7. Demand (passenger, air)

Overview

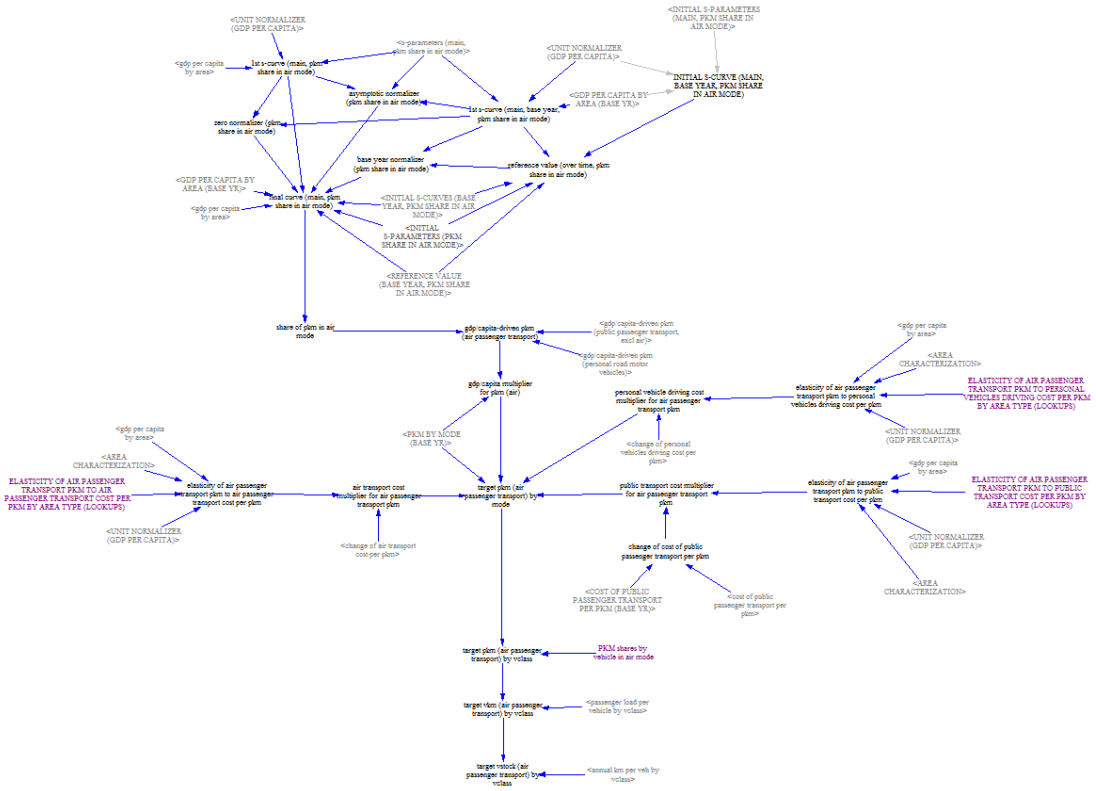
Target

The view is intended to forecast the target pkm in air transport through the S-curves that link the GDP per capita with the share of air transport pkm in the total pkm (personal vehicles, public and air transport). The final estimation of the target pkm in air transport takes into account not only the influence of the macroeconomic parameters, but also the impact caused by the changes on the cost of driving in the different modal options. The view includes calculations of the "target vkm" and "target vehicle stock" ("target" indicates that these values are the target values to be matched in model views like "vehicles by age", where vehicles are evaluated in detail).

Structure

The set of variables used in this view (Figure 7.1) and the structure of their organization are very similar to the one introduced for the "demand (passenger, public)" view. The top section contains calculations concerning the definition of the pkm share on public transport drivers on the basis of changes in the GDP per capita. The central variable is the key output of the view: pkm on air passenger transport, by mode. The vertical line of variables below it contains the flow of calculations allowing to move from pkm to vkm and the vehicle stock. Modules on the right and left of this vertical axis contain information on the elasticities of pkm with respect to changes in the cost of driving of different "passenger transport driving modes" (air, public transport and personal vehicles).

Figure 7.1 Demand (passenger, air): Vensim sketch



Detailed description of the view

This view addresses transport demand generation for all the vehicle classes (A to F) belonging to the passenger air mode, taking into account for values driven by changes in GDP per capita (as modified by the environmental culture index).

