8. Demand (large-freight, gdp & structure)

Overview

Target

This view is intended to generate, over time, the large-freight transport demand (all freight modes except TWO WHEELERS, THREE WHEELERS and LDVS) that depends on changes of GDP; and structural modification of the freight transport system.

Structural changes include, for instance, shifts towards more (or less) exports; behavioural or trade-related evolutions leading towards shorter (or longer) supply chains; and changes in the nature of the economy, e.g. from a condition where it is heavily dependent on primary materials to a situation where primary materials are locally processed in a large manufacturing sector, excluding effects due to changes in costs.

The effect of changes in transport costs, not taken into account in this view, is addressed in the views "demand (large-freight, tkm)", "travel per vehicle (freight)" and "load (freight)".

The view deals mainly with variables regarding haul length and tonnes lifted. Such variables are used to build up the freight activity in terms of tkm. There are several shares of tonnes lifted on both sides of the view which are split in various subscripts in order to work at different levels of aggregation.

Structure

The left part of the view contains information on the large-freight activity at the base year, while the right side contains the calculations determining the activity over time. The variables are symmetrically placed on the view (Figure 8.1).

The calculations flow on the left half side of the view goes from the top to the bottom. The combination of several inputs, needed to simplify the data introduced by the user, results in the full disaggregation of the shares and tonnes lifted.

Aggregating across sub-sets of subscripts the shares and tonnes lifted allows generating projections over time. The central part of the view contains indexes, applied to specific sub-sets of aggregated shares, which define the evolution over time of selected shares. Such indexes are specified by the user in the ForFITS input file. The user inputs affect parameters related to the economic structure, such as the type of goods transported, exports in comparison with in-area demand, and others. The indexes connect variables on the left part of the view (base year) to corresponding variables on the right side (over time).

Box 8.1 Note on the terminology

Note on the terminology: the shares used in this view are normally expressed "by" and "for" several subscripts. The difference between "by" and "for" is relevant to understand properly the operations carried out between different shares. For instance, shares "by W, X for each Y, Z", means that the sum of the shares across the "by" subscripts into which the variable is disaggregated (W and X, in this example) will be always 1 for each combination of the "for" subscripts (Y and Z in this example).

The calculations flow on the right half side starts on the bottom and progressively spreads towards the top of the view. The shares at different levels of aggregation are combined between each other to build up the whole picture of the large-freight system over time.

Figure 8.1 Demand (large-freight, gdp & structure): Vensim sketch

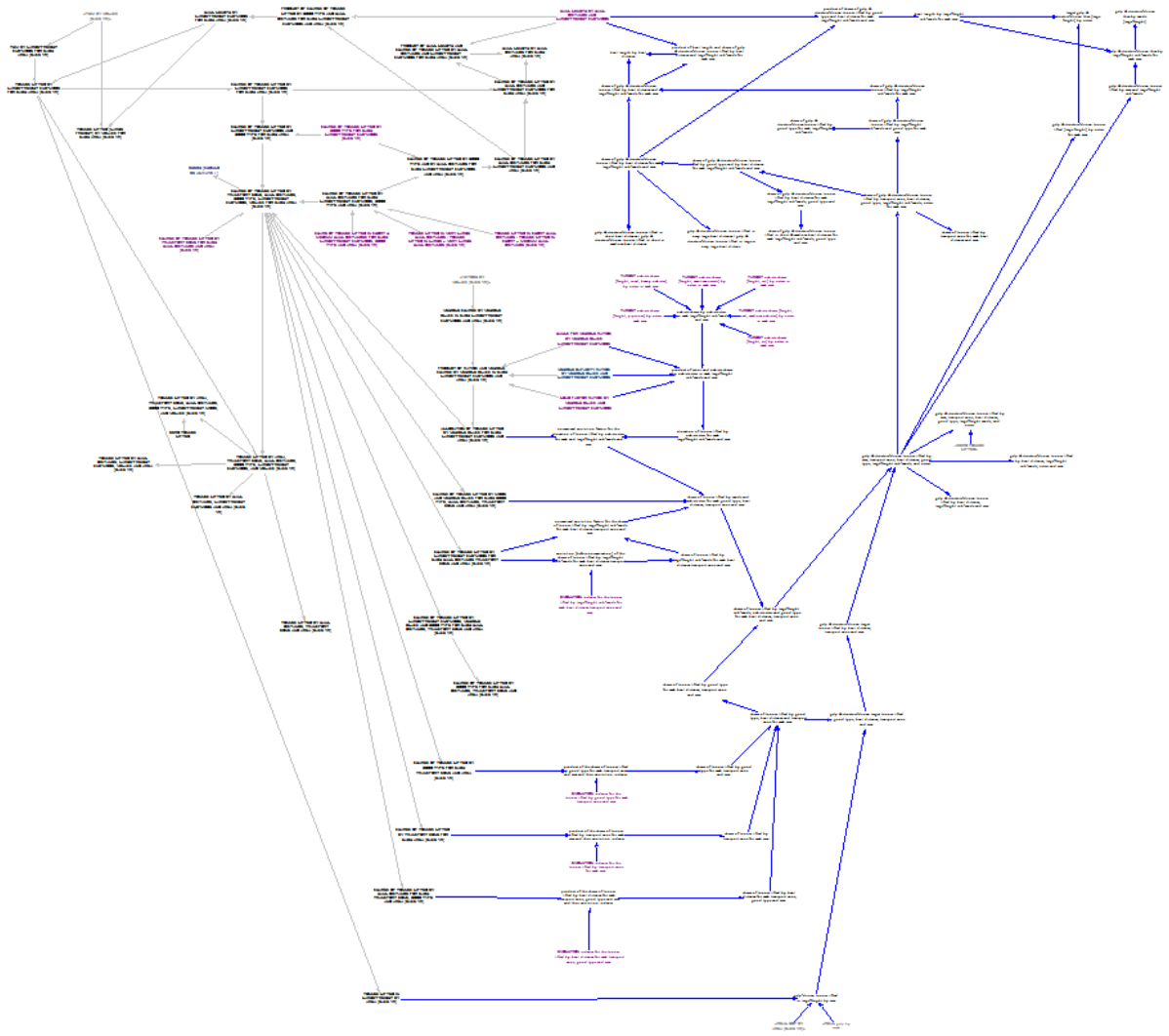


Table 8.1 lists the variables contained in the subscript sets that are used in this view.

Table 8.1 Options within each subscript

Subscript	*Available options in the subscript*
LARGE-FREIGHT SUB-MODE	LFR MDT, LFR HDT, LFR RAIL, LFR AIR, LFR PIPELINES, LFR IWW, LFR SHORT SEA, LFR MARITIME
HAUL DISTANCE	SHORT, MEDIUM, LARGE, VERY LARGE
GOOD TYPE	BULK, MANUFACTURED, FOOD, OTHER/NON-SPECIFIED GOODS
TRANSPORT ZONE	IN-AREA, EXPORT

Table 8.2 shows the relationships linking large-freight sub-modes, modes and vehicle classes (large-freight sub-modes correspond to vehicle class subsets within the different modes).

