TØI rapport 581/2002
Forfattere: Arild Vold, Jardar Andersen,
Inger Beate Hovi, Olga Ivanova,
Viggo Jean-Hansen, Lone-Eirin Lervåg,
Solveig Meland og Ragnhild Wahl
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Summary:

NEMO
Network model for freight transport within Norway and between Norway and other countries

Joint workgroup for transport analysis – NTP[1] provided financial support and engaged Institute of Transport Economics (TOI) to prepare the analytical part of the National Transport Plan for Norway 2006 – 2015 (NTP), by developing a new version of the network model for freight transport within Norway and between Norway and other countries (NEMO). SINTEF was subcontracted by TOI to do parts of the work. This report describes methods and data that were used to establish the new version of NEMO.

The new version of NEMO calculates the present volumes of 11 commodity groups transported on truck, boat and train in the different parts of the Norwegian transport network and between Norway and other countries. The model includes two STAN-databanks[2] with representative networks for the period around year 2000. One databank represents domestic freight flows, and one databank represents international freight flows from Norway to destinations in other countries (export) and into Norway from origins in other countries (import).

The transport network connects the zones. The zoning in the domestic part of NEMO is identical with the municipalities in Norway in 1999, i.e. 435 zones. The zones and network in the international part was based on the STEMM-network (Wahl et al., 1998) that was coupled with the Norwegian network in NEMO.

Transport from the mainland to the Continental plinth (mainly supply to the North Sea) and transport from the Continental plinth to municipalities on the mainland in Norway or zones abroad (mainly oil- and gas and pelagic fish) is not represented in NEMO. Neither is the transport to and from Svalbard (mainly coal). However, transport of commodities to the Continental plinth and Svalbard is represented in the model on the way to the last municipality until shipment to the Continental plinth. The part of the transport chains from the Continental plinth and Svalbard that takes place after unloading in municipalities on the main-land are also represented in the model.

NEMO is capable of calculating the short term effects of changed transport costs, and it can be used in combination with the model for prediction of regional- and interregional freight transport, PINGO (Ivanova, Vold and Jean-Hansen, 2002), for long term basic forecasts and effects of infrastructure changes, new taxes, new prices on commodities and services etc.

Based on experience so far, we have the impression that the new version of NEMO is suitable for:

- Extracting data for the number of tons transported and the number of tonne kilometres on national level and for transport flows within and between three aggregated domestic regions (Eastern part, Southern- and Western part and the Northern part) for the 11 commodity groups in the base year (1999). The model is also suited for extracting data at national level of the mode choice of each commodity group and the distribution of transport shares of each commodity group in different distance intervals.
- Analysing the effects of changed diesel fuel taxes on mode choice at national level and transport within and between the three domestic regions.
- Analysing the effects of reduced sea transport taxes on the mode choice.
- Analysing how a reorganisation of the port structure in the Oslo fjord affects transport users costs.
- Analysing how changed demand for Norwegian commodities in one or more abroad zones affects transport in the Norwegian transport network.
- Analysing how changed import to Norway affects transport in the Norwegian transport network.

Based on experiences, we have the impression that the uncertainty in the new version of NEMO is too large for most application at the municipality level. We have for

[1] Nasjonal Transport Plan 2006 - 2015
[2] STAN is an interactive software package for transport planning that is specially designed for national and regional strategic analysis and planning of multi modal freight transport (INRO, 2001).

instance that the model will be unsuitable for evaluating the effects of a toll cordon around the city of Fredrikstad. It will neither be suited for analysing capacity utilization on arbitrary road links.

Main structure

NEMO consists of four main elements:

1) A network that represents links and nodes in the infra structure for road, sea and rail.
2) Cost functions for freight transport.
3) Yearly freight flows between pairs of municipalities and between municipalities and other countries subdivided by 11 commodity groups.
4) Optimisation algorithms that find multi modal transport routes that minimises the sum of the total transport cost in the transport network.

The reference year is 1999, but it is possible together with PINGO (Ivanova, Vold and Jean-Hansen, 2002) to forecast freight flows in any future year.