Inputs and general calculation flow

Calculations concerning values driven by changes in GDP per capita, as modified by the transport characteristic and environmental culture indexes

Following the same methodology as in the previous views, the first step concerns the base year. This step needs to make sure that the final pattern defining the share of pkm on air transport ("final S-curve") is: i) intercepting the historical data in the base year; and ii) driven by the patterns of the families of S-curves defined in the view "demand (passenger, main drivers)", represented by dotted blue lines in the figures below.

Historical data are characterised by the variable "REFERENCE VALUE (BASE YEAR, PKM SHARE IN AIR MODE)". They enter the calculation flow of from the view "activity, loads and stock aggregates". The "first S-Curve" on the share of pkm in air transport, defined in the view "demand (passenger, main drivers)" enters this view as input in "S-PARAMETERS (MAIN, PKM SHARE IN AIR MODE)". The part of the Vensim sketch dealing with the modification of this curve is shown in Figure 7.2.

Figure 7.2 Calculations concerning values driven by changes in GDP per capita: Vensim sketch

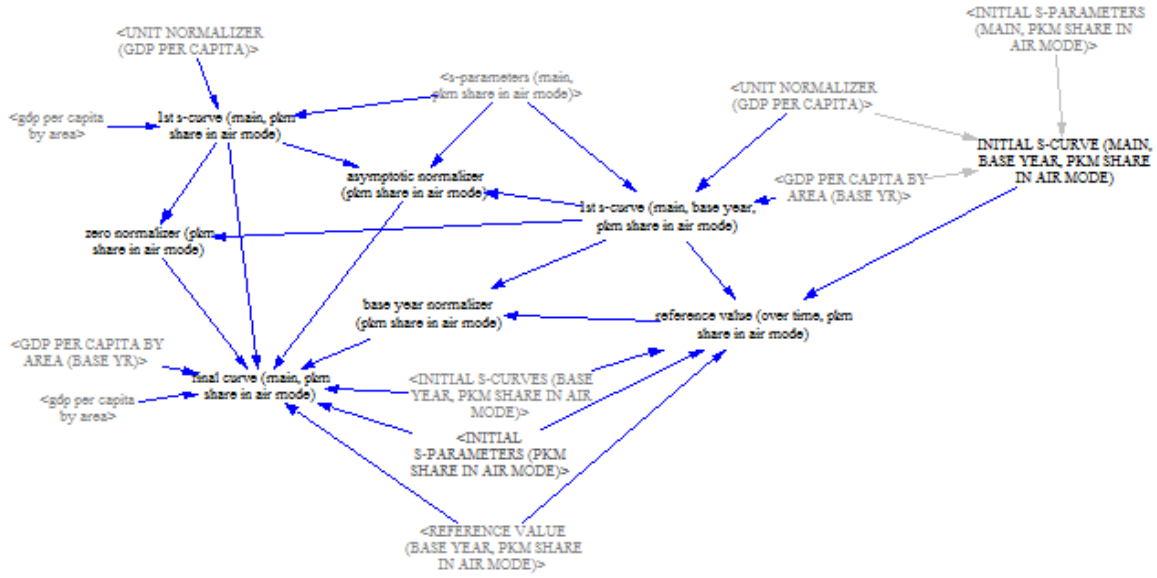


Figure 7.3 and Figure 7.4 show the starting point (first S-curve), the target (final S-Curve), and the point representing the situation at the base year (when, as explained in the "demand (passenger, main drivers)" view, the first S-curve coincides with the initial S-curve).

When the calibration point falls out of the range represented by the LOW and HIGH driving S-Curves (case of Figure 7.3), the normalizers ensure that the final S-Curve contains the reference value when the GDP per capita equals the GDP per capita at the base year and tend to the first S-Curve for a GDP per capita moving towards zero and infinity. Over time, both the reference value and the first S-

Curve are re-evaluated. The re-evaluation of the first S-Curve over time takes into account the changes of the environmental culture index (the share of pkm on air transport modes is not sensitive to the passenger transport characteristic index nor to the cost of driving). The re-evaluation of the reference value/calibration point takes into account of the change of the first S-Curve for a GDP per capita equal to the GDP per capita of the base year, as well as the distance from the relevant (LOW or HIGH) driving S-curve of the initial reference value/calibration point. If the calibration point at the base year is above the HIGH driving S-Curve, the reference value is recalculated over time as follows:

$$Reference\ value\ (over\ time)$$
$$= Initial\ value\ (i.e.share\ of\ air\ passenger\ transport\ pkm\ at\ the\ base\ year)$$
$$+ (First\ SCurve_{GDP\ per\ capita\ (base\ year)} - Initial\ SCurve_{GDP\ per\ capita\ (base\ year)})$$
$$\times \frac{Upper\ Ceiling\ of\ SCurve\ families - Initial\ value}{Upper\ Ceiling\ of\ SCurve\ families - Initial\ SCurve_{GDP\ per\ capita\ (base\ year)}}$$

