Summary:

Software for Cost-Benefit Analysis of Freight Improvement Measures

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We have developed a first draft version of a tool to compute the economic benefits of measures to enhance the efficiency of the freight transport system. This is based on results from the Norwegian national model system for freight transport, composed of a general equilibrium model, a network model and a logistics model. From the Logistics Model we collect changes in system-wide logistics costs and changes in tonne-kilometres and freight vehicle kilometres for the computation of the external costs of emissions, accidents and noise. Since the Logistics model is still under development, we have not yet implemented an integrated module for all of the calculations. Instead, results from the Logistics Model will have to be inserted in a spreadsheet model. The report specifies which result files from the Logistics Model that are to be used in the benefit calculation.

Introduction

The Norwegian transport authorities, represented by the Public Roads Administration, the National Rail Administration and the Coastal Administration, have commissioned the Institute of Transport Economics (TØI) to develop software to compute the economic benefits of measures to improve freight transport, based on input from the national freight transport model system that exists in Norway.

The national freight transport model system consists of the spatially computable general equilibrium model PINGO, a network model implemented in CUBE Voyager, a set of base case matrices and the so-called Logistics Model. Until now, this model system has never had its own benefit calculation module. The establishment of such a module may provide more systematic and consistent calculations of freight benefits than was achieved previously, when each authority used their own tools. It may also increase the probability that reliable freight benefit analyses will be included in transport impact assessments and provide a clearer picture of what the freight transport sector stands to gain from transport improvements. This report explains the principles of the benefit calculations and prepares the way for programming a benefit calculation module in the freight model system.

Assumptions

The benefit calculation module that we develop is based on three simplifying principles:

1. Freight flows between all pairs of zones are unaffected by measures taken on single modes,
2. Freight rates equal the cost of the operators, including returns on capital invested in rolling stock, and
3. Any change in costs is borne entirely by the transport customers (shippers).

What this means is, firstly, that the freight flows that are input to the calculations are kept constant from the base case to the policy case, and that new charges or measures to improve infrastructure or terminals will only affect mode choice or route choice for existing commodity flows. Secondly, the assumption that net benefits to carriers always will equal zero means that no policy measures will impact on carriers and other transport service providers. Finally, by these assumptions, cost reductions will completely end up in the hands of transport users (shippers/owners) and increase their benefits. Consequently, all benefits can be measured as reduced logistics cost for the shippers.

Not all relevant effects in a cost-benefit analysis are captured by our tool. These elements are missing:

- The interaction between freight transport and passenger transport in the form of congestion on the road and rail network.
- Tax revenues to the government are entered in a simplified way, and the distinction between taxes and payment for services in harbours, terminals etc. have not been exactly drawn. A more precise analysis would require an in-depth study of marginal costs, fixed costs and cost recovery for all the different harbour services and other transport services.
- The costs of uncertainty about transport time and other parts of the lead time are not considered.

Furthermore, certain other issues like environmental costs and accident costs are dealt with in simplified ways.

The Logistics Model

The Logistics Model takes base case matrices, in the form of commodity flows between the zones for 32 different commodity classes, as input. These are further distributed to commodity flows between firms, based on information on the number of firms that ship and the number of firms that receive the commodities of each class. Information about transport distances and transport times from the network model are used to compute the transport costs that enter the firms' choices of optimal transport solutions. The choice of optimal shipment size and shipment frequency is included in the firm's optimization. Shipment size is an important determining factor for the choice of a transport solution, partly because of diminishing returns to scale in transport, both in the dimension of vehicle loads and in the dimension of transport distance. Consequently, consolidation of shipments from different shippers may be profitable when shipment sizes are small. Consolidation terminals, harbours and rail terminals are coded in the network in addition to the terminals of some of the large producers (i.e. transport users).

The model may be used to compute effects of changes to one or more of the assumptions of the base case. Among the changes that may induce changed transport solutions are changes in taxes and other elements of transport or logistics costs, infrastructure provision, or changes in the base case matrices.

The choices of shipment size and logistics chain are governed by the total annual logistics costs, consisting of the following elements:

1. Order costs
2. Inventory holding costs
3. Warehousing costs
4. Cost of capital tied up in goods in transport, including time waiting for scheduled transport
5. Transport costs
6. Loading and unloading costs, including reloading
7. Costs of damage, loss and theft
8. Stock-out costs

The last two elements are not included in the model at the moment because the appropriate data is lacking.

The model is used to study the effects on transport mode choice and route choice of changes in one or more of the conditions governing the supply of transport services within one or more of the transport modes. Some examples are:

- Changes in taxes and charges
- Infrastructure changes (as for instance new roads or railroad tracks leading to changes in transport time and distance and consequently transport cost changes)
- Relocating, establishing or closing down terminals (as for instance harbours, railroad terminals or consolidation terminals)
- Improved access to a harbour or another terminal

Changes like these may lead to the total transport demand going up or down. This is where the demand model PINGO may come into the picture. The cost changes may be coded in PINGO, that will compute the ensuing effect on total freight demand as well as the freight flows between counties.

The model system may also be used to find the expected mode split and corridor freight flows from new assumptions concerning the growth rates of the different industries. Such new assumptions can for instance stem from the multisectoral macroeconomic model of Statistics Norway. For each new four-year period of the National Transport Plan, new assumptions are derived in this way.

Results from the Logistics Model are freight flow matrices by commodity group and transport mode, as well as total vehicle kilometres and tonne-kilometres and total transport costs. Freight flow matrices by mode can be transferred to the network model that will output map plots of the flows for each of the commodity groups and transport mode, and compute the traffic loads on links and in terminals.

Input to the freight cost-benefit module will be the total logistics costs as well as vehicle kilometre and tonne-kilometre changes, that are used to compute external costs of accidents, noise and emissions.

The module to compute the economic benefits

A simple spreadsheet model is established to compute the economic benefits of policy measures. The following elements are included in the benefit calculations of the spreadsheet:

The cost of the policy measure: The cost of the measure, such as for instance investment cost minus salvage costs (residual value), is an essential part of the economic calculation and must be included in the benefit calculation tool.

Costs to the shipper or commodity owner: As mentioned earlier, we assume that any improvement or increase in the logistics costs will be captured or borne by the shipper (the commodity owner), while for the carrier, revenue and costs cancel out. From the Logistics model we fetch the total logistics costs for shippers in both of the cases that are to be compared. The difference is entered as a benefit to shippers/commodity owners.

Public sector revenue: The public sector receives the fuel tax revenue. Fuel taxes are part of the transport costs as implemented in the Logistics Model, but the tax share of the fuel cost are not computed there, and so will have to be computed as part of the economic benefit calculations. It may be assessed from total fuel consumption, which is a function of vehicle kilometres by vehicle class. Public sector revenue and costs are multiplied by 1,2 to take account of the marginal cost of funds (the tax factor).

External costs: The effect of the policy measure on external costs is part of the economic benefits. The external costs include the costs or benefits of changes in the accident risk, noise, emissions and congestion. None of these are included in the Logistics Model, so they will have to be assessed separately based on input from the Logistics Model.

Little has been done in the last years with respect to valuation of external effects, which is why our benefit calculation module is mainly based on figures in ECON (2003). A new report from Vestlandsforskning (2010) provides us with figures concerning CO_2 equivalents (greenhouse gases) per tonne-kilometre for different classes of road freight vehicles, ships and trains.