Assessment of direct and indirect transport network effects

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Content

Samenvatting

Bepalen van directe en indirecte transport netwerk effecten

Transport netwerk effecten kunnen worden onderscheiden naar directe en indirecte effecten. Directe netwerk effecten worden gemeten met een standaard transport model. Indirecte netwerk effecten worden gemeten met een macro-economisch model. De resultaten van een dergelijk model vormt invoer voor het transport model. Het combineren van een transport model en een macro-economisch model staat centraal in de methodologie die is ontwikkeld om zowel directe als indirecte netwerk effecten te bepalen.

De methodologie is getest op 3 TEN-T corridors. Geconcludeerd kan worden dat het combineren van een transport model en een ruimtelijk algemeen evenwichtsmodel een goede manier is om zowel directe als indirecte netwerk effecten te ramen. De relatieve omvang van de indirecte netwerk effecten was in de gekozen TEN-T corridors beperkt. Op het niveau van het totale Europese netwerk kunnen de effecten van de afzonderlijke corridors worden opgeteld. Op herkomst-bestemmingsniveau is dat echter niet het geval. Over het algemeen kan worden gesteld dat indirecte transport netwerk effecten niet veronachtzaamd mogen worden.

Summary

Assessment of direct and indirect transport network effects

Transport network effects are distinguished into direct and indirect network effects. The direct network effects are measured by a standard 4-step transport model. The indirect network effects are measured by using a macro-economic model. The output of this model is fed back into the transport model. Combining a transport model and a macro-economic model is the main feature of a methodology to assess both direct and indirect transport network effects.

The methodology has been tested on 3 TEN-T corridors. The conclusion is that combining a standard transport model with a general equilibrium model works well to assess both direct and indirect network effects. The results for the 3 corridors show minor indirect transport network effects. At the level of the entire TEN-T the effects of the different corridors can be added up. However, this is not the case on OD-relations. The general conclusion is that indirect transport network effects cannot be neglected.

1. Introduction

Project assessment is an essential element in the continuous development of transport policy. By giving insights into the positive and negative effects of alternative policies and investments, it can assist in evaluating and prioritising alternatives, before they are implemented. The EU project IASON (Integrated Appraisal of Spatial ecOnomic and Network effects of transport investments and policies) provided improved assessment procedures and new input to assessment by studying spatial impacts of transport investments and policies.

Policymakers have been interested for some years now in transport network effects (e.g. Turro, 1999 & Pearman et al, 2003). There is a widely-held belief among policymakers, not only that these effects are real, but also that they will be an important source of benefits from the implementation of the EC's transport policy, set out in '*European Transport Policy for 2010: Time to Decide*' (EC, 2001).

Many of the projects specified in '*Time to Decide*' are fundamentally about developing the 'network' aspects of the TEN-T (Trans-European Network for Transport). For example, the harmonisation of track gauges in order to create an interoperable international network, thus integrating networks. Another set of projects are the border crossings: the High Level Group report on TEN-T (2003) identified and gave top priority to at least 15 infrastructure projects which will improve border crossings between countries in the EU15 and the newly associated states.

There is no doubt that, when implemented, these projects will make a difference to the perceived shape of the European transport network, to the use made of the network and to the cost of supplying the network. The question is: how exactly? To answer this question a methodology has been developed in the IASON project to assess direct and indirect network effects. This was tested on new EU-infrastructure projects. This paper describes both the methodology and the results of the application.

2. Transport network effects

The transport network is a system of links (like roads or railways), with connections provided at nodes (like intersections, stations or terminals). These networks are continuously changing. Sometimes these concern minor transport projects (maintenance of a road), while in other cases it concerns large infrastructure projects (think for example of the Øresund bridge or Eurotunnel). All these changes cause a chain of reactions (impacts) by the users of the network. These reactions are very broad and may vary from changing route to the relocation of activities. The reactions also have impact on other aspects outside the transport system. The amount of pollution may change, the employment may increase, etcetera. Transport networks are liable to constant alterations with impacts not only on the users of the networks but also outside the networks.

