A MODEL SYSTEM FOR FORECASTING NATIONAL AND INTERNATIONAL FREIGHT TRANSPORT IN NORWAY

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Abstract

The Norwegian model system for forecasting national and international freight transport consists of an SCGE (Spatial Computable General Equilibrium) model (PINGO) for prediction of regional and interregional freight transport for Norway and the Logistics model. The model system has been developed for Norwegian transport. The general equilibrium model is used to predict regional and interregional freight transport, handling transport as an input factor into production of goods and services (Ivanova et al. 2002, Vold and Jean-Hansen 2007). The Logistics model uses the predicted delivery pattern and freight flow volumes from the general equilibrium model, together with transport cost data and other logistics costs data, to estimate how the transport is distributed in the networks and between modes, following basic cost minimisation (Rand Europe and Sitma 2005, de Jong and Ben-Akiva 2007, de Jong et al, 2008). Different assumptions, or development scenarios, will of course yield different output from this freight transport modeling tool. The output constitutes useful information from the view of the National Transport Authorities, singular sectors, and even more for transport-dependent industries.

PINGO

The SCGE-model PINGO is developed for prediction of regional and interregional freight transport in Norway. The model is based on national account data at county level, delivery pattern from the freight flow matrices in the logistics model. The model gets exogenous growth rates for production/service sectors at national level from a Multi Sectored Growth (MSG) model; an applied national general equilibrium model calculating “consistent long run projections of the Norwegian economy” (Heide et al. 2004, p.3). Using predicted population growth per region, PINGO distributes the national growth rates from MSG to predict consumption per region and deliveries between pairs of regions. The model consists of 21 regions (zones), representing the 19 counties in Norway, one off-shore zone and one zone representing foreign trade. For the calculation of total export/import between regions, PINGO also applies input on current transport infrastructure represented as average logistics costs between pair of counties from a network module in the Logistics model described below. Transport is handled as an input factor into production of goods and services, which subsequently represent a cost to individual businesses. Each region in PINGO shelters nine
different production sectors producing 32 commodity groups, as well as six service groups and six investment types. There are also sectors for private and public consumption, as well as a specific public sector for taxes/subsidies and sectors for export/import. PINGO represents sectors and markets by Constant Elasticity of Substitution/Transformation (CES/CET) functions, while consumers are represented by CES utility functions. An iterative algorithm in PINGO updates exogenous demand changes annually over the forecasts period to new Walras equilibriums (Hovi et al. 2008).

PINGO is implemented in the GAMS/MPSGE programming package (Rutherford, 1995).

**The Logistics model**

The other part of the transport modeling tool is the Logistics model. This model takes the projected commodity flow matrices for each region from PINGO as exogenous given and estimates transport costs, frequency, shipment size and transport mode distribution. Information about transport infrastructure (distance and time for each mode) is given from the network module in the Logistics model (Hovi 2007). The Logistics model is a normative cost minimisation model (de Jong and Ben-Akiva, 2007). In a first step, the optimal transshipment locations, from the list of available terminals, are determined for each type of transport chain and origin-destination (OD) zone (the “transport chain generation”). In a second step, shipment size and transport chain, (i.e., the number of legs, selection of modes and vehicle types), are determined by enumerating all available options for a specific firm-to-firm flow and selecting the one with the lowest logistic costs (the “transport chain choice”). Different inventory-theoretic model specifications have been derived for the optimisation of shipment sizes (Baumol and Vinod 1970, Chiang et al. 1981, Vieria 1990, Park 1995). The optimisation in the Logistics model is made under the assumptions that each product and each company are optimised independently, and shipment sizes depend on the economies of scale in transport, through the transport cost functions.

