LIGHT DUTY VEHICLE TRANSPORTATION AND GLOBAL CLIMATE POLICY: THE IMPORTANCE OF ELECTRIC DRIVE VEHICLES

Valentina Bosetti and Thomas Longden, FEEM and CMCC, thomas.longden@feem.it

Overview

In order to analyse long term trends in transport and their repercussions on the rest of the economy we introduce a transport module representing the use and profile of light duty vehicles (LDVs) into the integrated assessment model WITCH (Bosetti et al, 2006; Bosetti, Massetti and Tavoni, 2007; Bosetti et al, 2009). The modification to the WITCH model has been designed to incorporate a range of competing vehicle types to assist in the determination of the dominant modes of LDV transport that will tend to be selected to adequately satisfy demand for mobility. Personal light duty vehicles have been selected as the vehicle type of interest as they have been identified as being one of the most favoured modes of transport and also one of the most damaging (Chapman, 2007). As national income increases, so too does the rate of automobile ownership and this has created an unsustainable relationship between rising income and emissions (Schipper and Fulton, 2003). The 4th IPCC Assessment report, working group III, notes that CO2 emissions are proportional to energy use and that virtually all of transport energy is derived from oil-based fuels – with diesel making up 31% and petrol 47% of total energy in 2004. (Kahn Ribeiro et al., 2007: 328) With forecasts of transport demand in the non-OECD growing at approximately three times the rate of those of the OECD (Kahn Ribeiro et al., 2007: 333), the global modelling of transport demand and the energy market proves to be an important exercise.

Method

WITCH – World Induced Technical Change Hybrid model – is a regional integrated assessment model structured to provide normative information on the optimal responses of world economies to climate policies. Transport has been included in the model through the incorporation of the impact of investments in LDVs and fuel expenditures on the level of consumption. This means that increased LDV travel (in terms of kilometres travelled per vehicle) as well as the costs of the vehicle and fuel expenditure directly impact utility through the corresponding effect of decreasing consumption on other goods and services. Demand for vehicles has been set exogenously based on the assumption that constant travel patterns correspond to given levels and growth rates of GDP and population. This assumption is important as the demand for private transport will likely continue to be high and have a strong correlation with national income, unless a significant change in the way public transport is provided occurs. This model with its current set up reviews the continuation of constant travel patterns and the constraint that this will place on the achievement of emissions reductions.

Technological change is endogenous in the model and it affects both the cost of batteries for electrified vehicles and that of conversion of advanced biofuel from biomass. Research capital in either of these technologies (RK_{TECH}) depreciates at a given rate of depreciation (D_K) and is accumulated with increased investments ($RI_{TECH}(n,t)$) and a ‘standing on the shoulders of giants’ effect based on the previous level of capital. The incentive to accumulate research capital can be seen by its role within the learning by searching curves, shown in equations 1 and 2, which improve the state of these technologies. In particular, cumulating knowledge decreases the cost of batteries used in EDVs (SC_{EDV}) and the cost of advanced biofuel (FE_{ADVB}).

$$\frac{SC_{EDV}(n,t)}{SC_{EDV}(n,1)} = \left(\frac{(RK_{EDV}(n,t)+RSpill_{EDV}(n,t-l)}{RK_{EDV}(n,1)}\right)^{-LR} \quad (1)$$

$$\frac{FE_{ADVB}(n,t)}{FE_{ADVB}(n,1)} = \left(\frac{(RK_{ADVB}(n,t)+RSpill_{ADVB}(n,t-l)}{RK_{ADVB}(n,1)}\right)^{-LR} \quad (2)$$

As spillovers are likely to occur in technologies that are so easily tradable we assume that the cost in each country is affected by the research cumulated in that country up to that period plus the incremental amount of research accumulated by the sector innovation leader, $RSpill_{ADVB}$, though with a lag time that accounts for the advantage of being the first mover.

Results

A range of simulations show that climate policy costs and the carbon price in the latter half of the century are sensitive to a lack of electric drive vehicles. Prevailing fossil fuel use within a no EDV scenario places notable strain on the other sections of the economy. For example, policy costs in the base stabilisation scenario tend to be 2.7% and 2.8% of global GDP, but for simulations with no electric drive vehicles, the policy cost for achieving a 550ppm GHG concentration at 2100 increases to 3.3% of global GDP. Policy costs of this magnitude confirm that the electrification and decarbonisation of the LDV transport sector is a notable issue in achieving a cost effective climate policy. In addition to the carbon price, the cost of having no breakthrough in EDVs also has a notable impact upon the world oil price. The increase in the world oil price due to the prevailing use of fossil fuels results in an oil price in 2100 that is approximately 54% higher than the price within the base stabilisation scenario. Already significant, these costs are sure to rise in the complementary case of no electrification within freight transport and this is an additional scenario that will be conducted in the next few weeks for inclusion in the full conference paper submission.

Conclusions

The results highlight that the light duty vehicles sector and policies affecting it can have major effects in the cost and feasibility of long term stabilisation policies discussed within international climate policy negotiations. Decarbonisation is important as it allows the fuel demand and the related travel demand of the transport sector to be matched to the advances being made in the energy sector. The results of the model show that while the relative fuel costs will assist in the penetration of alternative vehicles and the use of alternative fuels, the investment cost at the time of purchase proves quite decisive in an economic model of this type. The incorporation of income stratification would allow emerging technologies to penetrate sooner, however as a representation of the penetration of the dominant commercially successful technology this model is suitable.

References

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