Transport projects can be distinguished into two types: projects concerning the development of infrastructure and projects concerning the use of infrastructure. Examples of the first type of projects are construction or maintenance of roads (links in a network) or ports (nodes in a network). These types of projects usually aim at enlarging the capacity of a network or at improving the accessibility of cities and regions. Examples of the second type of projects are transport pricing, speed reductions or improved timetables. These types of projects usually aim at a change in behaviour of the use of a network or an improvement of the quality of the use of a network.

Adapting transport networks by implementing infrastructure projects causes several effects, both on the network as outside the transport network. These effects are often referred to as network effects. Network effects have several identities and definitions, for example in disciplines like economics, sociology and computer science. In this paper we explicitly exclude those disciplines and concentrate on the transport discipline.

Transport network effects are defined as the changes which occur on the transport network (trip patterns, volumes, travel times, operators cost etc), which are the result of interactions between conditions in one part of the network and another part.

At a conceptual level it is useful to distinguish, as in Mackie et al (2001), between:

- **Direct transport network effects** – such as the effects of a new road on complementary and competing links and modes;
- **Economic network effects –** such as the effects of a new road on the level and pattern of land-use, production and employment;
- **Indirect transport network effects** – such as the rebound effects in the transport market of the changes in regional production and employment.

Laird et al (2003) conclude that some transport network effect elements are unlikely to be captured fully in an appraisal. The primary reason for this is that the state of the art in modelling will in practice place limitations on the ability to fully capture all effects. Such transport network effects include changes in reliability, indirect transport impacts arising from the effects on the economic system, and benefits to non-transport users of a better quality network (i.e. option values). In very large scale models (e.g. EU wide) there will also be practical difficulties associated with obtaining a realistic description of transport network effects arising through congestion.

The appropriate modelling and appraisal specification will vary according to the size and other characteristics of the project or policy being considered. In the presence of strong economies of scale or density, congested networks, or large cost changes created by step changes in quality from a low base, transport network effects are likely to be significant and a suitably specified transport model will be required.

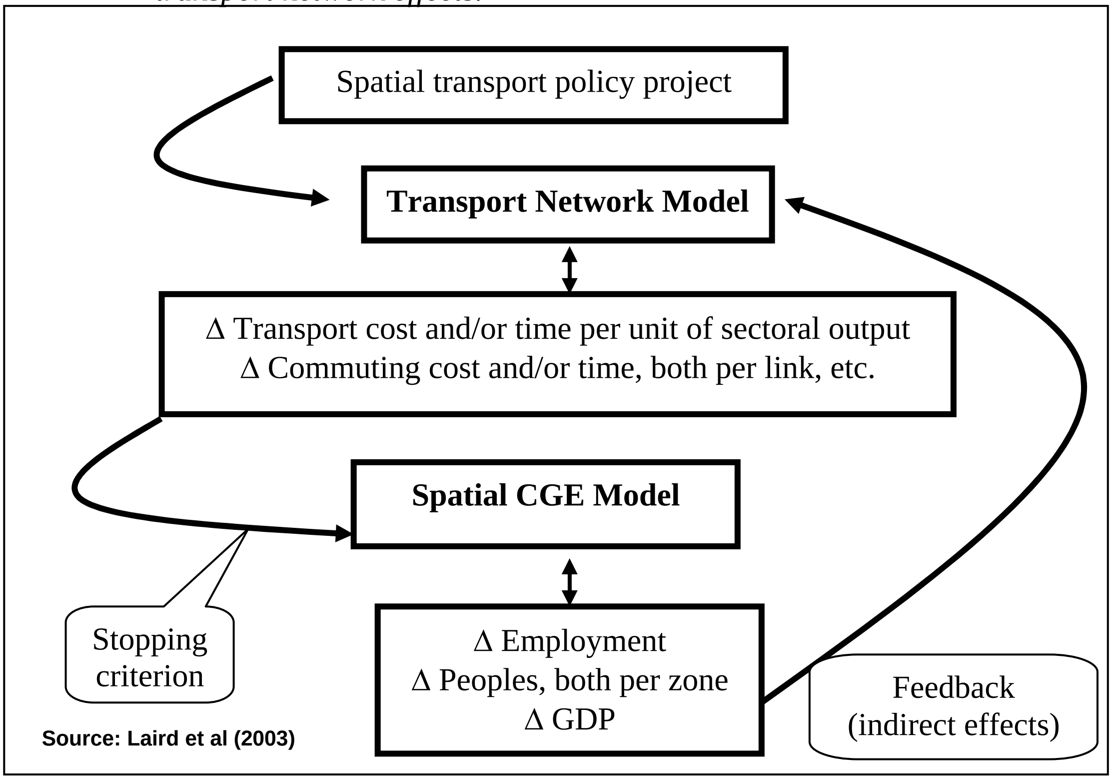
3. Methodology for assessment of transport network effects