The Logistics model is spatially more detailed than PINGO, operating mainly at municipality level (i.e., 535 units) for domestic transports and mainly at country level for other countries in Europe. The rest of the world is represented with one zone for each continent. The major components of the applied Logistics model are:

- Commodity flow matrices, representing annual commodity flows between Norwegian municipalities and between municipalities and abroad, distributed between 32 commodity groups (Hovi and Jean-Hansen 2006, Vold 2006).
- Zonal business information, i.e., number of delivering and receiving firms of each commodity in the matrices (Madslien et al. 2006).
- Cost functions, representing time and distance dependent freight costs of transport modes, including loading/discharging, ordering, storage, etc. (Grønland 2005).
Network, representing the physical infrastructure for each mode (road, sea, rail and air), by transport time and distance, including locations for terminal locations for consolidation and reloading between modes (Madslien et al. 2006).

The information on transport distance and transport time in the network module is used as basis for the estimation of transport costs, and the estimated transport costs are one of the elements when deciding the optimal transport solutions.

**A national model system for forecasting freight transport**

Interaction of PINGO and the Logistics model yields a national freight model system for Norway with elastic demand. The PINGO model is predicting future demand between different regions, given exogenous growth from a national general equilibrium model (the MSG model). The supply part of the model system consists of the Logistics model. There are no capacity constraints in the Logistics model, thus there is no need for iterative interaction between the two models to achieve equilibrium between transport costs and demand for transport calculated by PINGO.

The Logistics model can be applied independently to analyze short-term effects of changes in infrastructure and/or altered transport costs. To analyze future years, PINGO is used to forecast future freight demand. PINGO is applied in a top-down fashion to construct a do-min base case situation for future years by consistently distributing national growth rates from the national macroeconomic growth model MSG to counties. The freight transport modeling tool has been applied for forecasting freight volumes and modal split within Norway and freight transport connected to imports and exports, related to the work with a master plan for transport investments in Norway. PINGO can subsequently be applied bottom-up to assess effects of alternative strategies for infrastructure investments and pricing relative to the do-min situation.

To apply PINGO top-down for selected years, input for each commodity group in terms of estimated base year PWC matrices, transportation costs from the Logistics model and national economic growth rates for production and service sectors from the MSG model are needed. Future social and demographic conditions, new infrastructure and pricing measures are also needed as exogenous input. PINGO distributes the national growth to represent the level of activity in the counties in the selected future years by endogenously adjusting labour endowments to obtain an overall fit to the national growth. Growth rates for freight transport within and between counties and between counties in Norway and other countries from PINGO can be used to update the PWC matrices in the Logistics model, whilst the Logistics model can be used to calculate transport indicators like tonne km, vehicle km and transport share performed by different modes in rural and central areas.

**Weaknesses and further developments**

Experiences from use of the freight model system for forecasting purposes reveal needs for further developments particularly related to the Pingo model. The
original PINGO structure is part of a neo-classical general equilibrium modeling tradition, assuming constant return to scale in production and perfect competition in all markets. This structure renders it impossible to use PINGO to study the wider economic benefits of transport infrastructure investments. Economic theory shows that in a perfect competitive environment price mechanisms alone are unable to endogenously generate economic agglomeration (Starrett 1978). In order to build a model with the purpose of analysing the formation of economic agglomeration, one has to depart from the notion of a perfect competitive economy (Fujita and Thisse 1996).

In the current PINGO structure there is assumed that physical capital and labor cannot move between the zones in the model. Hence, in transport appraisals there are no short term effects on commuting of infrastructure changes neither any long term migration effects. In reality there is interregional migration as well as immigration to Norway from other countries, where the households may either move or commute to new working places.

In the new economic geography (NEG) literature there seems to be consensus on the two main forces behind agglomeration and regional dispersion:

1. Increasing returns to scale in production, and
2. market power through product differentiation

Following the core-periphery model of Krugman (1991), NEG demonstrates that the interplay between these two main forces and factor mobility and transport costs give rise to agglomeration in general equilibrium models (Fujita, Krugman et al. 1999; Fujita and Thisse 2009).

The future development plans for PINGO involves incorporating elements from NEG in the model. We want to embody increasing returns to scale in production and market power in the model through the use of the Dixit-Stiglitz framework of monopolistic competition. A further development would be to include passenger transport in the model and a migration sub model in order to analyse short- and long term effects on the labor marked of changes in the infrastructure.

References


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