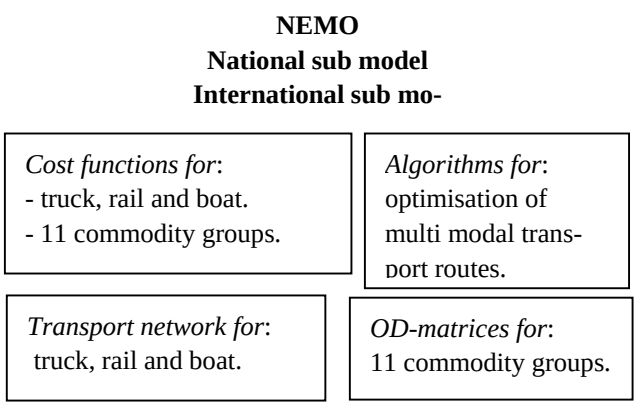

Figure I. Schematic view of NEMO
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Commodity groups

The old version of NEMO was based on a subdivision of all commodities in only four commodity groups. There were several reasons to define of a more refined set of commodity groups in the new version of NEMO. We choose 10 commodity groups based on the requirements (1) that commodity groups represents output from corresponding businesses, which makes them interesting to analyse from model users point of view, (2) that the collection of commodities within each commodity group should have approximately the same requirements for transport quality (and thus transport costs), (3) that available data are sufficient to construct OD-matrices for the commodity groups, and (4) that the shares of the commodity groups that are produced should vary little among the municipalities. The commodity groups are:

1. Food
2. Fish (fresh)
   Fish (frozen)
3. Thermo
4. Vehicles/machinery
5. General cargo
6. Timber and wood ware
7. Minerals in stone products
8. Chemical products
9. Metals and ore
10. Bulk commodities (liquid)

Both the domestic and international part of NEMO includes commodity- and transport specific cost functions for the 10 commodity groups, where the commodity group Fish can be split in two groups. We operate 10 commodity groups when we discuss statistical data, where fish is not split in fresh and frozen good. If fish is split, then fresh and frozen fish becomes commodity groups 2 and 11, respectively.

We consider the grouping to be convenient for many purposes. It is our opinion that the groups are relevant for many application purposes. Food, fish, thermo (food that require cooling or freezing while transported), and liquid bulk are all commodities with special requirements for transport quality. Chemical products and liquid bulk are both commodities that are classified as dangerous goods.

Our statistical data sources group commodities at a more disaggregated level than our 10 commodity groups but differently. Thus, it has been necessary to classify the commodities in each data source according to the NEMO-commodities.

Cost functions

The cost functions in the domestic and international NEMO is defined within the respective STAN-databanks. NEMO calculates the system optimal (SO) multi modal transport routes between pairs of municipalities or municipalities and zones in other countries on the basis of the cost functions.

A cost function expresses the commodity owner's total costs of transporting the commodity on a network link or loading, unloading and reloading in terminals between an origin and a destination. We have split these costs in two components:

- Operative costs (the transport operators time- and distance dependent costs and costs of load, unload and reload).

- Qualitative costs (commodity owners non-operative qualitative costs of delays, transport time, waiting time, degradation for fresh food and costs that represents how suitable the transport modes are for the different commodity groups).

The structure of the cost functions in both the domestic and international part of the new version is similar to the structure that is used in the Swedish model (Lundin, 1998 and 1999). But we have made some changes in order to adapt the functions to Norwegian conditions. Data for operative costs were collected from existing sources, whereas a special terminal cost survey was accomplished as part of the project to quantify costs of load, unload and reload in terminals (Lervåg et al., 2001).

Truck

The distance dependent cost for domestic truck transport is based on the estimates from Statistics Norway that were published in the report *Energy use and emission to air from transport in Norway 97/7*, from the *SIKA-report 5/1999* and the Public Roads Administration, whereas time costs for the commodity groups for truck transport is based on the Estimated lorry cost index and Survey of lorry transport in Norway from 1998-2000 (Statistics Norway).

Transport prices for truck were obtained from the Survey of lorry transport in Norway, obtained by Statistics Norway, that includes information about paid price per trip, where prices include operative costs, time dependent costs, and terminal costs.

Comparison of the average prices with the sum of time and km dependent operative costs from the cost functions (minus reload and tolls), demonstrated that the cost level in the cost functions and the transport prices co-varied quite well.

The distance dependent cost for trucks in other countries for the part of the trip that goes from the origin to the border and vice versa, were calculated on the basis of data from the Survey of lorry transport in Norway (Statistics Norway). The time dependent cost per tons per hour, for transport to and from other countries is considerably lower than for domestic transport, which could be explained by greater time of operation, greater average cargo per trip and higher average speed.