Transport network effects can be modelled in several ways, for both direct and indirect transport network effects. Laird (2003) distinguishes transport network effects on the supply side and demand side. Supply side modelling has been reviewed from both user and operator perspective. Modelling one or both perspectives on the supply side is rarely done. Modelling transport is usually done by modelling the demand side.

For modelling the demand side three categories of models are distinguished, the pure transport network models, the land use transport interaction models and the spatial computable general equilibrium models. The pure transport models are used to determine the direct transport network effects. These models can be linked to models that predict land use changes. In such situations the indirect transport network effects can be modelled.

In practice combining two models that have their own characteristics and goals is difficult. Before combining two models one needs to ask why we should combine them. What policy questions need to be answered? And if we combine them, how will this be done? The first question has been answered in Laird et al. (2003). In theory *all* network effects should be included in a CBA. Since a CBA should already include the direct network effects, especially capturing the indirect network effects in full should be a key development subject. In order to capture all network effects, including the indirect effects, a combination of models is needed. Figure 1 provides a concept of a method in which both direct and indirect network effects can be estimated.

Figure 1: Use of transport network model and SCGE model to estimate direct and indirect transport network effects.



The question is how to combine a transport network model and a SCGE. A transport network model and a spatial computable equilibrium model both contain various variables, which are either exogenous (input) or endogenous (modelled). A transport model for example uses exogenous variables like employment, GDP, population and income. It produces endogenous variables like time matrices and transport costs. A SCGE model uses exogenous variables like accessibility, time or cost matrices. Endogenous variables are variables like GDP or disposable income. The combination of two models should be through the exogenous or endogenous variables. Yet, another way to combine the models is achieved by using new functions. This however requires additional modelling.

For testing the methodology within the IASON project, use was made of NEAC and CGEurope. The aim of a NEAC differs from the aim of CGEurope. The aim of NEAC is to forecast freight transport. The aim of CGEurope is to make macro-economic forecasts. In order to combine the two models, one needs to seek for similarities in the input and/or output. Are there common variables in use? Do these variables have the same definition? Do the zoning systems fit? Also methodological questions may rise. Which model needs to be run first? How many feedback loops are needed? Several questions can be raised, yet answering them is difficult because the questions directly relate to specific cases. This case tries to indicate what problems were encountered and how they were tackled.

