26. Cost of driving

Overview

Target

The target of the view is to calculate the total cost of moving passenger or goods (shortened as "cost of driving"), including the following cost components: fuel cost, cost of crew, cost of vehicles and the cost due to road pricing (note: vehicle maintenance cost, insurance cost and other cost components are not taken into account, at the moment). The outputs are aggregated at different levels of detailed and are expressed in constant base year USD per vkm, as well as constant base year USD per pkm and per tkm (in case of passenger and freight services, respectively).
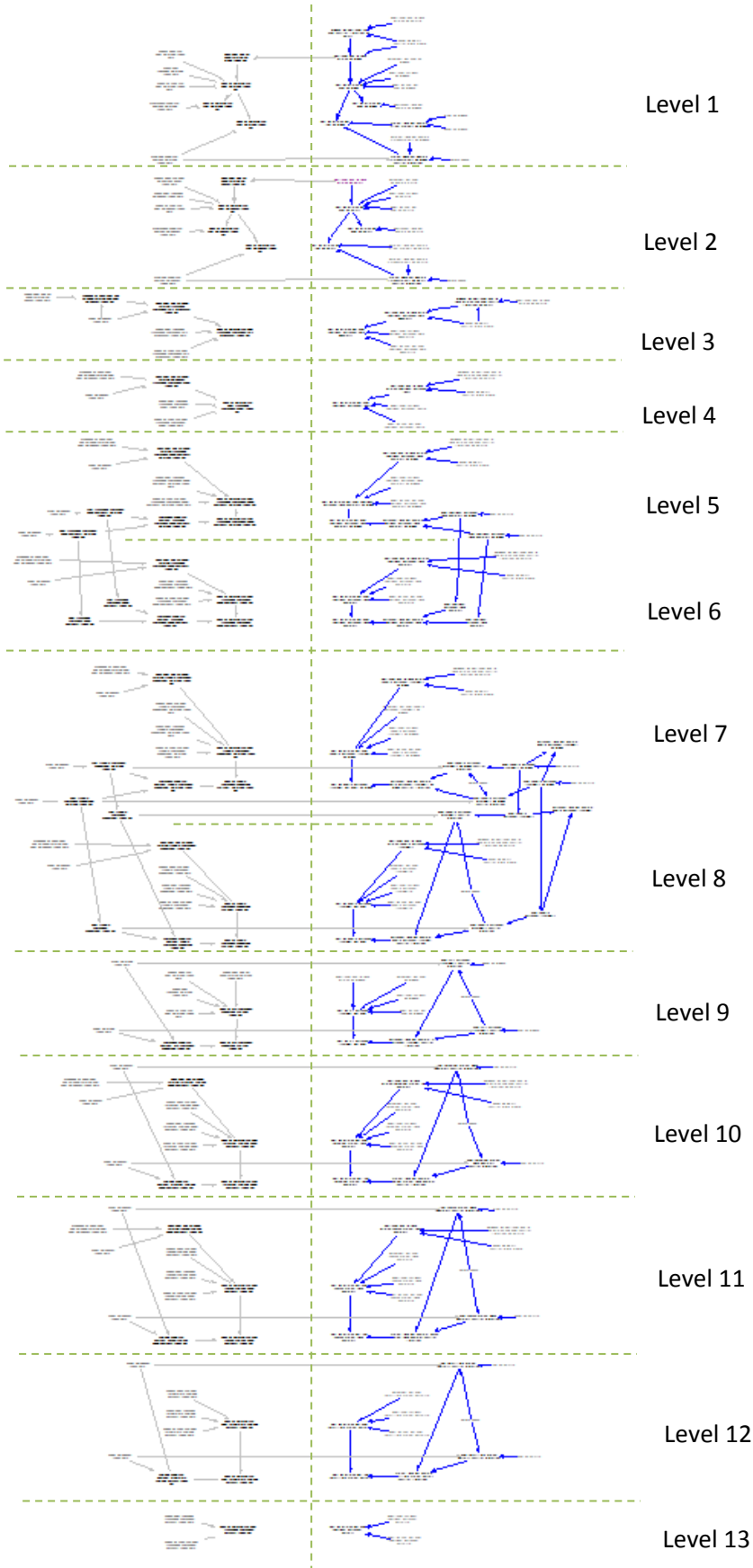
Structure

The left half of the view deals with the costs in the base year, while the right part focuses on the cost of driving over time.

