, Pricing Scenario, these benefits would appear pervasive and mostly visible in Spain, Portugal, central Italy and Poland as well as in Norway and Switzerland (Q2c).

Impacts on landscape and local identities

Landscape fragmentation and exposure to external visitors (I1 and I2) are the main impact indicators in this case. An increase in landscape fragmentation in the Baseline Scenario (I1a, Map5) will mainly happen in countries where most infrastructure will be built, and namely in Spain, Ireland, central Britain and along a large cross inside Poland. Adding new infrastructure will generate damage in almost all regions (I1b).

Map 5. Impact of Transport Policy on Landscape Fragmentation – I1a



Excessive exposure to external visitors, determining huge negative externalities to resident population and possibly to its cultural identity will hit mainly old Member countries, but also many capital cities in new Member countries (Warszawa, Praha, Budapest, Bucuresti, Sofiya, Tallinn and Riga) (I2a). Pricing would not change much this situation, though reducing it a little especially in large eastern capitals (I2c), while new infrastructure would multiply and possibly diffuse the phenomenon throughout almost the entire territory (I2b).

Overall, the analytical calculation of impacts of EU transport policy has highlighted interesting points. First, a generalized economic benefit of ongoing infrastructure provision (baseline scenario) and the particular advantage of eastern countries in the Enhanced Infrastructure scenario. Per capita GDP and market potential will increase, and also productivity of the network will increase, adding to territorial competitiveness. Related to this, The emergence of a new economic growth area in central Europe, eastward with respect to the "European Pentagon", defined by the "New Quadrangle" between Praha – Krakow – Budapest – Vienna. Increasing intra-regional integration is visible inside countries particularly engaged in ongoing infrastructure construction (Spain, Germany), but is going to spread towards new countries and regions in the Enhanced Infrastructure scenario, particularly towards New Member Countries. This last element looks crucial: increased internal integration is highly relevant in these countries in order to allow development to spread out of the major centres in the direction of cities of second and third rank.

In the baseline scenario, increased congestion is pervasive throughout the territory and particularly in large northern metropolitan areas: ongoing infrastructure looks insufficient to accommodate new forecasted mobility. In aggregate terms, the average impact on the EU will show the highest negative sign among all impacts, all countries scoring negatively – from the highest negative impacts in UK and Denmark to the lowest in Romania and Bulgaria. However, congestion is due to reduce itself, especially in eastern countries, according to the second scenario of new infrastructure provision and even more according to the pricing scenario, especially in most congested areas. Second and third rank airports would substitute for increased inland mobility. Similar results with respect to economic impact on GDP and productivity of networks will show up concerning impacts on new market potentials of regions: the emergence of a central-eastern European "quadrangle" is confirmed.

Increase in safety will, to a great extent, be secured in the baseline scenario, and enhanced in the Infrastructure one, especially in eastern countries. Traffic emissions, on the other hand, will expand, pervasively in the Baseline and mainly in eastern countries in the Infrastructure scenario: this result has to raise political concern. Hopefully, emissions would be slightly reduced in the Pricing scenario in a pervasive way, underlining the relevance of control and regulatory policies on road traffic.

Among impacts on territorial identity, all showing negative signs at the EU level, landscape fragmentation scores first and will particularly hit countries and regions where new infrastructure will or is being built.

5. Key findings on Summative Impacts on regions, according to different preferences systems

An appropriate comparison and weighted mixing of the previous impact indicators supplies us with possible synthetic indicators of territorial impacts of Transport policy. Here we refer to the three macro-criteria of territorial impact, namely territorial efficiency, quality and identity, and to the summative general territorial impact.

The weighting system, allowing the definition of the relative importance of the single impacts⁷, is crucial in order to perform this operation, and a wide attention was devoted. The initial weighting system employed in the previous version of the Tequila model – equal weights, taken as an initial step – was abandoned, and a new system was elaborated through:

- internal experts judgements (see Table 2 below);
- a questionnaire inquiry with policy makers and top national and regional officials.

⁷ And, implicitly, the compensation rate between criteria.