Table 8.2 Large-freight sub-modes allocation

Large-freight sub-mode	*Mode belonging to*	*Vehicle classes included*
LFR MDT (Medium Duty Trucks)	LARGE ROAD	A to C
LFR HDT (Heavy Duty Trucks)	LARGE ROAD	D to F
LFR RAIL	RAIL	A to F
LFR AIR	AIR	A to F
LFR PIPELINES	PIPELINES	A to F
LFR IWW (Inland Waterways)	VESSELS	A
LFR SHORT SEA	VESSELS	B
LFR MARITIME	VESSELS	C to F

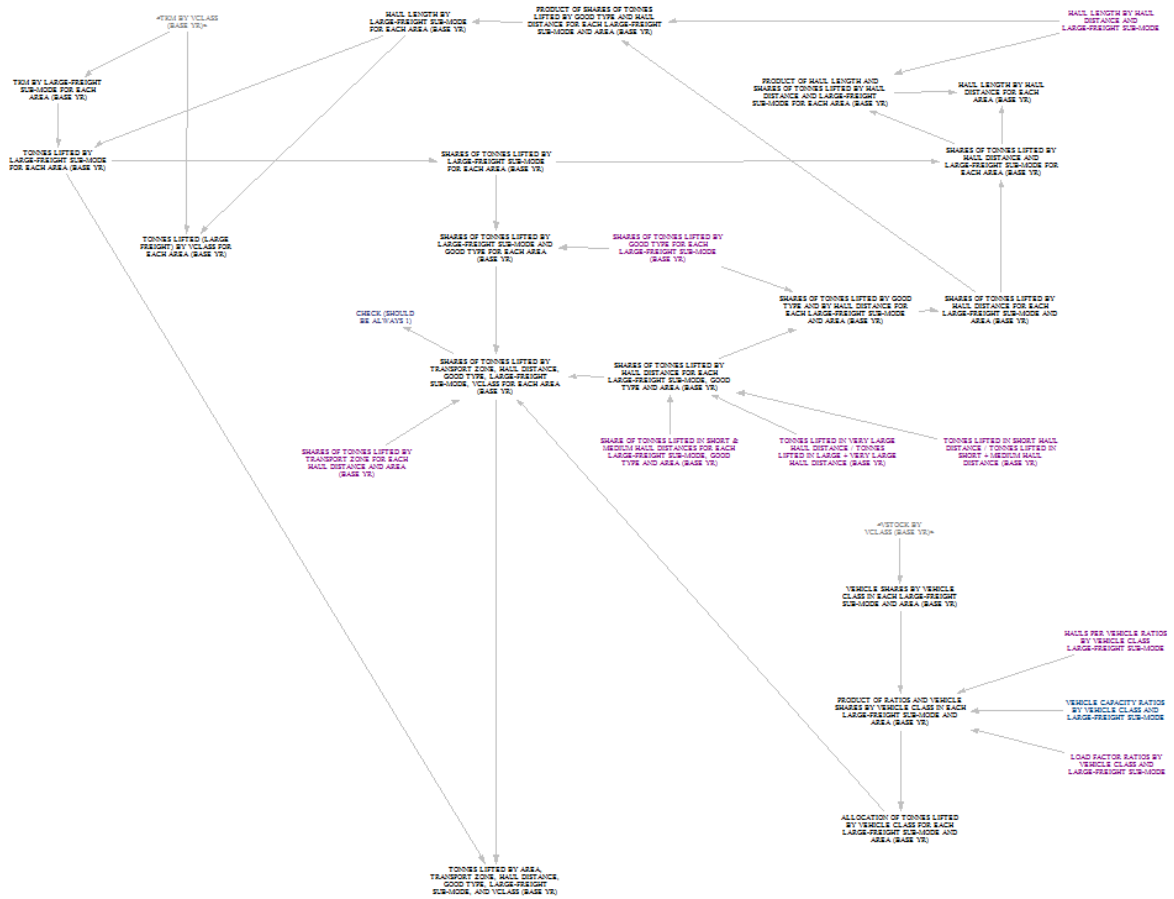
Detailed description of the view

Tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class (base year)

The approach selected requires the evaluation of information on the shares of tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class (maximum possible disaggregation) in the base year.

In order to limit the input burden for users, this is calculated with a combination of strategically defined subsets of shares.

Figure 8.2 Top left of the view-Determination of the shares of tonnes lifted at the base year disaggregated by all the subscripts



The haul length and freight activity (tkm), allowing to calculate the total tonnes lifted, are combined with the shares of tonnes lifted to calculate the actual tonnes lifted disaggregated by all the subscripts (area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class).

Figure 8.2 shows the calculations flow containing these calculations. This is laid out in Vensim on the top left of the view.

Inputs

The information concerning freight activity by vehicle class at the base year, expressed in tkm, comes from the view "activity, loads and stock aggregates". This endogenous information enables to calculate the freight activity for each large-freight sub-mode through aggregating the tkm across the vehicle classes belonging to each sub-mode.

The exogenous input "HAUL LENGTH BY HAUL DISTANCE AND LARGE FREIGHT SUB-MODE" introduced by the user in the inputs ForFITS Excel file ("Transport system (over time)" sheet) contains the definition of haul lengths, expressed in km, for each type of distance (SHORT, MEDIUM, LARGE, VERY LARGE) and for each large-freight sub-mode.

The user needs to enter inputs ("Transport system (over time)" sheet of the ForFITS Excel file) concerning the shares of tonnes lifted disaggregated at different levels. The information is requested according to the structure detailed below.[1]

By transport zone (IN-AREA, EXPORT)

The shares of tonnes lifted by transport zone are necessary for each type of distance and for each area.

By good type (BULK, MANUFACTURE, FOOD, OTHER)

The shares of tonnes lifted by good type are required for each area and for each large-freight sub-mode.

By transport distance (SHORT, MEDIUM, LARGE, VERY LARGE)

For each good type, large-freight sub-mode and area the user must specify the share of tonnes lifted in SHORT or MEDIUM distances, while the rest up to 100% corresponds to those tonnes lifted in LARGE or VERLY LARGE distances.

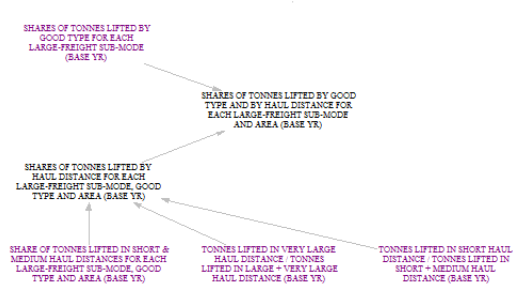
Moreover, the user details the share of tonnes lifted in SHORT distances in the total tonnes lifted including SHORT and MEDIUM distances, as well as the share of VERY LARGE distances in the total tonnes lifted in LARGE plus VERY LARGE distances. This is required for each area and large freight sub-mode, but without distinguishing the good type.

The combination of both exogenous inputs leads to the shares of tonnes lifted by transport distance for each large-freight sub-mode, area and good type. As it is shown in Figure 8.3, the product between these shares and those by good type introduced in the previous bullet point results in

[1] As mentioned earlier, this structure aims to limit the input burden for users (with respect to the need to enter detailed information on the shares of tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class).

shares of tonnes lifted by transport distance and by good type for each large-freight sub-mode and area.

Figure 8.3 Shares of tonnes lifted by haul distance and by good type for each large-freight sub-mode and area



This section of the view also uses ratios characterizing each vehicle class for the allocation of the shares of tonnes lifted by large-freight sub-mode, area, transport zone, haul distance and good type at the vehicle class level, within the large-freight sub-modes. This also allows disaggregating the tonnes lifted by vehicle class.