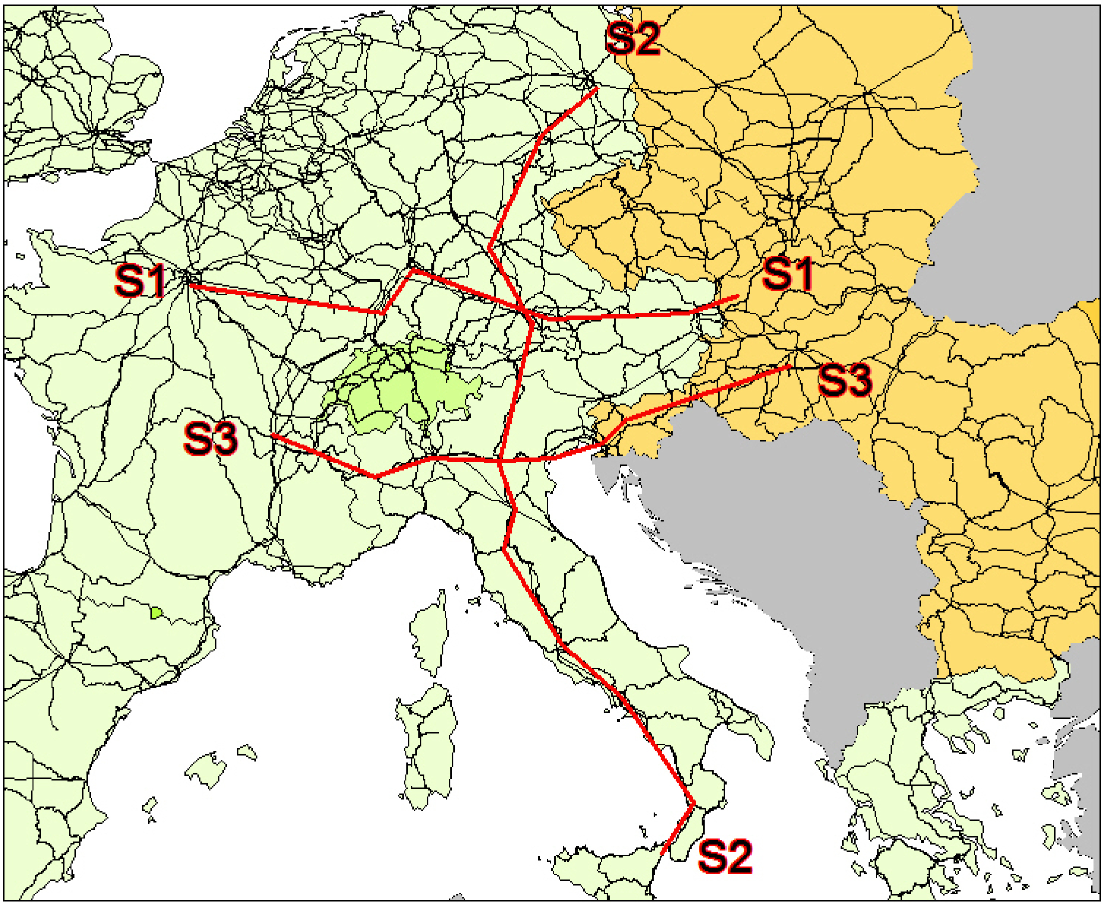
NEAC and CGEurope are combined in order to estimate the total network effects for freight transport. NEAC provides information on the direct network effects and CGEurope provides further information that is used to assess the indirect network effects (and thus the total network effects). The two models are able to ‘communicate’ through changes in GDP and time impedances (the time matrices). The zoning systems differ, NEAC uses NUTSII and CGEurope uses NUTSIII. The differences are overcome, using CGEurope at NUTSII level. Despite the differences in the zoning system, the combination of the two models is possible.

4. Application of the methodology

To investigate direct and indirect transport network effects, a case has been selected to test the methodology of transport network effects. This case comprises all the projects in three TEN-T corridors. These corridors are (S1) Paris – Bratislava, (S2) Berlin – Messina and (S3) Lyon –

Budapest. The first and third corridor are east-west corridors and more or less parallel. The second corridor is north-south directed. The cases were chosen, in order to have a mix of corridors, which enable us to detect additivity of effects. Figure 2 shows the corridors.