Boat

In order to calculate the distance- and time dependent costs for domestic transport by boat, we used maritime statistics for 1993 (Statistics Norway) to determine the shares of each commodity group that were transported with the different types of ships. We assumed that the shares have not changed from 1993 until 1999. The shares and operative costs for each ship type were used to calculate the transport costs for each commodity group.

The time dependent cost for domestic transport by boat is based on yearly accounts for domestic hired transport in Norway that Statistics Norway published yearly in Maritime statistics until 1996. After 1996, the only information we have is for the cost components for the total domestic transport by boat from National accounts.

Data for the costs of transport that is operated by the production sectors themselves are part of the internal accounts for each company, which are not available. However, of the 357 active ships in domestic transport there were only 16 ships that were operated by the production sectors themselves, which means that we do not introduce any large error by applying cost data for hired transport to all domestic transport by boat.

Data for international transport by boat were scarce. Construction of cost functions for international ferries was based on transport prices for 1999 from Official time and route tables for passenger transport in and to and from Norway. For liner trade (regular transport by boat between harbours in Norway and other countries) there was neither access to transport costs or prices or average load per trip. To deal with this, we have used distance- and time dependent costs from the first international part of NEMO (Madslien et al. 2000), but costs are adapted to the new commodity groups.

From the Foreign Trade Statistic, we have information about imported and exported tons, where ship or ferry was used while crossing the Norwegian border. Together with actual taxes from The National Coast Administration and “St.prp.nr.1” (2000-2001) from Ministry of Fisheries and a division of taxes on sum import and export, we obtained an average tax per tonne transported to and from Norway that we have put on the last network link in to the port for import, and the first link out of the port for export.

Rail

We calculated average distance dependent costs for domestic and international freight transport by rail. There is no available data, however, for the share of the rail capacity that is used when the different commodities are transported[3]. To circumvent this problem, we used data from for road goods transport for 1998-2000 (Statistics Norway) for the capacity that is used for the different commodities for respectively domestic transport that are longer than 300 kilometres and international transport, and adjusted the cost components accordingly. We were now in a position to calculate the distance dependent

[3] The capacity is measured as commodity weight per trip as the share of the vehicles carrying capacity

costs based on the commodities share of all rail transport and the total energy- and diesel consumption for freight rail in 1999 from the energy accounts of Norwegian Railway Company (NSB).

With the exception of container transport, we have that NSB Freight must pay an infrastructure charge to the Norwegian National Rail Administration. The infrastructure charge is based on the amount of cargo and the weight of the vehicles. The Infrastructure charge is calculated such that it becomes an average cost, independent of commodity group, 0.012 NOK/tonnekm that is added to the distance dependent costs.

The time dependent cost for rail is calculated on the basis of transport prices by subtracting the distance dependent cost from the transport prices minus the largest discount. This is not a very satisfactory method, since the profit in this case becomes part of the time dependent cost component. However, according to company accounts for NSB Freight it is not unreasonable to assume zero profit.

Reload costs

Domestic- and international operative costs for reload are based on a terminal cost survey accomplished by Lervåg et al (2001), where reload costs subdivided on general cargo and load units are estimated.

Generally the reload costs for NEMO-commodities that can be classified as bulk commodities are set at the reload cost for load units and the reload cost for other NEMO-commodities is set at the average of the reload cost for load units and general cargo. We also have some commodity specific corrections, e.g., somewhat higher costs for commodities that contain dangerous goods.

Calculations of the operator's time dependent costs for vehicles that are in the terminal are based on the assumption that load and unload are equally time consuming.

Quality cost (non-operative costs)

The quality costs describe characteristics of a transport service that may affect the choice of transport mode(s). This includes information about the risk of delays on links at the border and in terminals, which were obtained from the Swedish model, and estimates on transport frequencies (per week) for the available transport modes, which were obtained from Lervåg et al. (2001).

The quality costs also includes capital costs for commodities that are transported, where commodity value per tonne where obtained from the Foreign Trade Statistics 1999. We have also added depreciation costs for the commodity groups: fresh fish and thermo good that represent the value loss with respect to time for these commodities. The same quality costs were used in the domestic and international parts of NEMO.

