Problem statement and objectives

Externalities of the road transport sector such as greenhouse gas emissions and local pollution do not only depend on transport activity levels, but also on the composition of the vehicle stock. Indeed, emission factors and fuel consumption depend on the age structure of the vehicle stock, the shares of different powertrains and the distribution of the vehicles' weights. Therefore, long-term transport demand models need to be linked with vehicle stock models.

In the present paper, we focus on the new implementation of the Belgian CAr Stock MOdel (CASMO), which is linked to the national transport model, PLANET. PLANET is a multimodal transport demand model used for long term projections of transport demand (horizon 2040) for both freight and passengers transport.

Methodological approach

Ideally, modelling the size and the composition of the car stock requires a fully dynamic model of the car market. Due to data constraints, this is currently not feasible for the Belgian context. Modelling the evolution of the Belgian car stock thus requires a pragmatic approach, with several ad hoc decisions.

Our approach to the car stock model can be summarized as follows:

- The total desired car stock is determined as a Gompertz function of the country's population and GDP per capita.
- In order to produce the emissions of the car fleet, cars are classified according to their emission factors, which depend on their age, fuel and size. The emission factors for cars follow the COPERT methodology and use a tank-to-wheel approach.
- For each vintage in each car class we estimate the probability that a car is scrapped in the current year, as a function of its age and accumulated mileage (survival model with a loglogistic survival function). This determines the remaining car stock.
- The desired car stock is then confronted with the remaining car stock to determine total car purchases in a given year.
- For the allocation of the total sales to the respective COPERT classes, we use the parameter values of a Stated Preference discrete choice model estimated in The Netherlands. A direct application of the model to the Belgian market results in a poor predictive value, probably due to a combination of the following factors:
    - A still very low familiarity of users with electrified cars. A detailed analysis has shown that, in the current market context, the main barrier to the adoption of electric

cars in Belgium is no longer their total cost of ownership, at least for realistic values of the expected economic lifetime. Other elements appear to be crucial, some of which are easily quantifiable (such as the expected autonomy of an electric car, the availability of a charging infrastructure or the diversity of the car models on offer), others less (such as consumers' conservatism and range anxiety).

    - Company cars are an important component of the car stock, but the data do not allow to account for this in the demand model. Fleet managers do not just face different cost structures as private consumers – their choices are also governed by other criteria.

    - The "dieselgate" scandal and the policy measures that have been taken in response to it, have led to a very sharp decrease in the market share of diesel cars - higher than what we would expect a priori from the changes in car taxation only.

- Using non-linear least squares, we therefore re-calibrate the Alternative Specific Constants (ASCs) of the model to reflect the reality of the Belgian market in our reference period.

- We then use both a mixed logit (ML) model (not including interaction terms with household characteristics) and a multinomial logit (MNL) model (including interaction terms with household characteristics) for long term projections of the market shares.

<u>Results</u>

The detailed vehicle type-size inventory is then mapped into a new inventory that is aggregated according to the EURO emission class to which the cars belong. This is fed back to the PLANET model, and, combined with an estimate of annual travel, this results in an assessment of environmental impacts.

The key quantitative results are:

- Car ownership in Belgium is projected to grow from 5.76 million cars in 2018 to 7.04 million cars in 2040 - this is an increase with 22% and corresponds to 0.57 cars per capita by 2040. For comparison, over the same period, GDP is assumed to grow with 37% - this is consistent with the assumption that the car stock is nearing its saturation point.

- Although the projected evolution of the cost and performance parameters tend to make electric cars more attractive compared to their conventional counterparts, in the MNL specification, the projected market share for electric and hybrid cars in 2040 remains below 2%. The most important driver behind this low sensitivity of the market shares for alternative powertrains to changes in costs and performance are the high values of the estimated ASCs. Indeed, these constants represent the part of an alternative's utility that cannot be captured by the observed variables - this is in line with similar modelling approaches applied in other countries such as the UK.

- In the ML model, the markets share of BEV grows somewhat more (to almost 10%), mostly at the expense of gasoline and diesel cars.

Given that the calibration of the ASCs to the Belgian market leads to a much-improved match in the period used for the estimation but continues to drive the results until well in the future, we address whether this assumption of unvarying ASC is reasonable.

For instance, in the case of electric and hybrid cars, it could be argued that the low familiarity of consumers with these technologies leads to outdated perceptions regarding their total cost of ownership and range. Indeed, the spectacular improvements in terms of autonomy and costs of electric cars are a recent, and largely unanticipated, phenomenon. Outdated perceptions are likely to be corrected through actual experience and word-of-mouth effects (or “neighbour” effects). Such word-of-mouth effects are typically characterised by positive feedback loops.

Other elements are also likely to improve through time such as: the low density (or the perception of a low density) of the recharging infrastructure, especially of fast-chargers; the lack of diversity in the models that are available; long delays in the delivery of orders…

In order to represent those changes, we have implemented an alternative approach where the perceived acquisition costs decrease through time according to a logistic function. This reflects the typical dynamics of adopting new technologies: first imperceptibly, until a take-off point is reached, after which adoption will increase rapidly, until it converges to a new plateau when all learning effects have levelled out.

Assuming inflection point for hybrid cars around 2030 and for electric cars around 2030, we obtain much higher market shares. We have also found that, under this assumption, the market shares are much more sensitive to changes in the cost parameters. This approach with evolving subjective costs can be used, either to enlighten a debate between different experts, or to better understand the assumptions underlying existing alternative economic models.

Our work has also identified several data needs. In particular, the survival model would be more accurate if there were reliable and representative data on the accumulated mileages of individual cars and on the dates where they are retired from circulation in Belgium.