Figure 2: TEN-T corridors



For the transport network effects and their additivity, eight scenarios have been examined:

1. Reference 2020, do nothing (no corridor or any other transport policy)
2. Paris-Bratislava corridor included (everything else remains the same)
3. Berlin-Messina corridor included (everything else remains the same)
4. Lyon-Budapest corridor included (everything else remains the same)
5. Paris-Bratislava + Berlin-Messina corridors included
6. Paris-Bratislava + Lyon-Budapest corridors included
7. Berlin-Messina + Lyon-Budapest corridors included
8. Paris-Bratislava + Berlin-Messina + Lyon-Budapest corridors included

The results are distinguished in the transport network effects, the changes in volume, performance and cross-border effects, and in other network effects, the changes in European Value Added.

Changes in volume and performance

The direct transport network effects have been assessed for freight transport. Table 1 shows the results for the entire network in Europe. Five modes are distinguished, road, rail, inland waterways, short sea shipping and other (air and pipeline). Per scenario the absolute and relative changes are given. The total amount of volume does not change (fixed demand), only the modal split changes. The corridors contain mainly rail projects. The logical consequence is that the amount of volume transported by rail increases at the expense of road and inland waterways. Short sea shipping and the other modes do not change. European wide, the extra amount of tonne by rail amounts approximately up to 1%. The decrease for road and inland waterways is maximal 0.1% for both modes. The effects per scenario can be added up. There is no sub- or super additivity when looking at the entire network. As we will see later on, when discussing the cross border effects, sub- or super-additivity may occur on specific relations.

The projects in the three corridors also lead to a change in GDP (variable demand), due to the changes in travel time (see annex). The changes in GDP lead to a change in the amount of volume transported in Europe. The next table shows the total effects per scenario and mode.

Table 1: Direct transport network effects of freight volume transported per mode (bln tonne/year and index) on modal split with fixed demand.

	Road		Rail		Inland Waterways		Short sea shipping		Other		Total	
Scenario	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index
RF	19.843	100.00	1.566	100.00	0.923	100.00	1.280	100.00	0.313	100.00	23.924	100.00
S1	19.838	99.98	1.571	100.33	0.922	99.89	1.280	100.00	0.313	100.00	23.924	100.00
S2	19.838	99.98	1.570	100.32	0.923	99.99	1.280	100.00	0.313	100.00	23.924	100.00
S3	19.838	99.98	1.571	100.32	0.923	99.99	1.280	100.00	0.313	100.00	23.924	100.00
S12	19.834	99.95	1.576	100.65	0.922	99.88	1.280	100.00	0.313	100.00	23.924	100.00
S13	19.834	99.95	1.576	100.65	0.922	99.88	1.280	100.00	0.313	100.00	23.924	100.00
S23	19.833	99.95	1.576	100.64	0.923	99.98	1.280	100.00	0.313	100.00	23.924	100.00
S123	19.829	99.93	1.581	100.97	0.922	99.87	1.280	100.00	0.313	100.00	23.924	100.00

Source: NEAC model

The total amount of volume increases by maximal 0.1%. Not only rail, but also the other modes gain from the increase in total volume. As can be seen in the table, the effects can be added, there seems to be no sub- or super additivity at a European level. If there is any sub- or super additivity, then the value is small. The difference between the direct and total effects in volume transported should be regarded as the indirect effects upon the volume transported.

The table below shows that, due to changes in the regional GDP, the volumes transported by all modes change. The transport model does not use the changes in GDP for a specific mode. Modes like road show a (small) growth in volume compared to the results measured for the direct network effects. The volume transported by short sea shipping decreases. This is due to fact that especially the rail network has improved and thus transport overland.

Table 2: Total transport network effects of freight volume transported per mode (bln tonne/year and index) on modal split with fixed and variable demand.