Parameters for appropriateness

The operative costs on network links in both the domestic and international part of NEMO were multiplied by a mode- and commodity specific constant that represents elements that affects the mode choice that are not represented within other elements in the cost functions (e.g. appropriateness). This parameter was used for calibration such that the mode specific shares of the total transport of a commodity in NEMO resembled the corresponding shares in the domestic counts and the Foreign Trade Statistic.

OD matrices for the base year (1999)

Basic data were gathered and represented as OD matrices for each commodity group with respective transport volumes. The domestic OD-matrices of NEMO was based on basic data for production, input factors to production, commodity trade and consumption. The data were organised for representation of total transport of each commodity group within, into and out of every municipality in Norway in the base year 1999. The data were further used in a gravity model in order to assess OD-matrices for total transport of all commodities between senders and receivers.

As the OD-pattern for foreign trade is already present as part of the Foreign trade statistic, it was much easier to establish OD-matrices for the international part of NEMO.

The OD-matrices are defined such that we avoid any double counting when the OD matrices for domestic and international trade are merged. The OD-matrix for domestic transport contains transport between all pairs of municipalities in Norway. This includes transport of imported commodities from the place where custom is paid and further into the Norwegian transport network.

OD matrices for international transport contain export from the municipalities where the commodities are produced and import from other countries to the place where custom is paid in Norway, where 42 zones represent other countries.

The OD-matrices for domestic transport do not contain transport in the Norwegian transport network from producers and out of the country and neither import before custom is paid. However, much export from Norway is send directly by boat and transport to the place where custom is paid is minor compared to the total transport in Norway. Thus the domestic OD-matrix is considered

representative for transport between municipalities in Norway.

Domestic

The domestic OD-matrices were based on basic data from Agricultural Counts and –Statistics (Statistics Norway), Manufacturing statistics, Statistics Norway, Statistics on the trade industry, Statistics Norway, (subdivided on wholesale and retailers) and the Household Expenditure Surveys, Statistics Norway, for 1999. The statistics contain data for production, buy and sell of commodities and consumption. Most of the data are given in terms of values for the 11 NEMO commodities. The values must be transformed to tons in a way that gives an unambiguous picture of the transport of each commodity group between and within each of the 435 municipalities in Norway and between Norway and other countries.

We have no detailed information that can be used to quantify the shares of domestically transported fresh- and frozen fish. To subdivide transport of fish in transport of fresh- and frozen fish, we used information from the Foreign Trade Statistic supplemented by information from the Directorate of Fisheries.

We use information form the statistics for industrial production, wholesale, retailers, consumption, import and export for all municipalities in order to asses the value of the commodity flows into, within and out of the municipalities in 1999. The Manufacturing statistics, Statistics Norway, includes data that were used to determine a conversion factor from value to tons. The Manufacturing statistics, Statistics Norway, contains:

- Production value for industrial products
- Sales value of industrial products
- The cost of inputs that are used in industrial production
- Sales value of traded commodities that the industries sell
- Purchase value of traded products that the industries sell

where the units are NOK (VAT not included) for 1999 and classified according to NSTR/2.

The Statistics on the trade industry, Statistics Norway, contain data for the sales value for sales from establishments in the trade industry in different sectors in 1999. The establishments in the trade industry are mainly subdivided in wholesale, agency and retailers, where we have merged agency trade with retailers.

The prices we have determined with the conversion factors are used as a starting point for wholesale and retailers. The calculations are adjusted for all commodities such that Sum In (all commodity trade) + Sum internal (commodities bought and used in the municipalities by production sectors and consumers) equals Sum out (commodity sale from establishments in the trade industry and producers), where Norwegian export and import it is accounted for.

We set the consumption in the municipalities (Sum internal) at the ton volume that is consumed by the population, companies and public sectors in the municipalities. The private consumption is calculated in a separate calculation based on data from the Household Expenditure Surveys, Statistics Norway for households and national accounts for private consumption.

We see from Table I that there is direct trade between retailers and producers (food and chemical products) of 1 million tons and also a significant direct buy from wholesalers (28.8 million tons).

International

OD-matrices for transport (tons) between counties in Norway and other countries is obtained from the Foreign trade statistic for 1999 (Statistics Norway). The elements in the OD-matrix represents transport from the county where the producers are located in Norway to destinations in other countries and from origins in other countries to the first place of custom declaration in Norway. The commodity groups for import is the same as for domestic transport and export, except that imported fish is not subdivided in fresh and frozen good[4].