It is assumed that there are four factors that influence the distribution of the shares of tonnes lifted across the different vehicle classes:

- The number of vehicles in the vehicle fleet: the higher is the number of vehicles belonging to a particular vehicle class, the higher will be the amount of tonnes lifted assigned to that vehicle class. The exogenous user input "VSTOCK BY VCLASS (BASE YR)" ("User inputs (BASE Y)" sheet of the ForFITS Excel file) enables to take into account the share of each vehicle class in the total number of vehicles in the stock at the base year;

- The number of hauls per vehicle: this may be higher is some vehicle classes rather than other (e.g. on vehicles distributing mail, rather than on vehicles used to transport goods to a specific location). If the average haul length is the same, a higher number of hauls results in a higher amount of tonnes lifted. This is considered by means of ratios that differentiate the number of hauls per vehicle in each of the vehicle classes. These average haulage ratios are set to 1 by default ("Transport system (over time)" sheet of the ForFITS Excel file), considering that a higher number of hauls is typically associated with shorter hauls (within the same haul distance category). In other words, it assumed that the higher number of hauls is compensated by the shorter haul length. Unless it is changed, this default assumption has no influence on the allocation of the tonnes lifted across vehicle classes within a large-freight sub-mode;

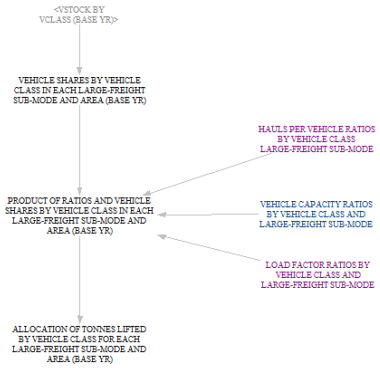
- Vehicle capacity: with constant load factors, vehicles with higher capacity lift more tonnes than those with lower capacity. This is taken into account by means of ratios that differentiate vehicle capacity of each of the vehicle classes (with respect to the modal average). Ratios by vehicle class are required ("Transport system (over time)" sheet of the ForFITS Excel file) to consider the effect of different carrying capacities across the vehicle classes. The default data in the ForFITS Excel file are coherent with the capacities defined by default for each vehicle class;

- Load factor per vehicle: it results from the combination of the average load on laden trips and the share of km which are run empty. Changes in the load factor lead to changes of tonnes lifted by vehicles. As in other cases, this is taken into account by means of ratios that differentiate the average load factors in each of the vehicle classes. This input (located in the "Transport system (over time)" sheet of the ForFITS Excel file) enables to take into account for changes when they are structurally different across vehicle classes. By default, this parameter is set to 1 (no differences in load factors across classes).

Figure 8.4 and the equation below show how these four factors are multiplied and how the share to be assigned to each vehicle class is calculated.

$$Share_{vclass\ i} = \frac{Product\ between\ the\ four\ ratios/factors\ in\ the\ vehicle\ class\ i}{\sum_{vehicle\ classes} Product\ between\ the\ four\ ratios/factors\ in\ the\ vehicle\ class\ i}$$

Figure 8.4 Shares by vehicle class for each large-freight sub-mode and area



Outputs

The shares of tonnes lifted disaggregated by transport distance (but not by good type) are achieved through summing up across the different goods in the variable "SHARES OF TONNES LIFTED BY GOOD TYPE AND BY HAUL DISTANCE FOR EACH LARGE-FREIGHT SUB-MODE AND AREA (BASE YR)". This output enables to calculate the haul length by large-freight sub-mode as an average of the lengths by transport distance weighting by the share of each one:

$$Haul\ length\ by\ large-freight\ sub-mode\ for\ each\ area =$$
$$= Length\ by\ haul\ distance\ and\ sub-mode \times Shares\ of\ tonnes\ lifted\ by\ haul\ distance$$

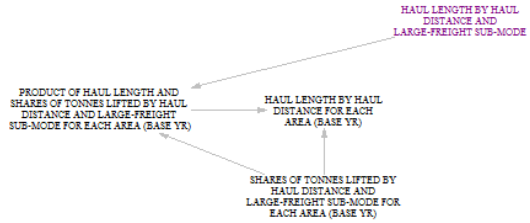
The tonnes lifted by large-freight sub-mode at the base year are isolated from the following equation:

$$tkm\ by\ sub-mode\ (available\ from\ the\ view\ "activity, loads\ and\ stock\ aggregates")=$$
$$= tonnes\ lifted\ by\ sub-mode\ (output) \times Haul\ length\ by\ sub-mode\ (already\ calculated)$$

The share corresponding to each large-freight sub mode in the total tonnes lifted is calculated for each area. The multiplication between these shares and those by transport distance for each large-freight sub-mode leads to the shares of tonnes lifted for each area disaggregated by haul distance and by large-freight sub-mode.

Figure 8.5 and the equation below it show the calculation of the weighted average that allows the evaluation of the average haul length by haul distance for all large-freight sub-modes.

Figure 8.5 Haul length by haul distance for each area



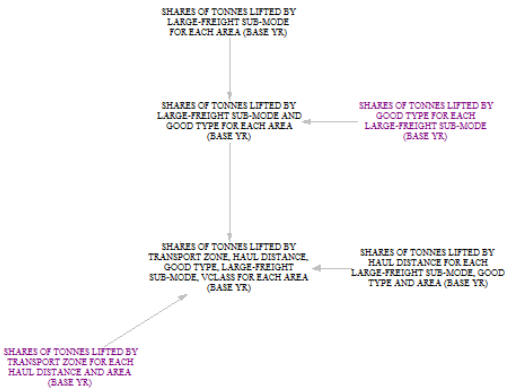
$$Haul\ length\ by\ haul\ distance\ for\ each\ area = \\ = \frac{\sum_{large-freight\ sub-modes} Length_{sub-mode\ i,haul\ distance\ j} \times Shares_{sub-mode\ i,haul\ distance\ j}}{\sum_{large-freight\ sub-modes} Shares_{sub-mode\ i,haul\ distance\ j}}$$

The shares of tonnes lifted by transport zone, haul distance, good type, large-freight sub-mode, vehicle class for each area (in the base year) is the result of multiplying the following shares disaggregated at different levels:

- Shares of tonnes lifted by haul distance for each large-freight sub-mode, good type and area (exogenous input from the user);
- Shares of tonnes lifted by transport zone for each haul distance and area (exogenous input from the user);
- Shares of tonnes lifted by large-freight sub-mode and good type for each area (product between the exogenous user input on the shares by good type for each large-freight sub-mode and the shares of tonnes lifted by large-freight sub-mode already calculated).

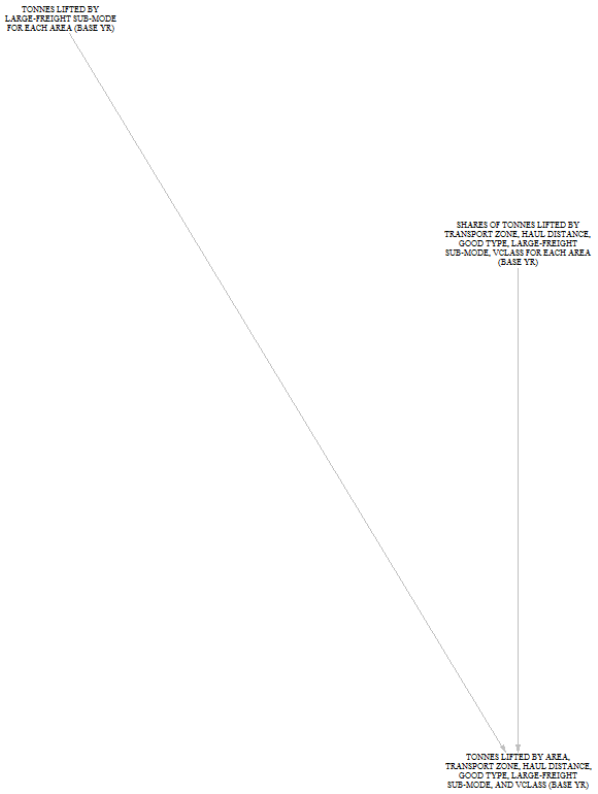
Figure 8.6 shows how this calculations flow is reflected in Vensim.