If the calibration point at the base year is above below the LOW driving S-Curve, the equation becomes:

$$Reference\ value\ (over\ time)$$
$$= Initial\ value\ (i.e.share\ of\ air\ passenger\ transport\ pkm\ at\ the\ base\ year)$$
$$+ \frac{(First\ Curve_{GDP\ per\ capita\ (base\ year)} - Initial\ Curve_{GDP\ per\ capita\ (base\ year)})}{Initial\ Curve_{GDP\ per\ caita\ (base\ year)}} \times Initial\ value$$

Figure 7.4 considers an initial situation where the calibration point falls between the HIGH and LOW limits. In this case, the normalizers are not operational. The final S-Curve equals the first S-Curve calculated in the view "demand (passenger, main drivers)". If the environmental culture index changes over time, the final S-Curve of the share of pkm of air modes would not intercept the initial calibration point (Figure 7.5).

Figure 7.3 **Share of air transport pkm: base-year evaluation of the final S-curve when the share of air transport pkm on personal vehicles falls out of the LOW and HIGH driving S-curves range**

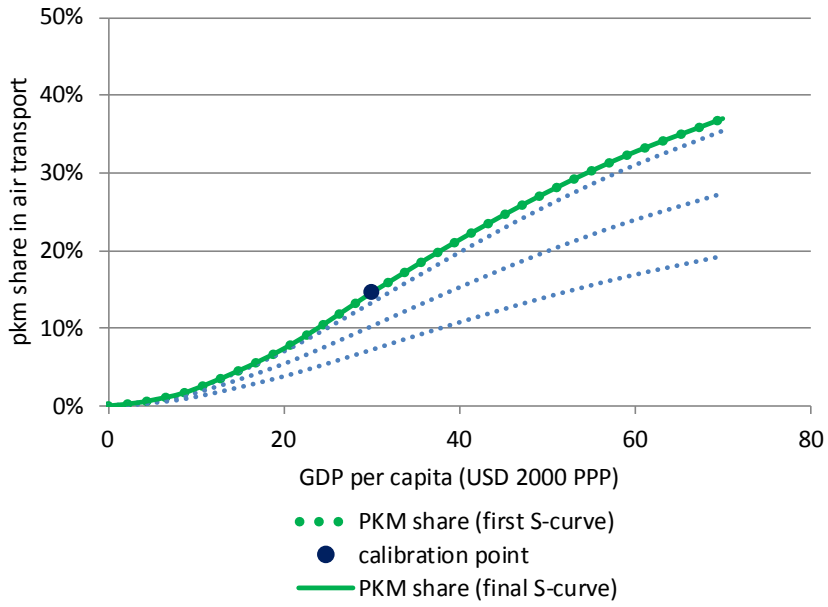


Figure 7.4 Share of air transport pkm: base-year evaluation of the final S-curve when the share of air transport pkm on personal vehicles falls within the LOW and HIGH driving S-curves range