Table 2. Transport Policies - preferences concerning priority goals

	EXPERTS	Policy makers		Public Officials		Academics		Practitioners	
		EU View	National View	EU	National View	EU	National View	EU	National View
TE⁸	47	45,00	42,50	49,16	46,66	39,75	36,50	39,00	39,00
TQ	30	30,00	33,75	31,31	33,81	36,75	38,00	34,00	34,00
TI	23	25,00	23,75	19,52	19,52	23,50	25,50	26,86	26,86
	100	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
E1	18	27,50	31,25	28,08	28,57	27,50	28,50	26,67	30,83
E2	10	22,50	21,25	23,46	21,79	20,75	21,25	18,33	14,17
E3	54	28,75	28,75	32,69	30,36	31,75	31,75	35,00	35,00
E4	18	21,25	18,75	15,77	19,29	20,00	18,50	16,67	18,33
	100	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
Q1	16	23,75	22,50	23,46	27,86	22,75	25,50	20,83	23,33
Q2	25	23,75	26,25	29,23	24,29	32,00	28,75	35,00	33,33
Q3	35	27,50	25,00	20,77	22,50	20,75	19,75	18,33	20,00
Q4	24	25,00	26,25	26,54	26,07	24,00	25,50	25,83	23,33
	100	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
I1	45	33,75	35,00	27,69	30,71	38,17	42,42	45,00	40,00
I2	38	28,75	27,50	23,08	23,93	24,92	25,42	24,17	27,50
I3	17	37,50	37,50	49,23	43,21	36,42	32,17	30,83	32,50
	100	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

The weighting system defined in the first way (experts) implies:

- as of the weight of the three macro-criteria, territorial efficiency scores 43%, territorial identity comes second with 30% and territorial quality third with 27%;
- inside territorial efficiency, the most important score is given to economic growth (54%), the other criteria ranging between 18% (congestion and network productivity) and 10% (airport productivity);
- inside territorial quality, the maximum score is given to safety (35%), around 25% is given to emissions and market opportunities, 16% to through traffic;
- inside territorial identity, the maximum score is attributed to landscape fragmentation (45%), followed by exposure to external visitors (38%) and by regional integration (17%).

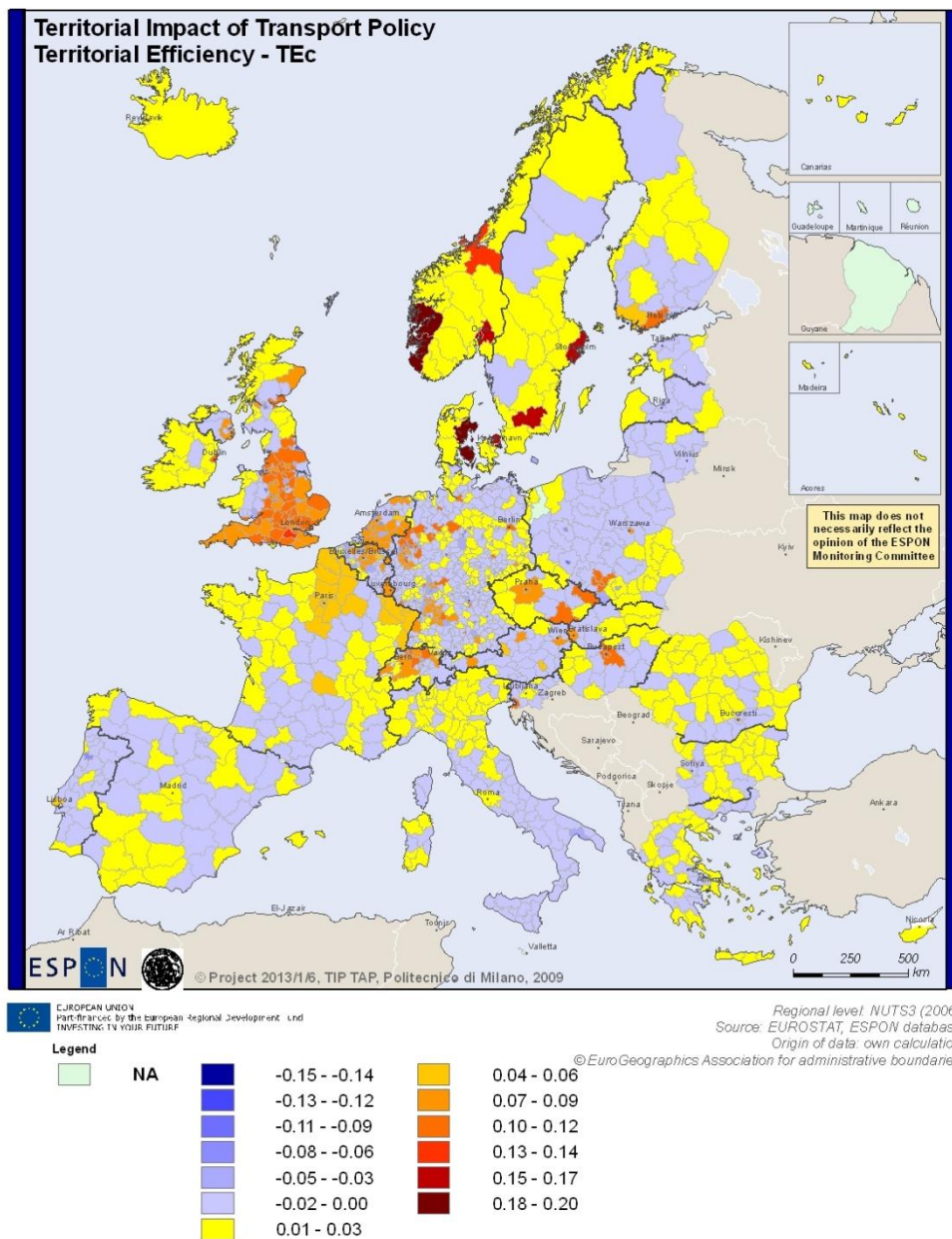
A different weighting system was prepared using the questionnaire delivered to attendants of the ESPON Prague seminar (49 responses). Table 2 above provides the weighting system of different professional groups (e.g. policy makers, civil servants, academics and practitioners). Interviewees were asked to provide us with their policy priorities by taking both a European and a national approach.