Figure 8.6 Shares by large-freight sub-mode, transport zone, haul distance and good type for each area



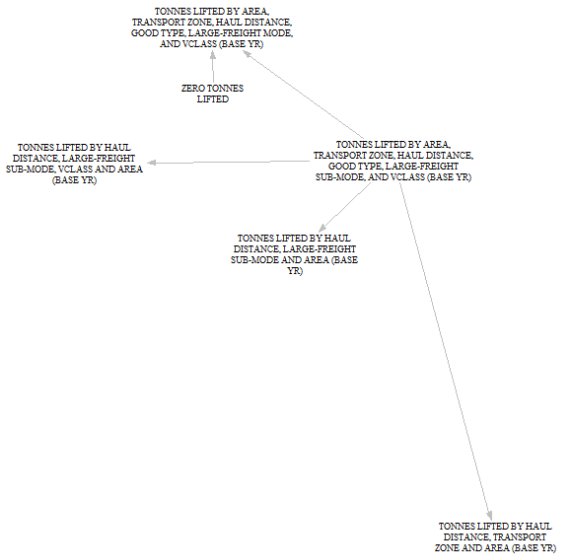
The tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class (base year) are calculated multiplying the tonnes lifted by large-freight sub-mode at the base year and the shares of tonnes lifted by transport zone, haul distance, good type, large-freight sub-mode, vehicle class for each area (Figure 8.7).

Figure 8.7 Tonnes lifted by large-freight sub-mode, area, transport zone, haul distance and good type



The tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class (base year) are summed up to evaluate the following base year partial aggregates (Figure 8.8): tonnes lifted by haul distance, transport zone and area; tonnes lifted by haul distance, large-freight sub-mode and area; tonnes lifted by haul distance, large-freight sub-mode, vehicle class and area; and tonnes lifted by area, transport zone, haul distance, good type, large-freight mode, and vehicle class.

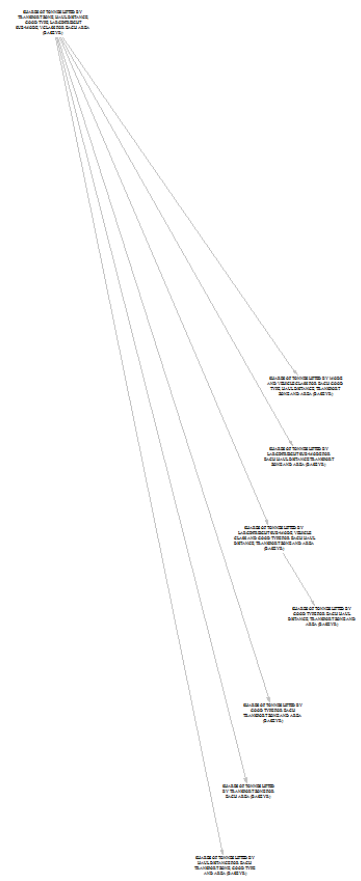
Figure 8.8 Aggregates of the tonnes lifted by large-freight sub-mode, area, transport zone, haul distance and good type



Calculation of shares disaggregated by different combinations of subscripts (base year)

The main output from this part of the view is the establishment of a structure with shares and tonnes lifted by and for different subscripts combinations.

Figure 8.9 Centre/bottom left of the view – Allocation by vehicle class and aggregations at different levels



This is achieved by means of performing different aggregations of the shares of tonnes lifted disaggregated at maximum level (by transport zone, haul distance, good type, large-freight sub-mode, vehicle class for each area) (Figure 8.9).

These aggregated shares represent the shares of tonnes lifted that the user can modify to characterize the evolution of the large-freight system over time.

Outputs

The shares of tonnes lifted by transport zone, haul distance, good type, large-freight sub-mode, vehicle class for each area represent the maximum disaggregation of this piece of information. The partial aggregation of these shares is used as a basis for the definition of the evolution of the freight transport system over time.

The list of outputs obtained from the shares of tonnes lifted by large-freight sub-mode, transport zone, haul distance, good-type and vehicle class for each area is reported below:

Shares of tonnes lifted by mode and vehicle class for each good type, haul distance, transport zone and area

They are obtained dividing the shares disaggregated at the maximum level by the sum of these shares throughout the LAGRE FREIGHT-SUB-MODE and VEHICLE CLASS subscripts. In other words, the calculation compares the shares disaggregated by all the subscripts with the shares by good type, haul distance, transport zone and area (without the LARGE-FREIGHT SUB-MODE and VEHICLE CLASS dimensions which have been aggregated).

$$Shares\ by\ sub-mode\ and\ class\ for\ each\ good, haul\ distance, transport\ zone\ and\ area = \\ = \frac{Shares\ by\ sub-mode, vehicle\ class, good\ type, haul\ distance, transport\ zone\ and\ area}{\sum_{sub-modes, vehicle\ classes} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}$$

Shares of tonnes lifted by large-freight sub-mode for each haul distance, transport zone and area

This is the result of the quotient between the shares by large-freight sub-mode, haul distance, transport zone and area, with the shares by haul distance, transport zone and area.

$$Shares\ by\ large-freight\ sub-mode\ for\ each\ haul\ distance, transport\ zone\ and\ area = \\ = \frac{\sum_{vehicle\ classes, good\ types} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}{\sum_{sub-modes, vclasses, goods} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}$$

Shares of tonnes lifted by good type for each haul distance, transport zone and area

They are calculated through the division between the shares by good type, haul distance, transport zone and area, with the shares broken down by haul distance, transport zone and area.

$$Shares\ by\ good\ type\ for\ each\ haul\ distance, transport\ zone\ and\ area = \\ = \frac{\sum_{sub-modes, vehicle\ classes} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}{\sum_{sub-modes, vclasses, goods} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}$$

Shares of tonnes lifted by good type for each transport zone and area

Calculated as the shares by good type, transport zone and area, divided by the shares disaggregated by transport zone and area.

$$Shares\ by\ good\ type\ for\ each\ transport\ zone\ and\ area = \\ = \frac{\sum_{sub-modes, vehicle\ classes, haul\ distances} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}{\sum_{sub-modes, vclasses, goods, haul\ distances} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}$$

Shares of tonnes lifted by transport zone for each area

The difference between the aggregation at the numerator and at the denominator determines the subscripts into which the resulting shares are disaggregated.

$$Shares\ by\ transport\ zone\ for\ each\ area = \\ = \frac{\sum_{sub-modes, vclasses, goods, haul\ distances} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}{\sum_{sub-modes, vclasses, goods, haul\ distances, zones} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}$$

Shares of tonnes lifted by haul distance for each transport zone, good type and area

This is the ratio between the shares by good type, haul distance, transport zone and area, and the same shares aggregated across the different HAUL DISTANCE subscripts

$$Shares\ by\ good\ type\ for\ each\ haul\ distance, transport\ zone\ and\ area = \\ = \frac{\sum_{sub-modes, vehicle\ classes} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}{\sum_{sub-modes, vclasses, haul\ distances} Shares\ by\ sub-mode, vclass, good, haul\ distance, zone\ and\ area}$$

Determination of the tonnes lifted over time by haul distance, transport zone and area (bottom of the view, in the middle)

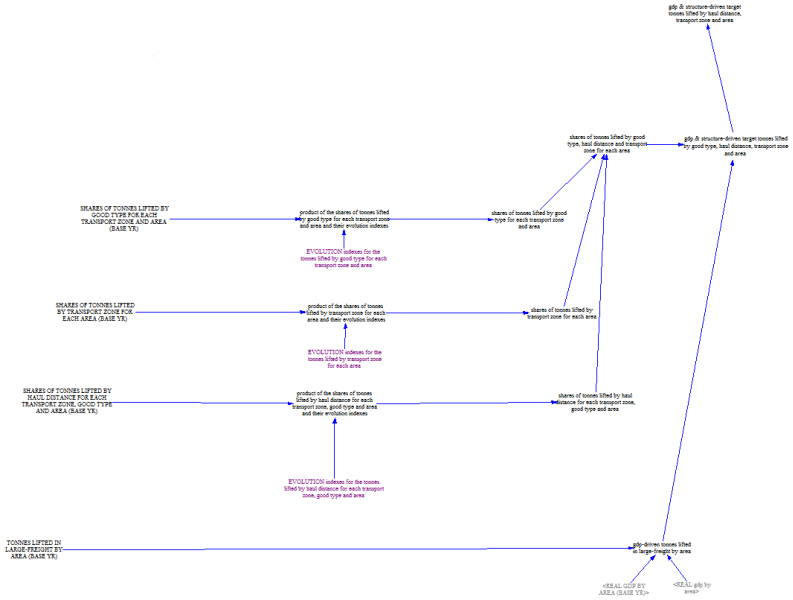
The base year shares resulting from the aggregation discussed earlier are converted into time-dependent parameters by means information on the structural evolution of the freight transport system provided by the user.