	Road		Rail		Inland Waterways		Short sea shipping		Other		Total	
Scenario	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index
RF	19.843	100.00	1.566	100.00	0.923	100.00	1.280	100.00	0.313	100.00	23.924	100.00
S1	19.843	100.00	1.571	100.37	0.923	99.94	1.279	99.97	0.313	100.03	23.929	100.02
S2	19.846	100.02	1.571	100.36	0.923	100.01	1.280	100.01	0.313	100.01	23.934	100.04
S3	19.845	100.01	1.571	100.36	0.923	99.99	1.279	99.96	0.313	100.01	23.932	100.03
S12	19.846	100.02	1.577	100.74	0.923	99.95	1.280	99.98	0.313	100.03	23.939	100.06
S13	19.845	100.01	1.577	100.72	0.923	99.93	1.279	99.95	0.313	100.03	23.937	100.05
S23	19.849	100.03	1.577	100.73	0.923	100.00	1.279	99.98	0.313	100.02	23.942	100.07
S123	19.848	100.03	1.583	101.09	0.923	99.93	1.279	99.96	0.313	100.03	23.946	100.09

Source: NEAC and CGEurope models

The difference between the direct network effects and the total network effects consists of the indirect network effects. These are the effects that are fed back from the economy into the transport system (variable demand). Though the effects for the entire network are relatively small, they cannot be neglected. Table 3 shows the indirect effects for road, rail and inland waterways. The factor in the table shows the relative change of the indirect effects compared to the direct effects. A value of -1.41 for road means that the direct network effects should be multiplied by -1.41 to get the indirect network effects on the volume (which is in this case totals up to 0.020 bln tonne per year). The table shows that road and inland waterways have relatively large indirect network effects, while those for rail remains small (close to zero).

Table 3: Indirect transport network effects of freight volume transport per mode (bln tonne/year and index indirect/direct effect) on modal split due to variable demand.

	Road		Rail		Inland Waterways	
Scenario	Abs	Factor	Abs	Factor	Abs	Factor
RF	0.000	1.00	0.000	1.00	0.000	1.00
S1	0.004	-1.03	0.001	0.11	0.000	-0.47
S2	0.008	-1.70	0.001	0.15	0.000	-2.03
S3	0.008	-1.57	0.001	0.14	0.000	0.82
S12	0.012	-1.37	0.001	0.13	0.001	-0.55
S13	0.011	-1.26	0.001	0.11	0.000	-0.39
S23	0.016	-1.64	0.001	0.14	0.000	-1.02
S123	0.020	-1.41	0.002	0.13	0.001	-0.47

Source: NEAC and CGEurope models, difference of table 2.2 and 2.1

Table 4 shows the changes in the performance of freight transport (in bln tonne km) on the entire European network due to the changes in the different corridors. Just like the changes in the volume on the network, the changes in performance can be added as well. Again, there is no sub- or superadditivity at European level (at specific relations sub- or super-additivity occurs). The changes are relatively small. The performance of rail increases by 0.9%. Transport by road and inland waterways decreases by maximal 0.2% and 0.3% respectively.

Regarding the relative changes, there is little difference between table 4 and 1. In table 1 the freight volume transported (in bln tonne/year) diminishes for road and inland waterways by less then 1%, while in both tables rail increase by about 1% at maximum. The fact that the relative changes are not equal is explained by changes in route choice, which leads to different distances and thus different performance (bln tonne km/year).

Table 4: Direct transport network effects of performance per mode (bln tonne km/year and index) on modal split with fixed demand (source: NEAC model)

	Road		Rail		Inland Waterways		Short sea shipping		Other		Total	
Scenario	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index
RF	2649.7	100.00	524.8	100.00	192.9	100.00	1560.9	100.00	90.0	100.00	5018.3	100.00
S1	2648.9	99.97	526.1	100.24	192.4	99.73	1560.9	100.00	90.0	100.00	5018.3	100.00
S2	2647.9	99.93	526.6	100.34	192.8	99.96	1560.9	100.00	90.0	100.00	5018.3	100.00
S3	2648.3	99.95	526.3	100.27	192.9	99.97	1560.9	100.00	90.0	100.00	5018.3	100.00
S12	2647.1	99.90	528.0	100.59	192.3	99.70	1560.9	100.00	90.0	100.00	5018.3	100.00
S13	2647.6	99.92	527.5	100.50	192.3	99.70	1560.9	100.00	90.0	100.00	5018.3	100.00
S23	2646.5	99.88	528.1	100.62	192.8	99.94	1560.9	100.00	90.0	100.00	5018.3	100.00
S123	2645.8	99.85	529.4	100.86	192.3	99.67	1560.9	100.00	90.0	100.00	5018.3	100.00