Concerning the weights of the macro-criteria, the preferences of policy makers (with a European point of view) are very similar and consistent with the experts view; weights are in general very similar across the different positions of the respondents. On the other hand, inside Territorial Efficiency our (transport) experts gave a much higher preference to impact on GDP (E3: 54%) than policy makers and other respondents (who indicated the interval 28%-32%); similarly they gave higher weights to safety (Q3) and to landscape fragmentation (I1), but the differences are lower in these cases.

According to the sectoral experts weighting system, impacts on territorial efficiency in the baseline scenario (TEa) show up with mixed signs throughout the EU: they are pervasively positive in eastern countries and Germany, but negative signs appear in those areas where congestion costs are higher. The picture does not change much in the Infrastructure Scenario (TEb) but changes in the Pricing scenario (Tec, Map 6) where many punctual strong positive impacts show up, particularly in UK and in more congested areas like the capitals and big city regions. The general synthetic value for this impact in the baseline scenario is negative (-0,01), but it increases slightly in the Infrastructure Scenario (+0,005) and more in the Pricing

Scenario (+0,023). This last result is mainly linked to the fact that in the Pricing Scenario, as already said, a relevant reduction in congestion is achieved (see Table 3)

Map 6. Territorial Impact Assessment of Transport Policy on Territorial Efficiency - TEc



Impacts on territorial quality are generally positive in the baseline scenario (TQa) throughout the EU regions, with some exceptions along the entire eastern border of the Union. Also the synthetic impact (weighted average across all regions) is, counter-intuitively positive (+0,040): this result is mainly due to the very positive score of the safety indicator (+0,137) and the positive score of the market opportunity indicator (0,011) which counterbalance the negative scores reached in the through traffic and emissions criteria (Table 3). The Infrastructure scenario adds new positive impacts on territorial quality (+0,088), mainly

located in eastern countries (TQb) still thanks to the increase in benefits on safety (+0,25), while the Pricing scenario shows a slightly negative impact with respect to the Baseline scenario mainly due to a slight negative (and counterintuitive) impact on safety (-0,022).

Impact of transport policy on territorial identity (TIa) looks negative (-0,029), mainly due to a relevant negative impact on landscape fragmentation (-0,056). This last effect remains somehow negative in the Infrastructure Scenario (TIb), but it is more than counterbalanced by a positive impact on intra-regional integration (+0,055), showing up mainly in Romania, Bulgaria and in some regions of Germany and the other eastern countries. Under the Pricing Scenario (TIc), no relevant impacts will be felt on the landscape criterion, but positive impacts are revealed on external visitors and regional integration; the general outcome on the territory is a widespread positive impact, especially visible in New Member countries and in northern and central Old Member countries.

Table 3. Synthetic impacts on all regions by criterion and scenario

(Macro)-Criterion	Transport-Baseline	Transport-Infrastructure	Transport-Pricing
E1 – Productivity of inland transport infrastructure	0,0496	0,0252	-0,0412
E2 – Productivity of airports	0,0462	-0,0127	-0,0083
E3 – Economic growth	0,0277	0,0000	-0,0001
E4 – Congestion costs	-0,2191	0,0089	0,1744
Q1 – Traffic passing through	-0,0146	-0,0051	0,0019
Q2 – Emissions	-0,0308	0,0002	0,0005
Q3 – Safety	0,1372	0,2530	-0,0219
Q4 – Market opportunities	0,0114	0,0034	0,0002
I1 – Landscape fragmentation	-0,0563	-0,0154	0,0000
I2 – Exposure to external visitors	-0,0060	-0,0008	0,0241
I3 – Regional integration	-0,0123	0,0550	0,0272
TE – Territorial Efficiency	-0,0109	0,0049	0,0231
TQ – Territorial Quality	0,0407	0,0886	-0,0072
TI – Territorial identity	-0,0297	0,0021	0,0138
SI – Summative impact	-0,0005	0,0293	0,0115