The combination of these time-dependent shares allows the evaluation of shares that can be disaggregated by more subscripts, up to the maximum disaggregation level (as discussed later).

In this way, the user needs only to introduce key shares related to policy inputs involving the economy's orientation, while then the large-freight system is automatically being built up through the calculations flow towards the top of the view. The shares are applied to the total tonnes lifted, which are figured out according to the evolution of the GDP.

Figure 8.10 shows the implemented steps to calculate the shares of tonnes lifted (as well as the tonnes lifted) over time, disaggregating them by haul distance, transport zone and area.

Figure 8.10 Bottom middle of the view – Determination of the tonnes lifted over time by haul distance, transport zone and area

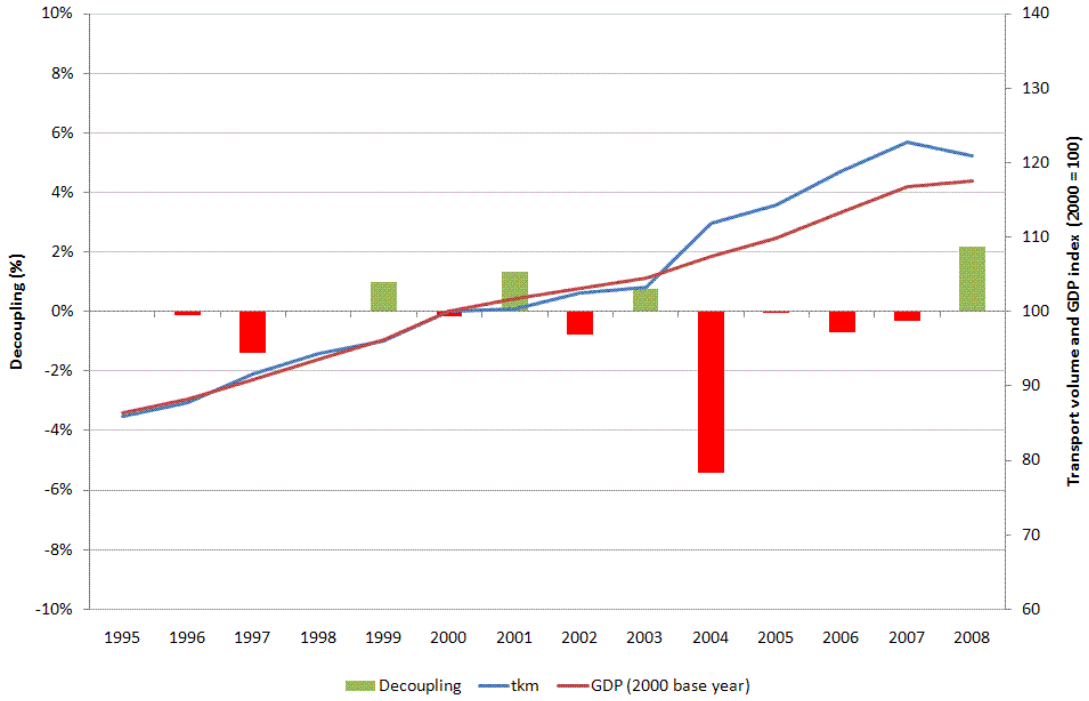


Inputs

The inputs needed in this portion of the view concern the GDP by area for the freight sector (already introduced in the view "economic parameters"). The evolution of the GDP over time is used in this view as the driver of the variation of the total number of tonnes lifted in large-freight transport over

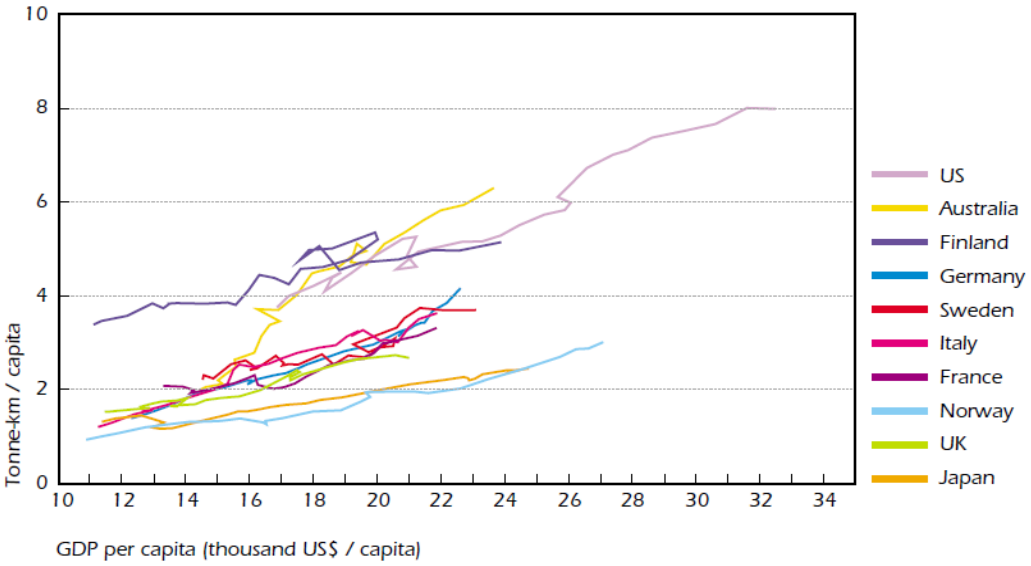
time. Given the limited changes over time of average travel per vehicle, this reflects the close coupling between freight transport activity and economic growth (Figure 8.11 and Figure 8.12).

Figure 8.11 Trend in European freight transport demand and GDP[2]



Source: EEA, 2011c

Figure 8.12. Trucking activity (tonne-km) per capita as a function of GDP per capita (1973-2000)



Source: IEA (2004)

[2] The increase in freight activity in 2004 is due to a change in the methodology used to calculate the estimates for this year.

The user needs to introduce (in the "Transport system (over time)" of the ForFITS Excel file) a number of indexes in order to describe how the shares at the base year, laid out on the left side of the view, evolve over time. This, in particular, concerns information on:

- Evolution indexes for the tonnes lifted by good type for each transport zone and area;
- Evolution indexes for the tonnes lifted by transport zone for each area;
- Evolution indexes for the tonnes lifted by haul distance for each transport zone, good type and area.

Outputs

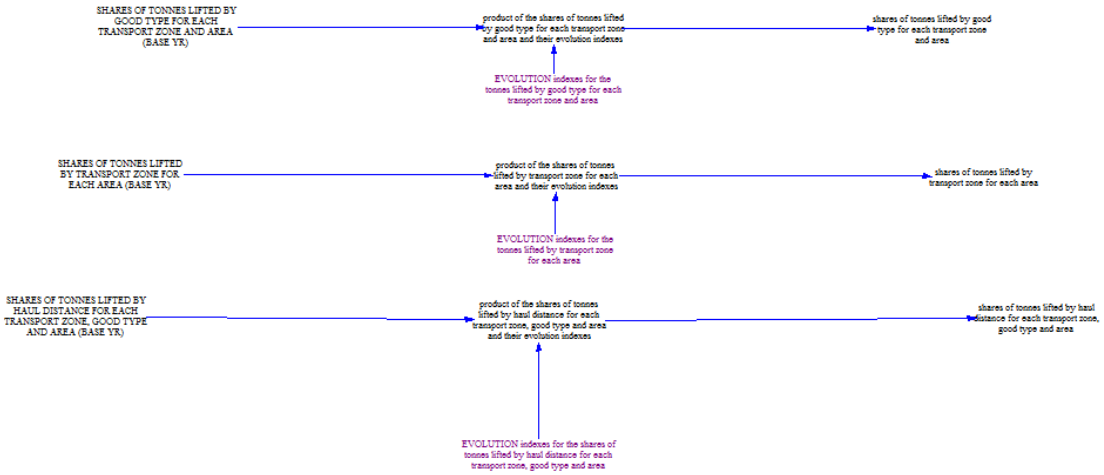
The percent variation of the tonnes lifted in large-freight compared to the base year value is assumed to be the same as the percentage change of the GDP.

$$gdp - driven\ tonnes\ lifted\ in\ large - freight\ by\ area\ over\ time =$$
$$= Tonnes\ lifted\ in\ large - freight\ by\ area\ (base\ year) \times \frac{Real\ GDP\ by\ area\ over\ time}{Real\ GDP\ by\ area\ (base\ year)}$$

The shares at the base year are multiplied by their evolution indexes and subsequently normalized in order to ensure that the sum across the subscript into which the variable is disaggregated "by" (see Box 8.1 for more information on the "by" disaggregation) is always 1.