The total transport network effects concerning the performance of freight transport is shown in table 5. Again, the effects can be added at European level, but there seems to be no sub- or superadditivity of effects (if there is any, it is small). The relative changes, compared to those in table 2 (total effects on freight volume in bln tonne/year) are small. In both tables rail grows by 1%. The differences between the tables are explained by a change in route choice for the different modes.

Table 5: Total transport network effects of performance per mode (bln tonne/year and index) on modal split with fixed and variable demand.

	Road		Rail		Inland Waterways		Short sea shipping		Other		Total	
Scenario	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index	Abs	Index
RF	2649.7	100.00	524.8	100.00	192.9	100.00	1560.9	100.00	90.0	100.00	5018.3	100.00
S1	2649.7	100.00	526.3	100.27	192.5	99.79	1560.8	99.99	90.0	100.03	5019.3	100.02
S2	2648.9	99.97	526.9	100.38	192.9	99.99	1560.9	100.00	90.0	100.01	5019.6	100.03
S3	2649.8	100.01	526.6	100.33	192.9	99.98	1560.9	100.00	90.0	100.01	5020.1	100.04
S12	2648.8	99.97	528.3	100.67	192.5	99.78	1560.8	100.00	90.0	100.04	5020.5	100.04
S13	2649.7	100.00	527.9	100.59	192.5	99.77	1560.8	100.00	90.0	100.03	5021.0	100.05
S23	2649.0	99.97	528.6	100.72	192.9	99.97	1561.0	100.01	90.0	100.02	5021.5	100.06
S123	2648.8	99.97	530.0	100.99	192.5	99.76	1560.9	100.00	90.0	100.04	5022.3	100.08

Source: NEAC and CGEurope models

Cross border effects

The selected corridors contain several ‘cross border links’. It is expected that in case of cross border projects the transport network effects can be significant. The combination of NEAC and CGEurope gives an idea of the possible cross border effects. Yet, one has to keep in mind that locally calibrated models may provide more accurate results. Also, the cultural and institutional barriers are not sufficiently taken into account in these models. Furthermore the intention of this case is not to make accurate forecasts, but to test the methodology. Nevertheless the models provide an idea of the possible border effects.

Together the selected corridors for this case cover several border crossings. The corridors cover France, Germany, Italy, Austria, Slovakia, Slovenia and Hungary. One may expect to see changes at border crossings, due to the projects in the corridors. However, as stated in Laird (2003) cross border effects may go beyond borders between just two countries. The effects may occur in the entire EU. As we saw in the previous section, the changes in GDP occur anywhere in Europe. Annex A provides information on the changes in regional GDP throughout Europe.

Table 6 and table 7 show the effects upon the international freight transport by road, rail and inland waterways for the entire network in Europe (the national transport is excluded). The effects are relatively small, though at the level of origin-destination these effects may be substantial. An interesting aspect is that the transport network effects do not differ too much from those for the entire network (see previous section). Road and inland waterways show a small decrease in volume, while the volume transported by rail increases approximately 1%.

Again, the effects can be added up, both for the direct and total effects. On specific relations however some sub- or super-additivity occurs. This effect is usually small, especially for relations with larger volumes. If small volumes occur, the sub- or super additivity may become larger.

Table 6: Direct transport network effects of international freight volume transported per mode (bln tonne/year and index).