Calibration data

The data we used for calibration of NEMO includes the Survey of vessels in coastal trade in Norway and the Survey of lorry transport in Norway (Statistics Norway), and some figures for transport flows between relations for rail.

The Survey of lorry transport contains registered data from trips for a sample of trucks. These counts are scaled to represent total truck transport between municipalities in Norway. The counts were made yearly since 1993, and we have used information from all the counts from the period 1993–2000, but scaled to match the total level in 1999.

The Survey of vessels in coastal trade in Norway (Statistics Norway, 1995) do only contain data for spot trade on the coast, and is used together with the counts for loads in the regular service that were collected by MARINTEK.

[4] The majority of import of fish to Norway is transported with fishing boats to ports in Norway, whereas truck is major transport mode for export of fresh fish.

Table I. Commodity trade account for all NEMO-commodities for 1999 according to calculations on the basis of production statistics (Statistics Norway), population in the municipalities, the Households Expenditure Surveys and Statistics on the trade industry, Statistics Norway, (Continental plinth is not included)

NEMO commod-ity	In-dust. input	Indust. com-modity buy	Whole salers buy	Retailers direct buy	Export	Sum in	Private Con-sump-tion	Indust. Buy	Sum internal	Indust. production	Sale from indust.	Sale from whole-salers	Sale from retailers	Agricul-ture, forestry and fish	Import	Sum out	Difference sum in + sum inter-nal – sum out
Food	0,4	0,1	3,1	0,5	0,1	**4,2**	3,4	0,5	**3,9**	1,9	0,1	0,0	3,7	1,2	1,1	**8,1**	**0,0**
Fish	0,4	0,1	2,4	0,0	1,7	**4,6**	0,1	1,8	**1,9**	0,8	0,1	2,5	0,0	2,8	0,3	**6,5**	**0,0**
Thermo	3,5	0,5	1,5	0,0	0,1	**5,6**	0,2	1,0	**1,3**	2,4	0,4	0,9	0,0	2,7	0,5	**6,9**	**0,0**
Vehicles /machinery	1,0	0,1	2,8	0,0	0,3	**4,1**	0,2	2,5	**2,7**	2,9	0,1	1,8	0,9	0,0	1,0	**6,8**	**0,0**
General cargo	9,6	1,7	30,9	0,0	8,8	**51,0**	4,5	19,1	**23,6**	29,8	1,8	11,9	23,9	0,6	6,6	**74,6**	**0,0**
Timber and wood ware	3,9	0,3	9,6	0,0	0,9	**14,7**	0,0	5,2	**5,2**	4,7	0,3	4,3	0,2	7,1	3,4	**19,9**	**0,0**
Minerals in stone products	7,5	0,3	0,0	0,0	15,8	**23,6**	0,0	16,2	**16,2**	32,8	1,6	0,0	0,0	0,0	5,4	**39,8**	**0,0**
Chemical products	2,4	0,4	0,8	0,6	9,4	**13,6**	0,9	0,5	**1,4**	9,8	0,4	0,0	1,4	0,0	3,4	**15,0**	**0,0**
Metals and ore	2,8	0,1	2,1	0,0	0,6	**5,7**	0,0	6,1	**6,1**	5,2	0,1	1,9	0,0	0,0	4,6	**11,8**	**0,0**
Bulk commodities (liquid)	5,0	0,0	12,5	0,0	4,4	**21,9**	6,0	3,2	**9,2**	8,0	0,0	5,5	11,9	0,0	5,7	**31,1**	**0,0**
All commodities	**36,6**	**3,5**	**65,9**	**1,0**	**42,0**	**149,0**	**15,5**	**56,1**	**71,6**	**98,4**	**5,0**	**28,8**	**42,0**	**14,4**	**32,0**	**220,6**	**0,0**

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NSB Freight provided a dataset that were based on accounts for 2001 for transported units (i.e., not subdivided by commodity group). NSB Freight has the experience that there has only been a marginal change in structure and volume from 1999 to 2001. We used data from the transport operator Linjegods to obtain some knowledge of the commodity shares. The data are not grouped according to the NEMO commodity groups, but were transformed to match NEMO commodity groups. Linjegods send approximately 20% of all the containers and is probably the most representative customer with respect to the commodity mix in the containers.