Figure 8.13 shows the symmetrical structure between the right side (shares over time) and the left side (shares at the base year).

Figure 8.13 Shares over time as result of the shares at the base year and the evolution indexes from the user



The next equation below shows how the shares over time are calculated.

$$Shares\ of\ tonnes\ lifted\ by\ X\ for\ each\ Y\ and\ Z\ (over\ time) =$$
$$= \frac{Shares\ by\ X\ for\ each\ Y\ and\ Z\ at\ the\ base\ year \times Evolution\ indexes}{\sum_{across\ subscript\ X} Shares\ by\ X\ for\ each\ Y\ and\ Z\ at\ the\ base\ year \times Evolution\ indexes}$$

Due to the normalization calculation, the following relationship is always true.

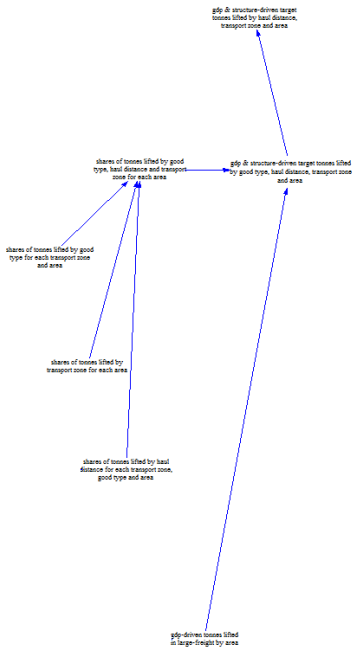
$$\sum_{across\ subscript\ X} Shares\ of\ tonnes\ lifted\ by\ X\ for\ each\ Y\ and\ Z\ (over\ time) = 1$$

The shares of tonnes lifted by good type, haul distance and transport zone for each area, are obtained by multiplying the three shares over time already calculated, i.e. the shares of tonnes lifted by transport zone for each area; the shares of tonnes lifted by good type for each transport zone and area; and the shares of tonnes lifted by haul distance for each transport zone, good type and area (again, for more information on the "by" and "for" disaggregation, see Box 8.1).

The tonnes lifted over time disaggregated by good type, haul distance, transport zone and area, can be expressed as the product between the total tonnes in large freight by area and the shares of tonnes lifted by good type, haul distance and transport zone for each area.

Figure 8.14 shows the calculation of the tonnes lifted by haul distance, transport zone and area over time, achieved through summing up across the GOOD TYPE subscript.

Figure 8.14 Tonnes lifted over time by haul distance, transport zone and area



Determination of the tonnes lifted over time by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class (centre of the view)

This section is the continuation of the calculations flow towards the top of the view intended to describe the whole picture of the large freight system over time. In particular, the maximum level of detail is reached with the calculation of the shares disaggregated by all the subscripts on the basis of the outputs from the previous section and exogenous inputs from the user on the target large-freight system.

As it is shown in Figure 8.15, this section targets the calculation of tonnes lifted disaggregated by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class. This is calculated as product of the following factors: a) the tonnes lifted by haul distance, transport zone

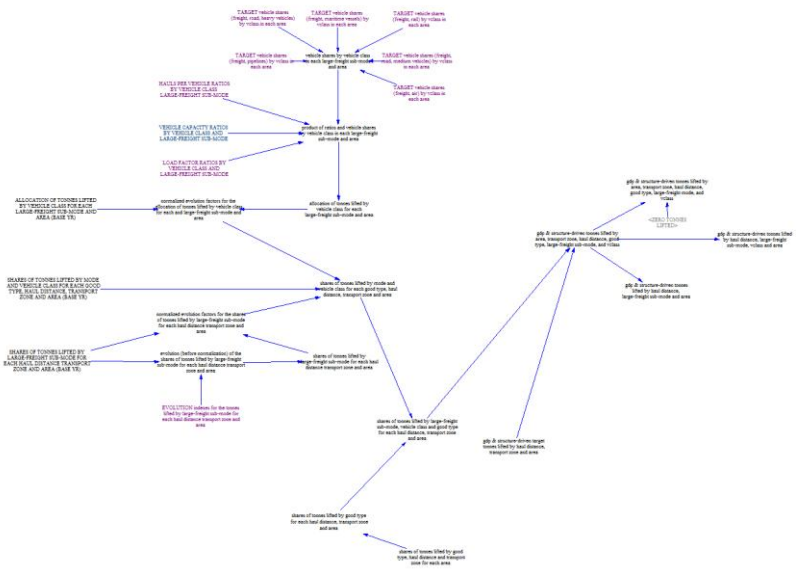
and area (output of the earlier section); and b) the shares of tonnes lifted by large-freight sub-mode, vehicle class and good type for each haul distance, transport zone and area.

The latter is calculated multiplying: a) the shares of tonnes lifted by large-freight sub-mode, vehicle class and good type for each haul distance, transport zone and area (achieved through the combination of base year values and parameters targeted over time by the user); and b) the shares of tonnes lifted by good type for each haul distance, transport zone and area.

This last parameters is obtained by manipulating the output from the earlier section on the shares of tonnes lifted by good type, haul distance and transport zone for each area, as in the following equation.

$$Shares\ by\ good\ type\ for\ each\ haul\ distance, transport\ zone\ and\ area = \\ = \frac{Shares\ by\ good\ type, haul\ distance\ and\ transport\ zone\ for\ each\ area}{\sum_{good\ types} Shares\ by\ good\ type, haul\ distance\ and\ transport\ zone\ for\ each\ area}$$

Figure 8.15 Middle centre of the view – Determination of the tonnes lifted over time by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class



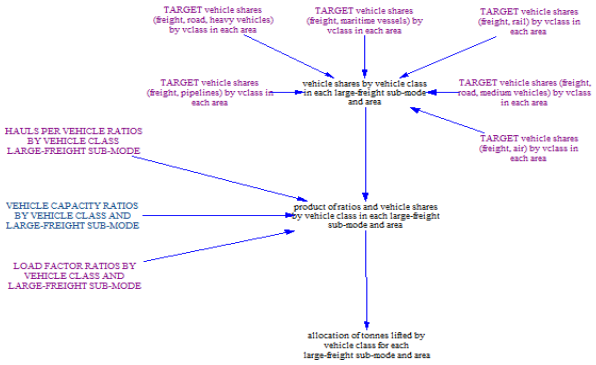
Inputs

The user specifies (in the "Transport system (over time)" sheet of the ForFITS Excel file) the evolution over time for the tonnes lifted by large-freight sub-mode for each haul distance transport zone and area.

The first three of the four factors influencing the allocation of the shares of tonnes lifted in each vehicle class (hauls per vehicle, vehicle capacity, load factor per vehicle, number of vehicles in the vehicle fleet) are considered constant parameters. The last parameter is set over time by means of exogenous inputs (entered in the "User inputs (over time)" sheet of the ForFITS Excel file). In particular, the user specifies the target vehicle shares by vehicle class within each large-freight sub-mode and area.