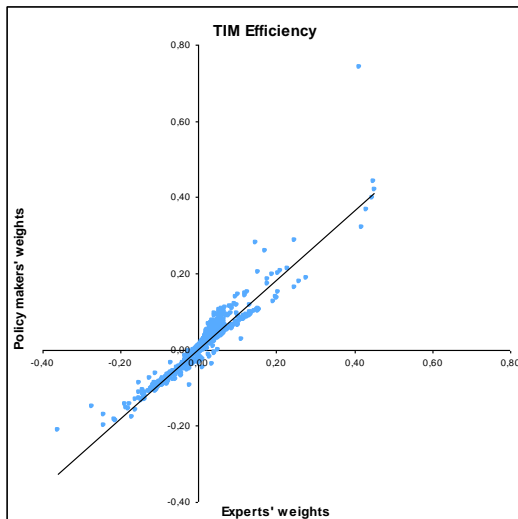
Summative Impact, considering all the macro-criteria, shows a very weak negative sign in the Baseline Scenario, but the sign becomes visibly positive in the Pricing and more so in the Infrastructure Enhancement scenario. Looking at maps, the Baseline scenario (SIa) looks generally positive for eastern countries, northern Sweden and southern Italy, and for many northern and southern regions in Spain. In the other cases, the result is slightly negative. The Infrastructure scenario (SIb) adds robust positive impacts to almost all regions in eastern countries, plus the almost entire Germany, parts of Portugal and Denmark. The Pricing Scenario (SIc) enlarges further these positive impacts westward, particularly towards southern Sweden, Holland, England, northern and eastern France, the Po valley in Italy.

Finally, Table 4 shows and compares the average summative impacts in the three scenarios obtained by adopting the policy makers' weighting system and those using the experts' weighting system. The results are eventually quite similar and this similarity is confirmed by looking at correlation between single scores on TE (Figure. 1, for the Baseline scenario).

Table 4. Average summative impacts according to policy makers' and experts' weights

	EXPERTS' WEIGHTS			POLICY MAKERS' WEIGHTS		
	BASILINE	INFRASTRUCTURE	PRICING	BASILINE	INFRASTRUCTURE	PRICING
TE	-0,0109	0,0049	0,0231	-0,0146	0,0060	0,0238
TQ	0,0407	0,0886	-0,0072	0,0298	0,0693	-0,0054
TI	-0,0297	0,0021	0,0138	-0,0254	0,0152	0,0172
SI	-0,0005	0,0293	0,0115	-0,0039	0,0273	0,0134

Figure 1. Correlation between impacts on Territorial efficiency in two weighting systems (experts' and policy makers' weights) – Baseline Scenario



Figures 1 capture synthetically the differences between the impacts on Territorial Efficiency in each NUTS3 region according to Experts' weights (Y axis) and Policy makers' weights (X axis) respectively, in three different policy scenarios. The degree of correlation is pretty high, and Experts evaluate Territorial Efficiency very closely to Policy makers (the intercept is in the origin of the axes); this is consistent with the similar weight they attribute to Territorial Efficiency impact indicators.

In conclusion, Summative impact on Territorial Efficiency in the baseline scenario show up negative on the average in the EU, in all western countries and in regions where congestion is higher; on the other hand, it scores positive in all eastern countries. The picture changes in the Pricing scenario where many punctual strong positive impacts show up, particularly in UK and in more congested areas like the capitals and big city regions, once again showing the relevance of regulatory policies. Differently, impacts on territorial quality are generally positive in the baseline scenario throughout the EU regions. This counter-intuitive result is mainly due to the very positive score of the safety indicator and the positive score of the market opportunity indicator, which counterbalance the negative scores generally reached in the through traffic and emissions criteria. On the other side, impacts on territorial identity are generally speaking and synthetically negative, as a consequence of the expected negative impacts of network construction on landscape fragmentation in all countries and the limited positive effects on regional integration.

6. The FLAG model

The main purpose of the Flag Model, developed by Nijkamp, Ouwersloot and Vreeker (Nijkamp and Ouwersloot, 1997; Nijkamp and Vreeker, 2000), is to analyse whether one or more policy alternatives can be classified as acceptable/sustainable or not, in terms of their regional impact. Its use inside the TEQUILA model concerns the possibility of computing "summative" impacts of some policy, allowing a weighted averaging and consequently compensation among impacts on different criteria. If (negative) impact on one criterion exceeds a certain threshold, compensation with a more favourable impact on another criterion should be excluded. The Flag Model precisely does this by comparing impact values with a set of reference values (labelled as Critical Threshold Values (CTV) in the model).