Method of matrix balancing and calibration

To generate OD-matrices for the commodity groups for domestic transport, we used model input for total transport of the commodities into and internal in the municipalities B_j, and out of the municipalities A_j, and transport costs c_{ij} from the cost functions for transport between all municipalities in a gravity model to generate OD-matrices for the commodity groups.

The gravity model that was used to generate the OD-matrices for the commodity groups with elements t_{ij} for all pairs of municipalities, *ij* solves the system of equations

$$t_{ij} = \alpha_i \cdot \beta_j \cdot \exp(\gamma \cdot c_{ij}(\mathbf{p})) \quad \forall i, j$$

$$\sum_{i=1}^{n} t_{ij} = A_j \quad \forall j$$

$$\sum_{j=1}^{n} t_{ij} = B_i \quad \forall i$$

which consist of $n+n+n*n$ equations with the same number of unknowns, i.e., balancing parameters $\alpha_i, i = 1,...,n$, and $\beta_i, i = 1,...,n$ and elements in the OD- matrix $t_{ij}, ij = 1,...,n$, where n = 435 (the number of municipalities).

The transport costs between every pair of municipalities, c_{ij} are calculated by running STAN with an arbitrary OD-matrix as input. The reason why this works is because there are no capacity limits and hence no delays in the real network representation and because STAN assign all transport of a commodity groups between two zones to the cheapest route, i.e., the transport is not distributed to different routes. Consequently, the transport costs per ton for a commodity group are independent of which OD-matrix that is used as input.

The transport internal to the municipalities is considered to be the most uncertain since internal transport is to a greater degree influenced by transport with smaller cars that are not part of the Survey of lorry transport. Thus, for calibration of the OD-pattern in the model, we choose to consider no internal transport in model and accordingly that data for comparison include no counts for internal trips.

The first stage of the calibration process was to make sure that there is coherence between costs that are generated in the model and actual transport prices. Then, we considered to what degree the data from counts and official transport indicators resembled the mode specific OD-matrices we get when the OD-matrices for total transport generated by the gravity model are used as input to NEMO.

We reduced the deviation between the data from counts and the OD-matrices from the gravity model, and data and the mode choice shares we obtain while we use OD-matrices from the gravity model as input to NEMO, by calibrating the commodity- and mode specific coefficients in the cost functions and parameters γ_i in the gravity model for every commodity group *i*.

Calculations with NEMO in the base year were evaluated by comparison of results from the calibrated model and data we have calibrated against (Table II). The pattern is similar, but there are of course variations that are possibly caused by weaknesses in both model and the data.

To evaluate the gravity model and NEMO at a more disaggregated level, we compared 3x3 OD-matrices for the commodity groups for all transport between zones that subdivide Norway in three regions (Eastern part of Norway, county number[5]: 1-8, Southern- and Western part of Norway county number: 9-15, and Northern part of Norway, county number: 16-20).

If the 3x3 OD-matrices for the commodity groups is summed, then we get a 3x3 OD-matrices for all freight transport between and within the regions (Table III).

It is noticed that 79% of the transport is internal to the regions. This is not unreasonable in light of the relatively large regions. Over 50% of all transport has origin or destination in the Eastern part of Norway. The relative deviation is in general larger on relations where there is little transport.

[5] County numbers: (1) Østfold, (2) Akershus, (3) Oslo, (4) Hedmark, (5) Oppland, (6) Buskerud, (7) Vestfold, (8) Telemark, (9) Aust Agder, (10) Vest Agder, (11) Rogaland, (12) Hordaland, (14) Sogn & Fjordane, (15) Møre & Romsdal, (16) Sør-Trøndelag, (17) Nord-Trøndelag, (18) Nordland, (19) Troms, (20) Finnmark.

Table II. Total amounts (tons) transported, total tonne kilometres and average transport distance based on the sum of all transport with the three transport modes truck, boat and train, based on counts and input data to the new version of NEMO

	Food	Fresh fish	Thermo	Vehicles /machinery	General cargo	Timber and wood ware	Minerals in stone products	Chemical products	Metals and ore	Bulk com-modities (liquid)	Frozen fish	Sum
Counts (1000 tons)	8 091	742	6 199	3 534	37 673	9 252	30 614	3 918	2 335	11 610		**113 969**
Input to NEMO (1000 tons)	5 839	1 141	5 081	2 982	40 101	9 978	27 442	3 296	1 918	13 706	770	**111 950**
Counts (mill. tonnekm)	1 197	293	837	344	7 340	1 206	2 878	766	515	4 073		**19 449**
Input to NEMO (mill. tonnekm)	974	187	931	435	7 415	1 301	4 111	663	590	3 979	185	**20 771**
Average transport distance (km) based on counts (tonnekm/tons)	148	395	135	97	195	130	94	195	221	351		**171**
Average transport distance from NEMO (tonnekm/tons)	167	164	183	146	185	130	150	201	308	290	240	**186**
γ	0,006	0,009	0,014	0,02	0,003	0,08	0,07	0,008	0,09	0,006	0,009	