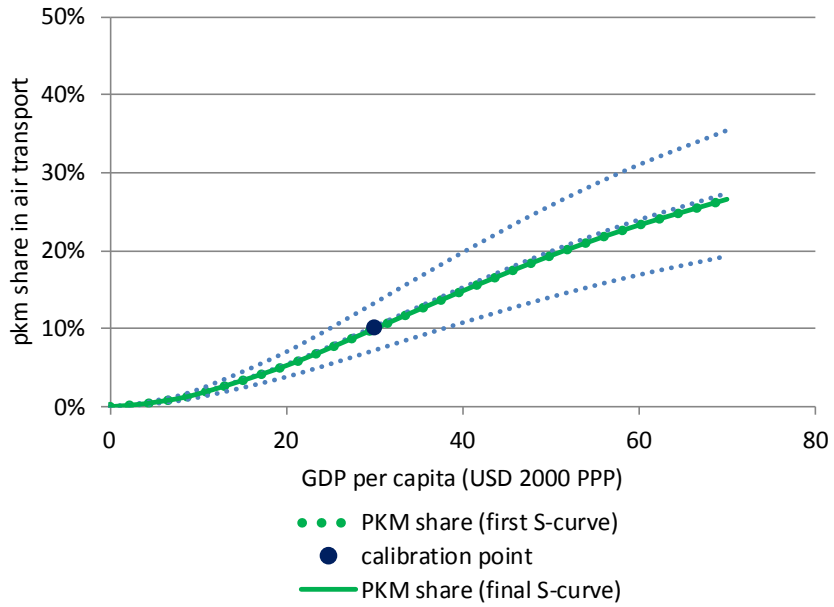
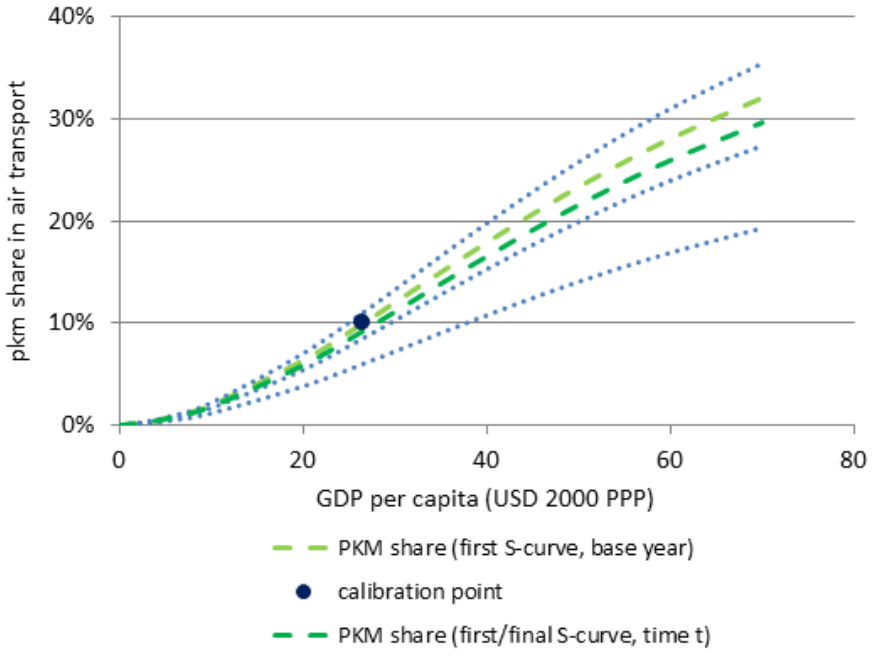


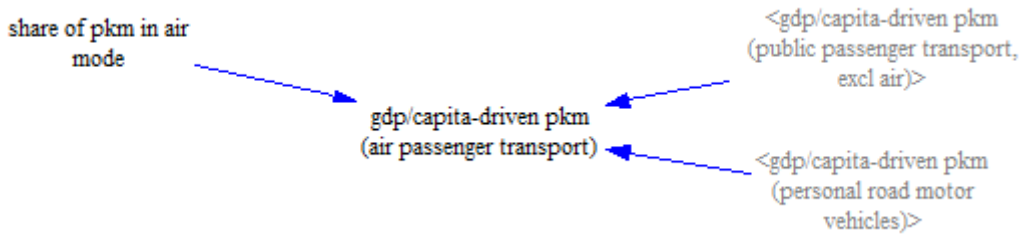
Figure 7.5 Share of air transport pkm: evaluation of the final S-curve when the share falls between the LOW and HIGH driving S-curves and factors such as the transport characteristic index change the first S-curve pattern over time



The "GDP/capita-driven pkm (air passenger transport)" is evaluated from: i) the share of pkm on all passenger transport modes but air; and ii) the pkm (driven by changes in GDP per capita) that are run on all passenger modes but air transport. The former is the complement to 1 of the share of pkm on air transport; the latter results from the sun of the "GDP/capita-driven pkm (public passenger transport, excl air)" and "GDP/capita-driven pkm (personal road motor vehicles)", both calculated in the view "demand (passenger, public)".

The variables performing this calculation in Vensim are shown in Figure 7.6.