The view is structured in different groups of calculations corresponding to different levels of aggregation of the data. Overall the levels represent the modes and sub-modes considered by ForFITS for passenger and freight services (see Table 26.1 and Figure 26.1).

Table 26.1   Levers covered in the view

Level 1	Cost of driving by mode
Level 2	Cost of driving by vehicle class
Level 3	Cost of driving for personal passenger two and three wheelers
Level 4	Cost of driving for personal passenger LDVs
Level 5	Cost of driving by mode for personal passenger road vehicles
Level 6	Cost of driving for personal passenger road vehicles
Level 7	Cost of driving by mode for public passenger transport
Level 8	Cost of driving for public passenger transport
Level 9	Cost of driving for air passenger transport
Level 10	Cost of driving for medium freight road vehicles
Level 11	Cost of driving for heavy freight road vehicles
Level 12	Cost of driving for maritime freight vessels
Level 13	Cost of driving for personal passenger vessels

Figure 26.1   Vensim sketch of the view "cost of driving"

Level 1

Level 2

Level 3

Level 4

Level 5

Level 6

Level 7

Level 8

Level 9

Level 10

Level 11

Level 12

Level 13

Detailed description of the view

Inputs

The cost of driving results from the sum of four components providing information on: the cost of fuel (applicable at all the levels), the cost of vehicles (applicable at all the levels), the cost of crew (applicable only for public and air passenger transport as well as for freight service) and the cost due to road pricing (applicable only for road vehicles and where road pricing policies are in place). The first three are calculated endogenously at the different levels of detail needed in the respective views ("cost of fuel", "cost of vehicles", "cost of crew"). The road pricing component enters directly in this view as an exogenous input[1]. The cost due to road pricing is specified by the user ("User inputs (over time)" sheet of the ForFITS Excel file) as cost per vkm disaggregated by mode, also distinguishing between personal and public for passenger serviced, as well as, in case of large road vehicles, between medium and heavy trucks[2]. This information from the user enables to split the cost per vkm due to road pricing by vehicle class. The latter must then be aggregated according to each of the 13 levels considered in this view.

Table 26.2 shows how the cost per vkm due to road pricing is aggregated, by means of averages weighted by vkm, in each of the 13 levels considered here. The variable "VKM BY VCLASS" is calculated in the view "activity, loads and stock aggregates". Since Vensim does not handle easily iterative calculations for data changing simultaneously over the same time step, "VKM BY VCLASS" is delayed by one time step (the simultaneous loop is due to the fact that the cost of driving affects the transport demand generation, and the demand generation is needed to estimate the cost of driving).

Table 26.2   Cost per vkm due to road pricing aggregated at each level

Level	*Cost due to road pricing*
1. By mode	$$\frac{\sum_{vclasses} cost\ by\ vclass \times vkm\ by\ vehicle\ class}{\sum_{vclasses} vkm\ by\ vehicle\ class}$$
2. By vehicle class	Available input from the user
3. For personal passenger TWO and THREE WHEELERS	$$\frac{\sum_{2\&3\ wheelers} \sum_{vclasses\ a\ to\ d} cost\ by\ vclass \times vkm\ by\ vehicle\ class}{\sum_{2\&3\ wheelers} \sum_{vclasses\ a\ to\ d} vkm\ by\ vehicle\ class}$$
4. For personal passenger LDVS	$$\frac{\sum_{vclasses\ a\ to\ d} cost\ by\ vclass[LDVS] \times vkm\ by\ vehicle\ class[LDVS]}{\sum_{vclasses\ a\ to\ d} vkm\ by\ vehicle\ class\ [LDVS]}$$
5. By mode for personal passenger	- For TWO WHEELERS, THREE WHEELERS and LDVS: $$\frac{\sum_{vclasses\ a\ to\ d} cost\ by\ vclass \times vkm\ by\ vehicle\ class}{\sum_{vclasses\ a\ to\ d} vkm\ by\ vehicle\ class}$$

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[1] The default value of the cost per vkm due to road pricing is set to zero in the ForFITS Excel file. This means that road pricing will not be considered in the total cost of driving unless data are introduced by the user.
[2] Road pricing inputs need to reflect average charges due to road pricing policies, integrating the effects due road pricing on changes in vehicle activity across different periods of the day and on different network patterns, since ForFITS is not suitable for the calculation of these effects.