	Road		Rail		Inland Waterways	
Scenario	Abs	Index	Abs	Index	Abs	Index
RF	1090.2	100.0	318.8	100.0	373.2	100.0
S1	1089.4	99.9	320.3	100.5	372.5	99.8
S2	1089.8	100.0	319.3	100.1	373.1	100.0
S3	1089.0	99.9	320.1	100.4	373.1	100.0
S12	1089.0	99.9	320.8	100.6	372.4	99.8
S13	1088.3	99.8	321.5	100.8	372.4	99.8
S23	1088.6	99.8	320.6	100.6	373.0	100.0
S123	1087.8	99.8	322.0	101.0	372.4	99.8

Source: NEAC model

Table 7: Total transport network effects of international freight volume transported per mode (bln tonne /year and index)

	Road		Rail		Inland Waterways	
Scenario	Abs	Index	Abs	Index	Abs	Index
RF	1090.2	100.0	318.8	100.0	373.2	100.0
S1	1090.0	100.0	320.4	100.5	372.7	99.9
S2	1090.1	100.0	319.3	100.2	373.1	100.0
S3	1089.5	99.9	320.3	100.5	373.1	100.0
S12	1089.8	100.0	321.0	100.7	372.7	99.9
S13	1089.2	99.9	321.9	101.0	372.6	99.9
S23	1089.3	99.9	320.9	100.7	373.1	100.0
S123	1089.0	99.9	322.5	101.2	372.6	99.9

Source: NEAC and CGEurope models

The impacts as lined out in the previous sections can be extended to other areas like transport costs and external costs (like emissions and safety). This case study was however limited to the transport network effects. The conclusion may be drawn that the methodology works well for the combination of NEAC and CGEurope. Though this case was limited to freight transport, the results presented here would probably look the same for passenger transport. On the other hand one needs to note that a passenger transport model has different input variables. The question then is whether it is easily feasible to combine such a model with a macro-economic model. The EU project TIPMAC provides the user with more details on combining a transport model and a macro-economic model.

5. Conclusions

1. The methodology to assess network effects works well. When applied, attention needs to be paid to the way the models are combined. Any time a combination of models is applied, the user needs to be careful using the right variables as an interface between the models. The combination of a transport network model (like NEAC) and a macro-economic model (like CGEuope) shows that there are indirect network effects (changes in volume and performance), though the magnitude of these effects is small at the level of the TEN-T. The total network effects (that is the final changes in volume and performance) are thus different than those that stem directly from a transport network model. For large infrastructure projects, especially when several projects are involved (e.g. all TEN-T corridors) it is recommended to use a combination of models, in order to get the full network effects. However, care must be taken as combining models do not give us the full assurance that all network effects are captured.

2. Additivity of network effects seems to occur when applying a transport network model like NEAC at a network wide level. The effects of two projects can then be added in order to get an idea of the total network effects. As most transport network models act in the same way (both passenger and freight), this conclusion will probably be true for most models. At the level of OD-relations however, sub- or super-additivity occurs. The amount of volume at OD level does not add up when combining the effects of two projects.

3. Additivity seems to occur in CGE at EU level. The relative changes in GDP per project EU wide could be added to get a first impression of the final relative changes EU wide. However, when looking at specific NUTSII zones, sub- or super additivity occurs. The network effects for the entire network remain small. Looking at the entire network, it seems that the effects of transport projects can be added up to get a first impression of the final effects for the whole network. At more detailed levels one needs to take care. The combination of CGE with a transport model results in sub- or super additivity on OD-level.

4. Though not always large, the indirect network effects cannot be neglected. Especially on OD-level they can be substantial. The relative changes in indirect network effects differ from mode to mode. In the projects that have been examined rail shows relatively small changes in volume, while those for road and inland waterways are relatively larger.

5. The cross border effects show that the effects can be significant, especially on country to country level. Looking at the entire network, the cross border network effects (measured in relative changes of volume and performance) are in size similar to those for the whole network. At local level they can be substantial. In these cases further research is needed with more detailed models. Cross border effects due to cultural and language differences are difficult to assess and thus difficult to incorporate in models. They are usually incorporated in models as dummy variables.

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