The FLAG model is applied to the Transport policy for a subset of indicators, namely to impacts on Congestion and Emissions. For each indicator a critical threshold value (benchmark value) was established⁹ through experts' consultation. Thresholds are set as follows:

- a. **Congestion**: when the number of hours driving under congestion conditions is greater than 3,5 hours per day, this is not considered acceptable. Regions exceeding this threshold are accordingly 'flagged';
- b. **Emissions**: when emissions increase as a consequence of policy interventions, this is not considered tolerable. The threshold value is thus stability at the present level (0% decrease); regions exceeding this threshold are accordingly 'flagged'. In other words, the limit to

⁹ An important problem faced in practice is the fact that a benchmark value is not always unambiguous; in different areas and under certain circumstances different experts and decision-makers may have different perspectives on the precise level of a CTV.

emissions is defined in the absence of increases as compared to the present condition. This limit is strict (but looser as compared to the Kyoto engagement on reductions), and partly unfair to regions with low present emissions (as a consequence of virtuous behaviour or low car ownership rate). Therefore it was decided to establish three levels of "flagging": yellow flag, with increases between 0 and 50%, orange flag with increases between 50% and 100%, and red flag with increases beyond 100%.

The impact values used are the PIMs – potential impacts – translated into "levels" (while in the model they are expressed as "increases") without considering desirability or vulnerability elements, in order to keep the analysis more neutral and based only on forecasts of physical elements.

As of congestion, alert situations in the baseline scenario, i.e. 'flagged' regions, are primarily clustered in a few regions: inside the Greater London area, in some areas in Wales (Bristol and Cardiff), in Greater Manchester, Liverpool and Merseyside in UK; in the Stuttgart and Tübingen areas in the Baden-Württemberg Land in Germany; in the Bergamo, Treviso and Venice provinces along the main transportation axis in Northern Italy plus in the Bologna-Florence link; in the wider Budapest metro area, and in the Goriska-Koper area in Slovenia. In all these cases, a summative territorial impact allowing compensations among different impacts should not be allowed.

As of emissions, almost all European regions – with just a few exceptions in central Germany and southern Italy – will overcome the threshold values, namely the present condition, in the baseline scenario. Main western countries, together with Czechia, Slovakia, Slovenia and Hungary, will remain inside the limit of +50%, but Poland and the Baltic Republics will go beyond this limit and especially Romanian and Bulgarian regions will overcome the 100% increase. Critical conditions are also apparent in Dublin and southern Ireland, in South-western Sweden from Malmö to Gothenburg, and in northern Greece.

It is important to underline the fact that only trend improvements in engine technologies is considered in the statistical modelling exercise, but no breakthrough discontinuities that could come from hybrid or hydrogen technologies. Furthermore, no policy intervention is included in the scenario, beyond what already decided by the EU or national Governments.

Taking up pro-active policies and regulatory countermeasures, the picture changes much. In the "infrastructure" scenario, in fact, the number of "flagged" regions decreases (meaning a lower relevance of the preceding conditions) and main problems would concern Eastern European countries (Poland, Romania and Bulgaria in particular), Spain, Ireland, northern Greece and some specific areas like the central north-Italian axis from Brescia to Trieste. In the "pricing" scenario, the number of "flagged" regions reduces even more, the flags being visible only in Romania and Bulgaria (countries with a relatively low present level of emissions), northern Greece and some other scattered regions.

Therefore, the conclusion on traffic emissions is straightforward: in a trend scenario, the conditions of emissions are clearly non-sustainable. A mix of policy measures are therefore urgently needed: strong support to technological change and innovation in energy efficiency of engines and emission control; important efforts on modal choice, favouring the rail, mass transit in cities and environment-friendly modes, through regulations, taxations, road pricing and cultural campaigns; new infrastructure investments in order to increase accessibility and energy saving in remote and least accessible areas and solve the most acute congestion problems.