Level	Cost due to road pricing
road vehicles	
6. For personal passenger road vehicles	$$\dfrac{\sum_{2\&3\ wheelers,ldvs}\sum_{vclasses\ a\ to\ d} cost\ by\ vclass \times vkm\ by\ vehicle\ class}{\sum_{2\&3\ wheelers,ldvs}\sum_{vclasses\ a\ to\ d} vkm\ by\ vehicle\ class}$$
7. By mode for public passenger transport	- For TWO WHEELERS, THREE WHEELERS and LDVS: $$\dfrac{\sum_{vclasses\ e\ and\ f} cost\ by\ vclass \times vkm\ by\ vehicle\ class}{\sum_{vclasses\ e\ and\ f} vkm\ by\ vehicle\ class}$$ - For LARGE ROAD: $$\dfrac{\sum_{vclasses} cost\ by\ vclass \times vkm\ by\ vehicle\ class}{\sum_{vclasses} vkm\ by\ vehicle\ class}$$
8. For public passenger transport	$$\dfrac{\sum_{2\&3\ wheel.,ldvs,large\ road}\sum_{pub.pass.trans.vclasses} cost\ by\ vclass \times vkm\ by\ vclass}{\sum_{2\&3\ wheel.,ldvs,large\ road}\sum_{pub.pass.trans.vclasses} vkm\ by\ vclass}$$
9. For air passenger transport	$$\dfrac{\sum_{vclasses} cost\ by\ vclass[AIR] \times vkm\ by\ vehicle\ class[AIR]}{\sum_{vclasses} vkm\ by\ vehicle\ class\ [AIR]}$$
10. For medium freight road vehicles	$$\dfrac{\sum_{vclasses\ a\ to\ c} cost\ by\ vclass[LARGE\ ROAD] \times vkm\ by\ vclass[LARGE\ ROAD]}{\sum_{vclasses\ a\ to\ c} vkm\ by\ vehicle\ class\ [LARGE\ ROAD]}$$
11. For heavy freight road vehicles	$$\dfrac{\sum_{vclasses\ d\ to\ f} cost\ by\ vclass[LARGE\ ROAD] \times vkm\ by\ vclass[LARGE\ ROAD]}{\sum_{vclasses\ d\ to\ f} vkm\ by\ vehicle\ class\ [LARGE\ ROAD]}$$
12. For maritime freight vessels	Not applicable
13. For personal passenger vessels	Not applicable

The load per vehicle allows converting the cost of driving per vkm into the cost per pkm or tkm. Inputs on load are available at the vehicle class level. They must be aggregated in concordance with the 13 levels (Table 26.3 and Table 26.4). Normally, this operation consist in dividing aggregates on passenger/freight transport activity by aggregates on vehicle activity, where the aggregates result from summing up the "PKM/TKM BY VCLASS" and "VKM BY VCLASS" (from the view "activity, loads and stock aggregates") across the corresponding subscripts.

Table 26.3   Levels that involve both services (PASSENGER and FREIGHT)

Level	Passenger load per vehicle	Freight load per vehicle
1. By mode	From view "activity, loads and stock aggregates"	- Light freight: ratio between tkm and vkm by mode, both from the view "activity, loads and stock aggregates" - Large freight: calculated in the view "load (freight)" but delayed one time step to avoid simultaneous errors. In particular, the variable" freight load per vehicle

Level	Passenger load per vehicle	Freight load per vehicle
		(large-freight) by mode" is deduced on the basis of the target tkm and vkm, both depending at the same time on the cost of driving through elasticities
2. By vehicle class	From the view "load (passenger)"	- Light freight: from the view "load (freight)" - Large freight: calculated in the view "load (freight)" but also delayed to avoid simultaneous errors. In particular, the variable "freight load per vehicle (large-freight) by vclass" derives from data on target tkm and vkm, which at the same time depend on the cost of driving.