Figure 8.16 shows how the same structure of the base year is reproduced on the right to calculate the shares by vehicle class for each large-freight sub-mode and area over time.

Figure 8.16 Shares by vehicle class for each large-freight sub-mode and area (over time)



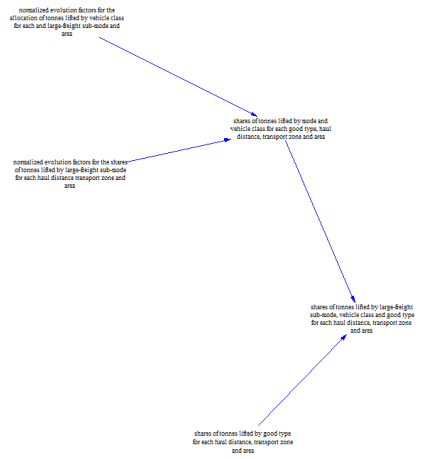
Outputs

The shares by vehicle class are divided by their value at the base year in order to get the "normalized evolution factors for the allocation of tonnes lifted by vehicle class for each and large-freight sub-mode and area".

The combination of the shares at the base year by large-freight sub-mode for each haul distance, transport zone and area, along with its evolution indexes (introduced by the user) enable to calculate the same shares over time. The quotient of the two shares (base year and over time) provides the "normalized evolution factors for the shares of tonnes lifted by large-freight sub-mode for each haul distance transport zone and area".

Figure 8.17 shows the shares by mode and vehicle class for each good type, haul distance, transport zone and area, as result of multiplying the base year shares by the two normalized factors detailed in the two previous paragraphs. These shares, along with those split by good type for each haul, transport zone and area, lead to the shares by large-freight sub-mode, vehicle class and good type for each haul distance, transport zone and area.

Figure 8.17 Shares by large-freight sub-mode, vehicle class and good type for each haul distance, transport zone and area (over time)



The shares by large-freight sub-mode, vehicle class and good type for each haul distance, transport zone and area, are applied to the tonnes lifted by haul distance, transport zone and area. This allows to calculate the tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-

mode, and vehicle class. They are subsequently aggregated at different levels of subscripts following the same structure as in the base year on the left side of the view.

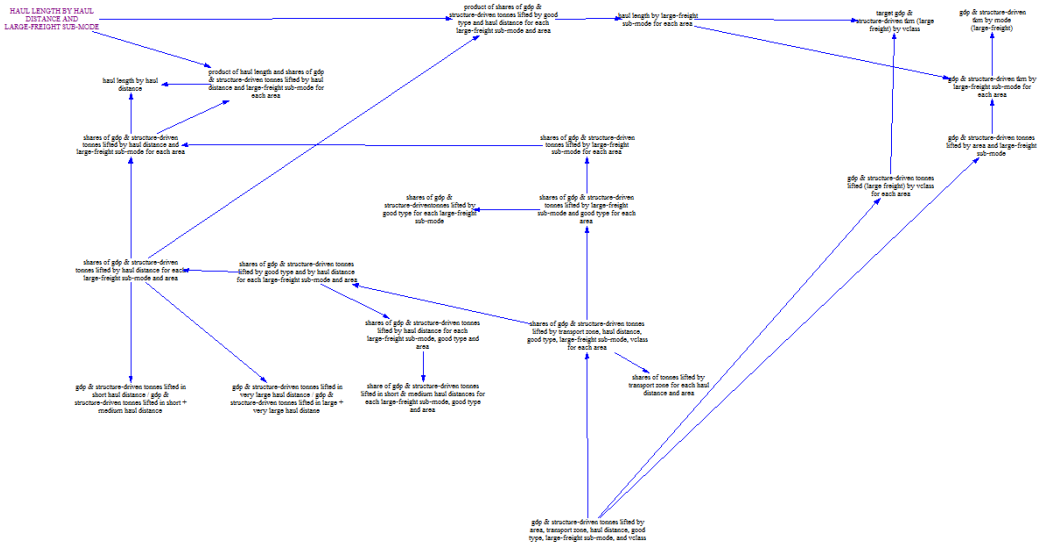
Determination of several outputs regarding shares, tonnes lifted, haul length and tkm (top right of the view)

This section uses the tonnes lifted disaggregated at maximum level the previous section to evaluate the haul length over time and the transport activity in the large-freight system.

The calculations carried out on the top left of the view are now performed on the reverse way. This section also provides outputs on shares and tonnes lifted at different levels of detail.

Figure 8.18 shows the steps leading to the haul length expressed in different ways and to the large-freight activity in tkm.

Figure 8.18 Top right of the view – Determination of haul length over time and large-freight activity



Inputs

The haul length by haul distance and large-freight sub-mode, associating a particular distance (expressed in km) to each transport distance class and large-freight sub-mode is also considered here in this section.

The starting point for all the following calculations are the tonnes lifted over time achieved in the earlier section, split in different ways:

a) Tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class;

b) Tonnes lifted in large freight by vehicle class for each area (result of aggregating the first one across the TRANSPORT ZONE, HAUL DISTANCE and GOOD TYPE subscripts, as well as allocating each large freight sub-mode to its corresponding MODE subscript);

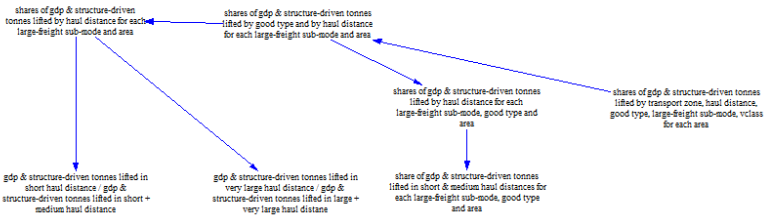
c) Tonnes lifted by area and large-freight sub-mode (result of aggregating the first one across the TRANSPORT ZONE, HAUL DISTANCE, GOOD TYPE and VEHICLE CLASS subscripts).

Outputs

The shares by transport zone, haul distance, good type, large-freight sub-mode and vehicle class for each area, are calculated through comparing: a) the tonnes lifted by area, transport zone, haul distance, good type, large-freight sub-mode, and vehicle class; with b) the tonnes lifted only split by area. These shares, disaggregated by all the subscripts, initialize a number of calculations that provide shares disaggregated "by" and "for" different subscripts (for more information on the "by" and "for" disaggregation, see Box 8.1) through various aggregations.

Figure 8.19 represents the flow of calculations that converts the shares by transport zone, haul distance, good type, large-freight sub-mode and vehicle class for each area, into the shares of tonnes lifted disaggregated only by transport distance.

Figure 8.19 Shares of tonnes lifted by transport distance over time



The equations below show the calculations performed to calculate all the parameters of Figure 8.19.