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Deviation that are larger than 100% is of course large, and demonstrates that even if we have calibrated the model such that the total number of tons transported, the total number of tonne kilometres and the overall shares of the total transport that are transported with the available modes is close to corresponding quantities from the counts, there is no guarantee that there is resemblance on a more disaggregated level.

Table III. OD-matrices based on gravity model and counts with total transport for all commodity groups (1000 tons) between 3 regions.

All commodities Model	To-region				Share of trips internal to the regions-
From-region	**1**	**2**	**3**	**Sum**	
Eastern part of Noway county 1-8 1	55 988	9 729	1 238	66 955	84 %
Southern and Western, county 9-15 2	7 413	21 577	1 229	30 219	71 %
North of Norway, county 16-20 3	1 881	2 064	11 132	15 077	74 %
Sum	**65 282**	**33 370**	**13 599**	**112 251**	
Shares of trips internal to the regions	86 %	65 %	82 %		79 %
Counts	**To-region**				
From-region	**1**	**2**	**3**	**Sum**	
1	54 265	4 702	2 573	61 540	88 %
2	3 945	29 621	2 257	35 823	83 %
3	1 494	1 165	13 946	16 605	84 %
Sum	**59 704**	**35 488**	**18 776**	**113 968**	
Andel regionsinterne	91 %	83 %	74 %		86 %
100%* (Modelcounts) Counts	**To-region**				
From-region	**1**	**2**	**3**	**Sum**	
1	3.2	106.9	-51.9	8.8	
2	87.9	-27.2	-45.5	-15.6	
3	25.9	77.2	-20.2	-9.2	
Sum	**9.3**	**-6.0**	**-27.6**	**-1.5**	

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To calibrate the International part of NEMO we estimated mode- and commodity specific constants such that the mode choices calculated with NEMO were similar to the mode choices derived from the Foreign Trade Statistic.

STANs graphical presentation module gives an alternative and a lot more detailed view of the commodity flows for each of the commodity groups than a 3x3 OD-matrix, but it is more difficult to read the total commodity flows between pairs of regions (Figure II).

Conclusions and suggestions for future work

The results demonstrated that model and data were coherent at national level. Further evaluation with 3x3 OD-matrices for transport between regions in Norway, demonstrated that the relative deviations were in an order of magnitude that indicate that the prediction power is not satisfactory for analyses of for instance capacity utilization on single road links. We have the opinion, however, that the new version is well suited for analysing effects of strategic measures (for instance taxes or capacity changes) or the effects that changes in other input data have on the OD-pattern and the mode choices. Another area of application is addressed if NEMO is used together with the model for prediction of regional- and interregional freight transport (PINGO). A short description of the latter is found in the next chapter.

Distinct cost profiles for short and long trips and/or more transport modes would possibly improve the calibration results. It is also an option to tune the model to fit data for specific areas or one could develop separate models for regional and local areas.

Forecasts with PINGO and NEMO

Input data to PINGO can be obtained from national models like MODAG or MSG, and transport costs and OD-matrices with total transport of every commodity group in the base year from NEMO.

PINGO (Ivanova, Vold and Jean-Hansen, 2002) forecasts the total OD-matrices for each of the NEMO-commodities in terms of growth rates for the commodity flows between all pair of counties. Calculation of the growth rates are based on assumptions about:

1. Demographic changes with time.
2. National economic growth.
3. Changes in the trade with other countries
4. Changes in the transport network on one or more links.
5. Taxes on produced goods, services and/or transport.
6. Work force endowments in the counties.
7. Location of special types of production.
8. Subsidies and transfers to consumers (Income from transfers gives a basis for consumption which gives a foundation for production and employment, which may have influence the regional development and import to the region).

The projected OD-matrices are used as input to NEMO, where the OD-matrices for the total transport volumes are subdivided on mode specific OD-matrices.