Table 26.4   Levels that involve only one service (PASSENGER or FREIGHT)

Level	Passenger/Fright load per vehicle
3. For personal passenger TWO and THREE WHEELERS:	Not applicable because only the cost per vkm is calculated.
4. For personal passenger LDVS:	Not applicable because only the cost per vkm is calculated.
5. By mode for personal passenger road vehicles:	For TWO WHEELERS, THREE WHEELERS and LDVS: $$\frac{\sum_{vclasses\ a\ to\ d} pkm\ by\ vclass}{\sum_{vclasses\ a\ to\ d} vkm\ by\ vclass}$$
6. For personal passenger road vehicles:	$$\frac{\sum_{2\&3\ wheelers, ldvs} \sum_{vclasses\ a\ to\ d} pkm\ by\ vclass}{\sum_{2\&3\ wheelers, ldvs} \sum_{vclasses\ a\ to\ d} vkm\ by\ vclass}$$
7. By mode for public passenger transport:	- For NMT, TWO WHEELERS, THREE WHEELERS, LDVS and VESSELS: $$\frac{\sum_{vclasses\ e\ and\ f} pkm\ by\ vclass}{\sum_{vclasses\ e\ and\ f} vkm\ by\ vclass}$$ - For LARGE ROAD and RAIL: $$\frac{\sum_{vclasses} pkm\ by\ vclass}{\sum_{vclasses} vkm\ by\ vclass}$$
8. For public passenger transport:	$$\frac{\sum_{nmt,2\&3\ wheel.,ldvs,large\ road,rail} \sum_{pub.pass.trans.vclasses} pkm\ by\ vclass}{\sum_{nmt,2\&3\ wheel.,ldvs,large\ road,rail} \sum_{pub.pass.trans.vclasses} vkm\ by\ vclass}$$
9. For air passenger transport:	$$\frac{\sum_{vclasses} pkm\ by\ vclass[AIR]}{\sum_{vclasses} vkm\ by\ vclass\ [AIR]}$$
10. For medium freight road vehicles:	$$\frac{\sum_{vclasses\ a\ to\ c} tkm\ by\ vclass[LARGE\ ROAD]}{\sum_{vclasses\ a\ to\ c} vkm\ by\ vclass\ [LARGE\ ROAD]}$$

Level	Passenger/Fright load per vehicle
11. For heavy freight road vehicles:	$$\frac{\sum_{vclasses\ d\ to\ f} tkm\ by\ vclass[LARGE\ ROAD]}{\sum_{vclasses\ d\ to\ f} vkm\ by\ vclass\ [LARGE\ ROAD]}$$
12. For maritime freight vessels:	$$\frac{\sum_{vclasses\ c\ to\ f} tkm\ by\ vclass[VESSELS]}{\sum_{vclasses\ c\ to\ f} vkm\ by\ vclass\ [VESSELS]}$$
13. For personal passenger vessels:	Not applicable because only the cost per vkm is calculated.

Note   Normally these calculations use the pkm/tkm/vkm variables delayed by one time step to avoid simultaneous errors.
As explained earlier, this due to the fact that the load per vehicle depends on vehicle and transport activity, which, in turn, are affected by the cost of driving.
In some occasions, the load is considered as completely independent on the cost of driving. This happens for personal passenger vehicles or light freight service, where the average load is considered as a function of vehicle ownership and vehicle shares, respectively.

Outputs

The cost of driving per vkm is generally calculated as the sum of the following components:

$$Cost\ of\ driving = Cost\ of\ fuel + Cost\ of\ vehicles + Cost\ of\ crew + Cost\ due\ to\ road\ pricing$$

The combination of the cost per vkm and information on vehicle load lead to the cost per pkm/tkm:

$$Cost\ of\ driving\ per\ pkm = \frac{Cost\ of\ driving\ per\ vkm}{Passenger\ load\ per\ vehicle}$$

$$Cost\ of\ driving\ per\ tkm = \frac{Cost\ of\ driving\ per\ vkm}{Freight\ load\ per\ vehicle}$$

The outputs on the cost of driving are especially relevant for the transport demand generation module, since the projections on passenger and freight activity over time take into account the effect of the costs through direct and cross elasticities. The cost of driving is also influent on the determination of the annual travel per vehicle in case of personal passenger vehicles and light freight service.