Abatement Technologies and their Social Costs in a Hybrid General Equilibrium Framework

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We present a novel methodology to directly integrate heterogeneous micro-founded preferences into a computable general equilibrium (CGE) model with technological detail to quantify the social costs of an endogenous, demand-driven abatement technology (electric vehicles) in a general equilibrium framework. With this methodology, we not only present a novel way to hard-link microeconomic preference structures to a CGE model with technology-sharp resolution for specific sectors (passenger vehicles, electricity), but we also demonstrate an innovative method to model endogenous, demand-driven technological change.

To this end, we develop a hybrid model that directly integrates consumers' decisions on conventional and emission-reducing technologies derived from a discrete choice (DC) model into a fully dynamic CGE model. The abatement technologies focused on in this study represent four individual transport technologies, namely conventional vehicles (CV) and three cleaner alternatives such as hybrid (HEV), plug-in hybrid (PHEV), and battery electric (BEV) vehicles.[e] Demand for vehicles determines the vehicle fleet through an embedded stock-flow accounting model, affecting the use of fuel and electricity, and vehicle production sectors in the CGE model. Endogenously determined demand for electricity is satisfied by production optimised in a bottom-up electricity model to supply it by a least-cost combination of fuels and power technologies. Emissions stemming from vehicle use, electricity generation, and economic production provide an input to quantify the external environmental effects associated with the technological change.

We apply this methodology to Austria as a blueprint for further use, considering current policies to support the uptake of alternative technologies. We assess the impacts of three policy scenarios on the economy, electricity production, air quality pollutants and GHG emissions, and environmental benefits associated with the emission reductions. *MODEST* assumes modest investments in the expansion of EV charging infrastructure, and a preference shift of households to EVs due to increased environmental awareness and increasing traction of EVs as a viable alternative to conventionally-fueled vehicles. *EM+* then assumes a more rapid expansion of EV charging stations and hence more investments, as well as an increase in the mineral oil tax and vehicle registration tax (a feebate system) to foster a large-scale introduction of electromobility in individual road transport. *TARGET95* is a much more ambitious policy defined by the target that almost all (95%) newly-registered vehicles in Austria will be EVs by 2030 through increasing the mineral oil tax and registration vehicle tax, as well as introducing stricter emission standards (as reflected in a higher purchase price of emission-intensive cars). We also explore how the economic costs to reach the 95% target in the

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e Hereinafter, electric vehicles (EVs) comprise both PHEVs and BEVs.

new registrations will differ if one of these measures is implemented alone compared to a policy that introduces all of these measures jointly.

We find that, as a consequence of these policies, new registrations of EVs rapidly increase particularly at the end of the modelling period, reaching 44% in MODEST and 68% in EM+ in 2030. Hence, the share of 28% of EVs in the vehicle stock in EM+ is almost doubled in comparison to MODEST, and can be expected to be further increasing and replacing CVs beyond the model horizon. However, the relatively swift uptake of EVs in Austria in both scenarios is also supported by measures to foster electromobility that are already in place.

In terms of the macroeconomic effects, investments in charging infrastructure enhance economic growth. We show that efforts to decarbonise the transport sector can also positively contribute to growth. However, the tax-related incentives (EM+) would have a negative impact on GDP. We highlight, however, that this effect is relatively small in a range of –0.12 to –0.32% compared to the business-as-usual scenario. Still, the shift from CVs towards EVs is a relatively expensive carbon abatement measure – over the whole analysed period GDP loss is €490 per tCO_2eq: abated in EM+, and €447 in TARGET95, respectively, and these costs are declining over time, reaching €294 and €242 per tonne after 2020.

Welfare is reduced as well, but the effects are rather small and partly balanced by avoided negative environmental externalities mainly adversely affecting human health. While these incentive measures might have slightly negative effects on GDP growth, they lead to higher net government revenues. We also find that the vehicle registration tax is a more efficient measure to reach a 95% EV target in new registrations than the mineral oil tax. In particular, a balanced mix of policy instruments implies costs in terms of GDP of about 0.29% in 2030, while reaching this target only by increasing the mineral oil tax implies costs of 0.4% GDP in 2030. Increasing the vehicle registration tax alone to reach such a target is even less costly in terms of GDP than the balanced scenario with GDP costs of about 0.27% in 2030.

Part of the criticism of electric vehicles derives from the fact that air quality improvements achieved along the roads can be outweighed by the costs of increased environmental damage associated with increased production of electricity to charge vehicle batteries. We show that this criticism can be averted, at least in the case of Austria. We find that a considerably large shift towards EVs in Austria may indeed lead to an increase in emissions and hence environmental damage. However, we also find that these increases are always counter-balanced by emission reductions, environmental benefits attributed to a reduction in fuel use, and changes in the economic structure. We conclude that the economic impacts are very small and the total environmental benefits are positive. If the EM+ policy scenario is considered as a set of climate change mitigation measures, it will generate ancillary benefits due to air quality improvements at ≈50 euro per tonne of CO_2eq abated.

Overall, our modelling approach is clearly able to capture economic and environmental effects due to the shift in purchasing passenger vehicle technologies, providing a useful tool to assess the social costs in comprehensive manner.