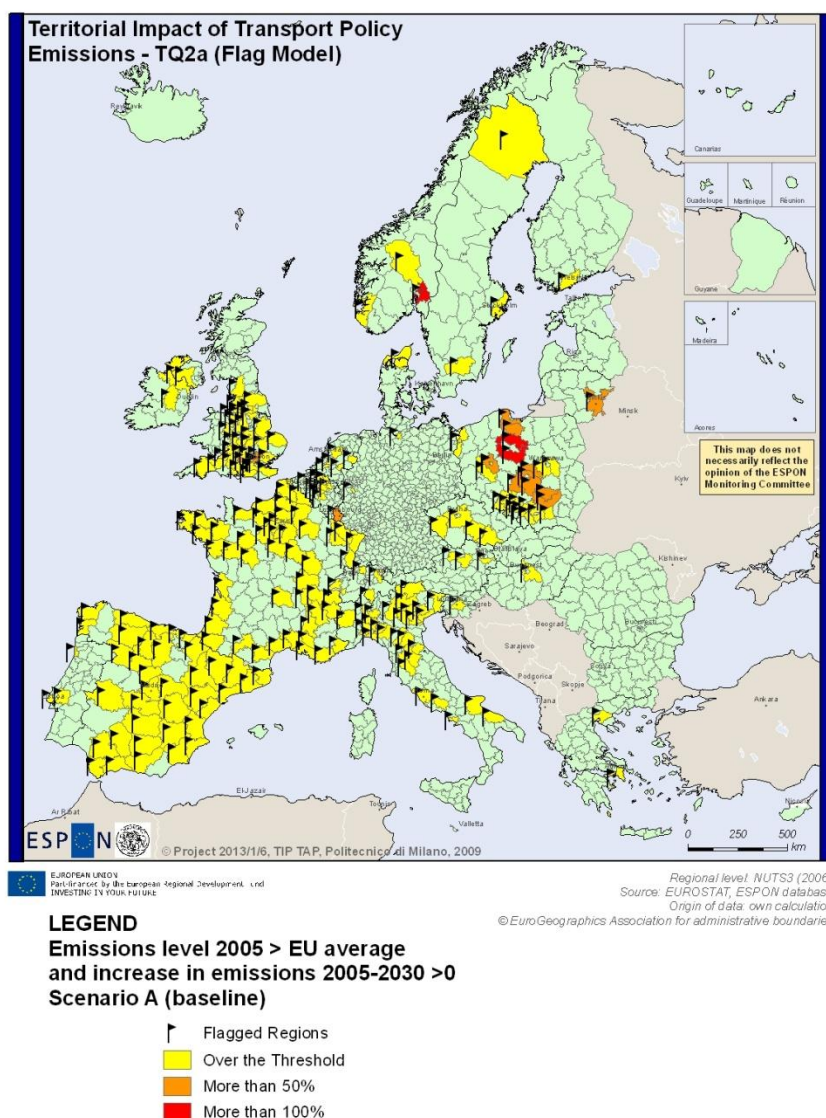
Next, in order to take into account the unbalance of the emissions threshold against regions with low present emissions (e.g. as a consequence of low car ownership rate), an additional criterion was adopted, namely, present emissions being above EU.

Therefore, those areas presently exceeding the EU average and not able to reduce their emissions are 'flagged'. The three levels of "flagging" described above were kept.

As a consequence of the new criteria, the number of flagged regions is sharply reduced and especially in Eastern countries and Germany. Countries with a relatively low present level of emissions, such as Romania and Bulgaria, are not flagged anymore.

Still, several European regions are 'flagged' in the baseline scenario (Map 7). Most countries will remain inside the limit of +50% (many regions in Spain, France, Northern Italy, England and Czech Republic, plus Attiki and Thessaloniki in Greece), but some regions in Norway (the corridor north of Oslo), Poland (on the north-south corridor from Dantzig to Lodz and Krakow) and Lithuania (Vilnius), together with Luxembourg and Inner London will go beyond this limit. Again, taking up pro-active policies and regulatory countermeasures, the picture varies much. In the "infrastructure" scenario in fact, which indicates changes to the baseline scenario, the number of "flagged" regions decreases and main problems would still concern many regions in Poland and Spain, the Po Valley in Italy and many capital regions (Zagreb, Praha, Budapest, Vilnius, Luxembourg). In the "pricing" scenario, the number of "flagged" regions reduces even more, the flags being visible only in Romania and Bulgaria (countries with a relatively low present level of emissions), northern Greece and some other scattered regions.

Map 7. Territorial Impact of Transport Policy on Emissions – TQ2a, FLAG MODEL



Overall, the use of the FLAG model in order to convey strong warnings when some critical thresholds in physical indicators on congestion and emissions are attained or overcome, supplies very interesting results. As of congestion, alert situations are primarily clustered in a

few regions: inside the Greater London area, in some areas in Wales (Bristol and Cardiff) and in Greater Manchester, Liverpool and Merseyside in UK; in the Bergamo, Treviso and Venice provinces along the main transportation axis in Northern Italy plus in the Bologna-Florence link; in the wider Budapest metro area and in some areas inside the Baden-Württemberg Land (Stuttgart and Tübingen).