Shares by good type and by haul distance for each large-freight sub-mode and area

$$Shares\ by\ good\ type\ and\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area = \\ = \frac{\sum_{zones,vclasses} Shares\ by\ zone, haul\ distance, good, sub-mode\ and\ vclass\ for\ each\ area}{\sum_{zones,goods,haul\ distances,vclasses} Shares\ by\ zone, haul\ distance, good, sub-mode\ and\ vclass\ for\ each\ area}$$

Shares by haul distance for each large-freight sub-mode and area

$$Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area = \\ = \sum_{good\ types} Shares\ by\ good\ type\ and\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area$$

Share of tonnes lifted in short haul distance in short plus medium haul distances

$$Share\ of\ tonnes\ lifted\ in\ short\ haul\ distance\ in\ short\ plus\ medium\ haul\ distances = \\ = \frac{Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area\ [SHORT]}{Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area\ [SHORT] + [MEDIUM]}$$

Share of tonnes lifted in very large haul distance in large plus very large haul distances

$$Share\ of\ tonnes\ lifted\ in\ very\ large\ haul\ \ distance\ in\ large\ plus\ very\ large\ haul\ distances = \\ = \frac{Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area\ [VERY\ LARGE]}{Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area\ [LARGE] + [VERY\ LARGE]}$$

Shares by haul distance for each large-freight sub-mode, good type and area

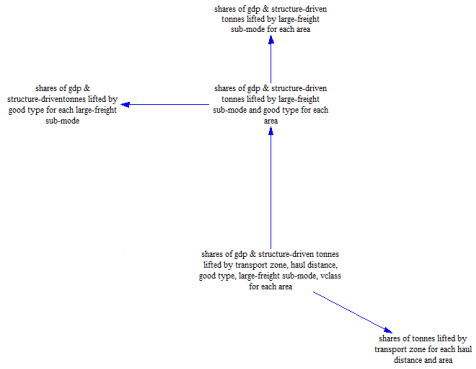
$$Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode, good\ type\ and\ area = \\ = \frac{Shares\ by\ good\ type\ and\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area}{\sum_{haul\ distances} Shares\ by\ good\ type\ and\ haul\ distance\ for\ each\ large-freight\ sub-mode\ and\ area}$$

Share of tonnes lifted in short or medium haul distances for each large-freight sub-mode, good type and area

$$Share\ of\ tonnes\ lifted\ in\ short/medium\ haul\ distances\ for\ each\ sub-mode, good\ type\ and\ area = \\ = Shares\ by\ haul\ distance\ for\ each\ large-freight\ sub-mode, good\ type\ and\ area\ [SHORT] + [MEDIUM]$$

Figure 8.20 shows the calculations flow that starting from the shares by transport zone, haul distance, good type, large-freight sub-mode and vehicle class for each area, leads to aggregated shares mainly split in GOOD TYPE and LARGE-FREIGHT SUB-MODE subscripts.

Figure 8.20 Shares mainly split in GOOD TYPE and LARGE-FREIGHT SUB-MODE subscripts



The equations below show the calculations performed to calculate all the parameters of Figure 8.20.

Shares by transport zone for each haul distance and area

$$Shares\ by\ transport\ zone\ for\ each\ haul\ distance\ and\ area = \\ = \frac{\sum_{goods,submodes,vclasses} Shares\ by\ zone, haul\ distance, good, sub-mode\ and\ vclass\ for\ each\ area}{\sum_{zones,goods,submodes,vclasses} Shares\ by\ zone, haul\ distance, good, sub-mode\ and\ vclass\ for\ each\ area}$$

Shares by large-freight sub-mode and good type for each area

$$Shares\ by\ large-freight\ sub-mode\ and\ good\ type\ for\ each\ area = \\ = \frac{\sum_{zones,haul\ distances,vclasses} Shares\ by\ zone, haul\ distance, good, submode\ and\ vclass\ for\ area}{\sum_{zones,haul\ distances,goods,submodes,vclasses} Shares\ by\ zone, haul\ distance, good, submode\ and\ vclass\ for\ area}$$

Shares by good type for each large-freight sub-mode

$$Shares\ by\ good\ type\ for\ each\ large-freight\ sub-mode = \\ = \frac{Shares\ by\ large-freight\ sub-mode\ and\ good\ type\ for\ each\ area}{\sum_{good\ types} Shares\ by\ large-freight\ sub-mode\ and\ good\ type\ for\ each\ area}$$

Shares by large-freight sub-mode for each area

$$Shares\ by\ submode\ for\ each\ area = \sum_{good\ types} Shares\ by\ submode\ and\ good\ type\ for\ each\ area$$

The haul length over time is an output provided at different levels of aggregation. The haul length by haul distance is the result of the weighted average shown in the following equation, summing up across the LARGE-FREIGHT SUB-MODE subscript.

$$Haul\ length\ by\ haul\ distance = \\ = \frac{\sum_{sub-modes} Haul\ length\ by\ haul\ distance\ and\ submode \times Shares\ by\ haul\ distance\ and\ submode\ for\ each\ area}{\sum_{sub-modes} Shares\ by\ haul\ distance\ and\ sub-mode\ for\ each\ area}$$

The haul length by haul distance and large-freight sub-mode used in this equation is a user input. The shares by haul distance and large-freight sub-mode for each area results from the product of: a) the shares by haul distance for each sub-mode and area; and b) the shares by sub-mode for each area, as indicated in the equation below.

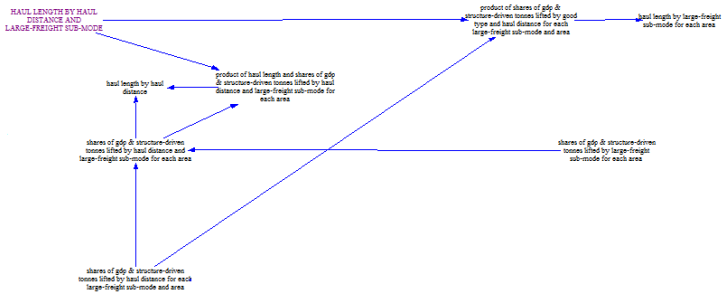
$$Shares\ by\ haul\ distance\ and\ large-freight\ sub-mode\ for\ each\ area =$$
$$= Shares\ by\ haul\ distance\ for\ each\ sub-mode\ and\ area \times Shares\ by\ sub-mode\ for\ each\ area$$

The haul length by large-freight sub-mode for each area is calculated as the average of the haul length by haul distance and large-freight sub-mode (exogenous input), weighting by the shares by haul distance for each large-freight sub-mode and area (already calculated earlier). This is shown on the following equation.

$$Haul\ length\ by\ large-freight\ sub-mode\ for\ each\ area =$$
$$= \sum_{haul\ distances} Length\ by\ haul\ distance\ and\ submode \times Shares\ by\ haul\ distance\ for\ each\ submode\ and\ area$$

The steps carried out to achieve the haul length over time, disaggregated by different subscripts, are reproduced in Figure 8.21.

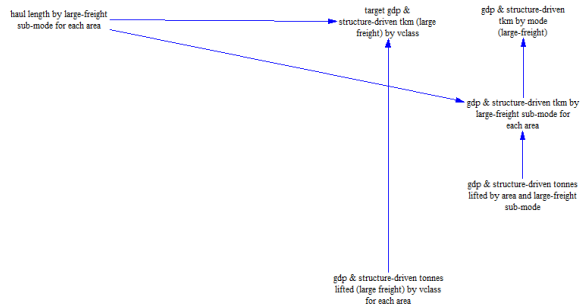
Figure 8.21 Haul length over time



Finally, freight activity is calculated over time in terms of tkm as the product between the tonnes lifted and the haul length.

As shown in Figure 8.22, tkm are evaluated at different levels of aggregation.

Figure 8.22 Tkm over time



Tkm by large-freight sub-mode for each area

$$tkm\ by\ large-freigth\ sub-mode\ for\ each\ area =$$
$$= tonnes\ lifted\ by\ area\ and\ \ sub-mode \times haul\ length\ by\ sub-mode\ for\ each\ area$$

Tkm in large freight by mode

This consists in the allocation of tkm by large-freight sub-mode for each area to its corresponding MODE subscript.

Tkm in large freight by vehicle class

$$tkm\ in\ large\ freight\ by\ vehicle\ class = \\ = tonnes\ lifted\ by\ vehicle\ class\ for\ each\ area \times haul\ length\ by\ sub-mode\ for\ each\ area$$

References

EEA (European Environment Agency) (2011), *Trend in freight transport demand and GDP*, http://www.eea.europa.eu/data-and-maps/figures/trend-in-freight-transport-demand-and-gdp-3

IEA (International Energy Agency) (2004), *Oil Crises & Climate Challenges. 30 years of energy use in IEA countries*, http://www.oecdbookshop.org/oecd/display.asp?sf1=identifiers&st1=9789264018822