Figure 7.6 GDP/capita-driven pkm (air passenger transport): Vensim sketch



The equations underlying this calculation are reported below:

$$pkm_{total} = pkm_{AIR} + pkm_{PUBLIC} + pkm_{PERSONAL} = \frac{pkm_{AIR}}{Air\ transport\ share}$$

$$pkm_{AIR} = \left(pkm_{PUBLIC} + pkm_{personal}\right) \times \frac{Air\ transport\ share}{1 - Air\ transport\ share}$$

Calculations concerning values driven changes in the cost of driving

The evolution of costs in each "driving passenger mode" (personal vehicles, public transport, and air) results from the comparison between the cost of driving per pkm over time and its value at the base year:

$$Change\ on\ the\ cost\ of\ driving\ per\ pkm\ (percentage) = \frac{Cost\ per\ pkm\ (over\ time)}{Initial\ cost\ per\ pkm} - 1$$

The changes on the cost of driving have an impact on the share of pkm in air transport through elasticities. The latter are exogenous inputs set by default on the basis of relevant literature. The elasticity of air demand with respect to own price is assumed around -1 (Gillen et. al. 2003; Intervistas, 2007). The cross elasticity of air transport demand with respect to train cost is very small (Oum 1990, page 20), and is assumed to be one tenth of the elasticity of air demand with respect to own price. The same value is used for the cross elasticity of air transport demand with respect to car cost.

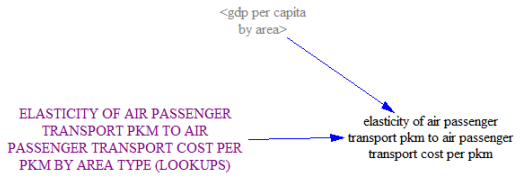
In case of air transport the elasticities do no differ depending on the area type but are considered as functions of the GDP per capita. According to literature (Intervistas, 2007) the elasticity of air demand is lower (reflecting a higher demand rigidity) for high average income countries and countries with low average incomes (because air users in this circumstances are affluent individuals whose elasticity is low). This is reflected in the default values used in ForFITS (half of the reference value, retained for average income ranges between 20 and 50 thousand USD 2000 PPP.

The following section includes a description in greater detail of the three elasticities taken into account.

Elasticity of air passenger transport pkm to air passenger transport cost

It is the direct elasticity quantifying the impact on the pkm in air transport provoked by a change on the air transport cost. The elasticity is always negative (Figure 7.7).

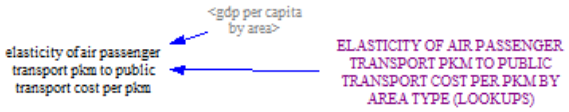
Figure 7.7 **Elasticity of air transport pkm to air transport cost: Vensim sketch**



Elasticity of air passenger transport pkm to public passenger transport cost

It is a cross elasticity that links the changes on public transport cost and the repercussion on passenger travel in air transport. The value of the elasticity is positive, since an increase of the cost in public transport promotes shifting to the air mode (Figure 7.8).

Figure 7.8 **Elasticity of air passenger transport pkm to public passenger transport cost: Vensim sketch**



Elasticity of public passenger transport pkm to driving cost of personal vehicles

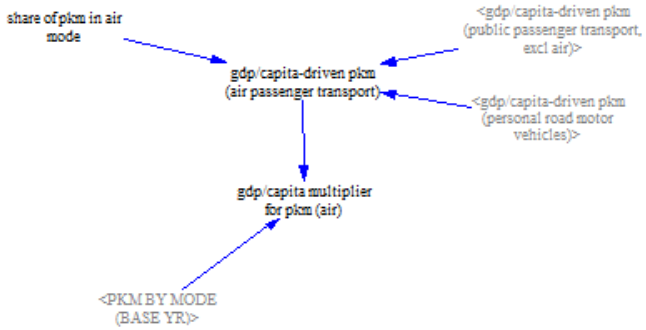
It is a cross elasticity representing the influence of the cost of driving for personals vehicles on the amount of pkm in air transport. As both transport solutions interact as competing options, the elasticity is positive (Figure 7.9).