The forecasted condition on emissions is crucial: almost all European regions will overcome the threshold assumed, namely the present emission condition, in the baseline scenario. Main western countries, together with Czechia, Slovakia, Slovenia and Hungary, will remain inside the limit of +50%, but Poland, the Baltic Republics, Romania, Bulgaria will go abundantly beyond this limit. Critical conditions are also apparent in Dublin and southern Ireland, in South-western Sweden and in northern Greece. Taking up pro-active policies and regulatory countermeasures, however, the picture greatly changes. In the "infrastructure" scenario in fact the number of "flagged" regions decreases and main problems would concern some Eastern European countries (Poland, Romania and Bulgaria), Spain, Ireland, northern Greece and some specific areas like the central north-Italian axis from Brescia to Trieste. In the "pricing" scenario, the number of "flagged" regions reduces even more sharply, underlining the effectiveness of road pricing and regulatory policies.

7. Conclusions

The results of the present application of a renewed TIA methodology look convincing in our opinion. Results as summarised on SDIs and SIs look widely reasonable and robust, and often even counter-intuitive results appear interesting and convincing. One of the weakness points of the previous TEQUILA model, namely the presentation of only summative impacts, is overcome here through the definition of single-dimension impacts on single criteria and explicitly on economy, competitiveness, society, environment, climate change, etc.

The computation of SDIs provides, in fact, interesting indications about the positive overall impact of new network construction, especially for eastern countries as well as the necessary attention to be paid to improvements in *internal* accessibility in New Member Countries - a goal that does not appear as a priority one in the ongoing policy (baseline scenario), as confirmed by our results. In fact, improved internal accessibility looks as a precondition for diffusing development outside the present concentration areas (capital cities and their surroundings, western border) and proves to be reached and very effective in the Enhanced Infrastructure scenario.

The summative elaborations can help only in case that compensations among different impacts look acceptable and rightly managed through the weighting system.

In this last case, two improvements look crucial: the use of two weighting systems (addressed to compare impacts on different criteria), one coming from internal experts and one coming from policy makers, and the use of the FLAG model. In the first case, possible doubts concerning the relevance of some single criteria or summative criteria – as the triad of territorial efficiency, quality and identity- are easily overcome, as some of them could have received a zero weight. This was not the case, and especially policy makers indicated a precise interest not just on traditional economic or environmental impacts but on more innovative, territorial impacts like the ones on landscape, community viability and identity, intra-regional integration. In the second case, the use of the FLAG model gave relevant warnings when certain impact thresholds were overcome, forbidding the process of inter-impact compensation (and therefore, the computation of summative impacts).

In particular, the FLAG model highlights the condition of congestion of the entire EU network at 2030 in the baseline scenario, i.e. also in case all the already decided infrastructure is built as well as the critical condition of emissions revealed which calls for a mix of countermeasures and renewed engagement by policy makers: incentives to technological change and to alternative modes out of road mobility; new regulations and road pricing policies, cultural campaigns and selected new infrastructure provision. In this regard, a regulation and pricing strategy can bring relevant results: reducing emissions, but also reducing congestion in presently most congested metro areas.

Besides this, another interesting feature of the TEQUILA models might be useful, namely the possibility of recalculating summative impacts during a meeting or a public presentation, considering new, proposed weighting systems and comparing the results with the internal ones. It is worth stressing, however, that the TEQUILA model provides a methodology particularly fit for *territorial comparisons* of impacts: the *relative* value of impacts as compared to other regions or surrounding territories is the main added value of the model, rather than the absolute value of the single impact on single regions. Therefore, it should be utilised always with a comparative goal, and applied to policy alternatives.

Consistency with the analytical tools and suggestions of the Commission concerning Impact Assessment procedures was also inspected, and the result looks positive. The general philosophy is very similar and the spectrum of impacts even wider in our case. The advantage of our methodology consists of the fact that impacts are defined by region, in a transparent and easily comparable way, showing where excessive or “outlier” impacts locate – provided that also the policy measures are sufficiently detailed by region.

This last consideration looks crucial for any impact assessment exercise, and not just for the utilisation of the present model. In fact, a sound TIA exercise on any policy requires that:

- *policy measures* to be examined are *clearly* and carefully defined,
- *policy intensity in each EU region* is also defined, as it constitutes the logical starting point of any elaboration,
- data concerning the expected impacts are available,
- possibly some quantitative tools (econometric models, simulation models, impact models) concerning the specific field are already available, at least for some typologies of impacts (environmental, economic, social, ...).

The availability of a modelling tool in order to forecast and simulate impacts generates an important trade-off. This availability in fact, as it is the case for transport policies, allows a more precise definition of impacts and, most importantly, allows to take care of the multiple interactions among the different impact dimensions; but on the other hand, the results are less transparent in terms of easy justification for particular results.

The availability of data for impact assessment is crucial; in the absence of it, only abstract reflections on logical chains and very general qualitative judgements are possible. Data should be available at NUTS 3 level (or a mix of NUTS3 and 2 level, for Germany and Belgium), the most appropriate for a really “territorial” inspection.

For all these reasons, we think that assessment of territorial impacts of EU policy measures, directives and regulations is both crucial and attainable on solid scientific grounds and that the TEQUILA model looks appropriate and flexible for utilisation in the analysis of territorial impacts of other policy measures.

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Annex I

Policy intensity in each region (NUTS 3) is defined considering the new infrastructure links passing through each region's territory, determining an increase in generalised accessibility.

Intensity of policy pricing and regulations is attributed to regions with the intensity indicated in Table A1 below, determining transport costs and emissions proportional to the traffic which is forecasted.

Table A1. Transport policy scenarios: main features

Scenario	Baseline	Infrastructure Enhancement	Pricing policies
Year	2030	2030	2030
Transport cost relative to 2005:			
- Rail and bus fare	50% GDP (max. 30%)	50% GDP (max. 30%)	50% GDP (max. 30%)
- Passenger car fuel cost	7%	7%	17%
- Air fare	0%	0%	15%
- Truck driving cost	4%	4%	10%
- Rail freight cost	-10%	-10%	5%
- IWW freight cost	0%	0%	0%
- Maritime transport cost	4%	4%	10%
Networks:			
- Road	Baseline 2030	High growth 2030	Baseline 2030
Passenger km cost	as in 2005	as in 2005	as in 2005
Passenger km internalisation	0	0	25 % of truck intern
Passenger km cost recovery vignette countries	0	0	0,02 EU on motorways
Truck km cost	as in 2005	as in 2005	as in 2005
Truck km internalisation	IMPACT table	IMPACT table	IMPACT table + 0,04 EU
Truck km cost recovery vignette countries	0	0	0,06 EU on Motorways
- Rail passenger	Baseline 2030	High growth 2030	Baseline 2030
- Rail freight	Baseline 2030	High growth 2030	Baseline 2030
- Air	2005	Extra low cost lines	2005
- IWW	2005	2005	2005

Annex II

The process to compute the territorial impact on the different criteria consist in two simultaneous steps:

1. TRANS-TOOLS results are regionalised at the NUTS3 (e.g. freight forecasts are obtained at NUTS2 level and need to be attached to NUTS3);
2. The specific TEQUILA2 indicators are computed.

A routine was being programmed in order to transform TRANS-TOOLS results into the indicators required by TEQUILA, linked to a GIS. Additionally, some refinement and additional work are required for the regionalization process, basically splitting networks segments or links at NUTS3 level.

TRANS-TOOLS follows a state-of-the-practice 4-step modelling framework, consisting of a successive modelling of transport generation (at NUTS3), distribution (among NUTS3 and NUTS2), modal split (between transport modes) and network assignment.

Policies are expressed in terms of networks (e.g. TENs), as well as in costs and times by passengers and/or freight travelling across the networks.

TRANS-TOOLS is the best state-of-the-practice transport-oriented 4-steps forecast model available at EU level¹⁰, that includes specific socioeconomic modules based on complementary modelling paradigms.

The modelling capabilities of TRANS-TOOLS are related directly to input variables describing the infrastructure networks and aspects related to the networks e.g. transport costs or transport times, as well as flows between NUTS3 and NUTS2 regions. Therefore, the TRANS-TOOLS model is also able to offer answers on policy questions indirectly affecting transport costs and transport times, as well as demand evolution.

Pros and cons of TRANS-TOOLS can be summarised as follows:

- It provides results only for 2020 and 2030 (or a fixed year, but it does not give evolutions over time).
- Policies are translated into generalised user costs in 2030, either in values of time or in costs vehicle operation.
- It covers EU27 and neighbouring countries (refined for Eastern European countries) but not Northern Africa.
- The new road assignment procedure implemented (Stochastic User Equilibrium (SUE) local traffic generated and preloaded, assignment by periods of the day) allows a detailed analysis of congestion on roads (and therefore the impact of transport policies such as speed-limits).
- The new trade model facilitates the analysis of import/export freight.
- Passenger trips with origin or destination outside EU27 are included but not explicitly modelled (except neighbouring countries, but not Northern Africa).
- In the case of aviation, trips with origin or destination outside EU27 are not modelled (EU-27 trip segments are included, in non-direct flights).
- Freight trips with origin or destination outside EU27 are included as if they had their origin or destination in a European port (except for neighbouring countries).
- Air freight is not included.
- There is no explicit modelling of ferries (included as road and rail links) There is no policy-interface, producing a synthesis of the 2 Gb results produced in each scenario run (leading to a very time-consuming process of analysis).

¹⁰ It is a 4-steps transport equilibrium model (version November 2008, developed by DTU and others in TEN_CONNECT), calibrated on 2005 data.