Figure 7.9 **Elasticity of public passenger transport pkm to driving cost of personal vehicles: Vensim sketch**

Outputs

The effect of the GDP per capita is symbolized by a multiplier that compares the pkm in air transport at the base year and the value over time led by the evolution of the macroeconomic parameters:

$$GDP\ per\ capita\ mulitpier\ for\ pkm\ in\ air\ transport = \frac{pkm_{AIR}\ (over\ time)}{initial\ pkm_{AIR}}$$



The changes on the cost of driving in each passenger modal option modify the target pkm in air transport through the corresponding elasticities. The impact is applied to the initial passenger travel in air transport by means of multipliers in concordance with the definition of elasticity:

$$Elasticity = \frac{\Delta y}{\Delta x} \times \frac{x}{y} \rightarrow pkm_{AIR} = Initial\ pkm_{AIR} \times Cost\ multiplier$$

Where:

$$Cost\ multiplier = 1 + Percentage\ change\ on\ the\ cost\ of\ driving\ per\ pkm \times Elasticity$$

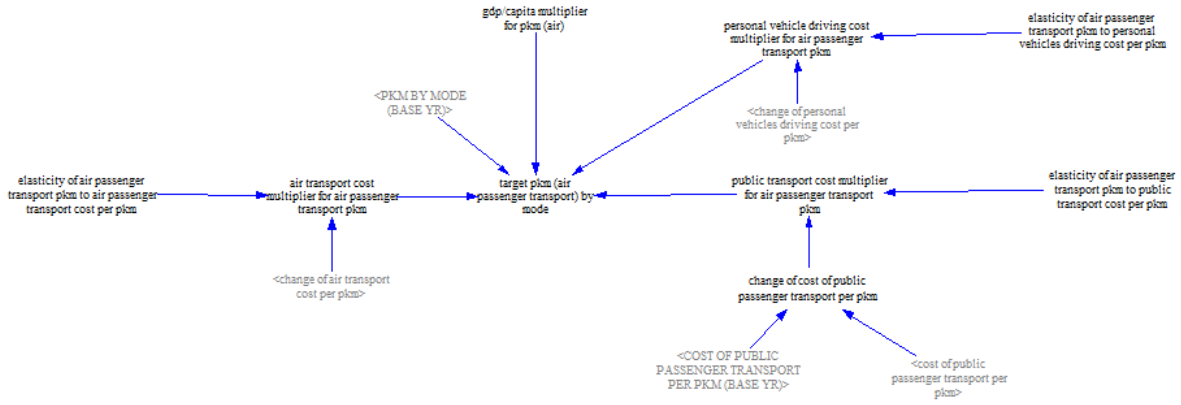
The target pkm in air transport are estimated as result of accumulating the independent effects caused by the different relevant factors (Figure 7.10):

$$pkm_{AIR} = Initial\ pkm_{AIR} \times GDP\ per\ capita\ mulitpier \times Cost\ multipliers$$

Where:

$$Cost\ multipliers =$$
$$= Air\ transport\ \ multiplier \times Public\ transport\ multiplier \times Personal\ vehicles\ multiplier$$

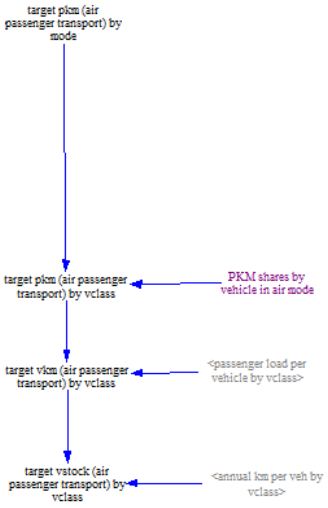
Figure 7.10 **Pkm on air transport by mode: Vensim sketch**



The target passenger travel in the air mode is distributed along the vehicle classes A to F by means of the shares exogenously introduced by the user (top of Figure 7.11).

Dividing the pkm by the passenger load per vehicle results in the target vkm. The annual travel per vehicle links the latter to the vehicle stock (bottom of Figure 7.11).

Figure 7.11 Pkm, vkm and vehicle stock by vehicle class: Vensim sketch



The outputs regarding air transport demand are used to calculate new vehicle registrations for air transport vehicles (view "vehicles by age").

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Intervistas (2007), *Estimating Air Travel Demand Elasticities,* Final Report prepared for IATA,

Oum T. H., Waters II, W. G., Yong J. S. (1990), *A Survey of Recent Estimates of Price Elasticities of Demand for Transport*, Infrastructure and Urban Development Department, The World Bank, http://www-wds.worldbank.org/external/default/WDSContentServer/IW3P/IB/1990/01/01/000009265_3960928230924/Rendered/PDF/multi_page.pdf