wege entstehen, indem wir sie gehen
paths emerge in that we walk them

Wegener Center
www.wegcenter.at

Forschungsgruppe Ökonomik des Klima- und Umweltwandels
EconClim

Promoting environmentally friendly passenger transport technologies

Veronika Kulmer[1,2] and Karl Steininger[1,3]

[1]Wegener Center for Climate and Global Change, University of Graz
[2] Centre for Economic and Innovation Research, JOANNEUM RESEARCH
[3] Department of Economics, University of Graz

Klimatag, Innsbruck // 3-4 April 2014

Research funded by: klima+ energie fonds

Objective and Introduction

- Private passenger transport is a major contributor to greenhouse gas emissions
- Emissions of private passenger transport are continuously rising over time
- Various efforts of mitigation strategies, but no emission trend-reversal in Austria to date
- Alternative propulsion technologies use alternative energy sources and do not depend on fossil fuels
- Several technologies exist (e.g. pure electricity and hydrogen) but have not succeeded in market penetration yet

- Aim of the paper
  1. we analyze policy instruments that aim to foster directed technical change of alternative, environmentally friendly passenger transport
  2. and assess the resulting economic and environmental impacts as well as transport market effects

- Fills a gap not covered by the literature so far by linking two strands of modeling techniques
  - a detailed bottom-up representation of passenger transport technologies (following Böhringer (1998))
  - and accounting for directed technical change (following Acemoglu et al. 2012)

Methodological approach

- Recursive dynamic CGE model with endogenous, directed technological change
- Comprises 40 sectors of production (7 energy sectors, 32 non-energy sectors, passenger transport)
- Passenger transport produced via technology *tec* (clean and dirty technologies)
- Factors: skilled & unskilled labor, capital
- Single country, small open economy

Methodological approach

- Passenger transport modeled by a set of Leontief technologies (active or inactive depending on profitability)
- Technological change of technology *tec* follows Acemoglu et al. 2012
- Centerpiece of study is the evolution of technological knowledge over time:
  - Skilled labor determines innovation
  - Furthermore, probability of success and an exogenous rate of cost improvement (learning rate) also trigger technological change
  - Previous level of technological knowledge

- Production

$$\pi_{tec}^{PT} = p^{PT} - \left\{ \sum_i \left(\theta_{tec,i}^{G} \cdot A_{tec} \cdot p_i^{G} \cdot \left(1 + t_i^{C,PT}\right)\right) \right\}$$

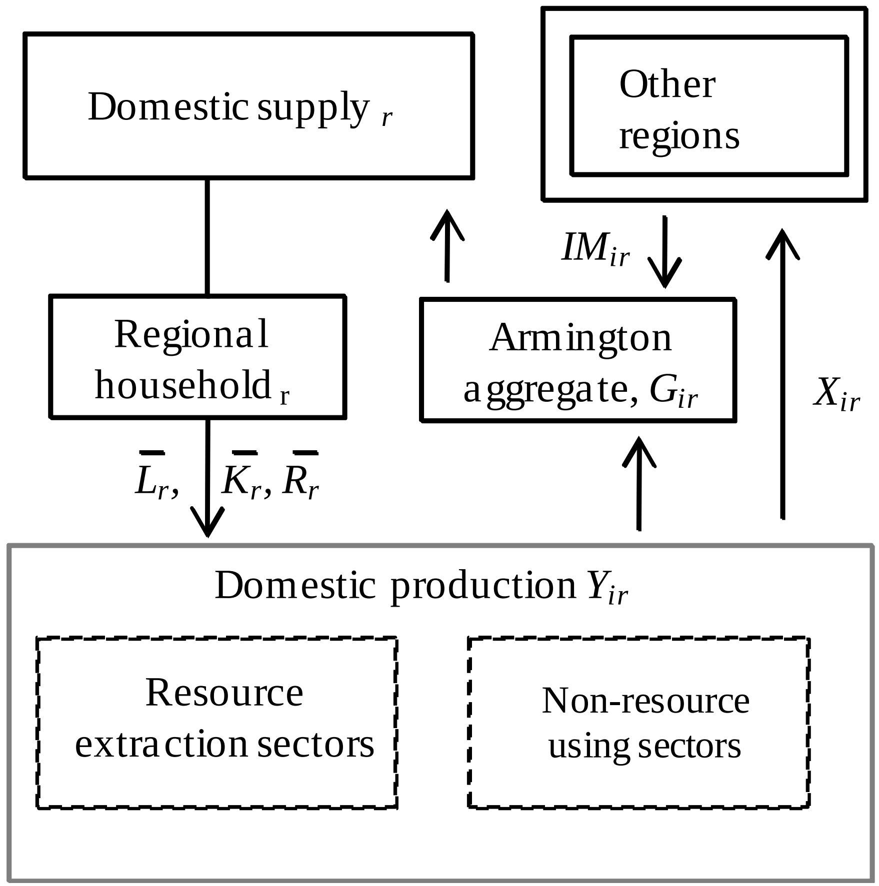
π_{tec}^{PT} unit profit of passenger transport technology *tec*
p^{PT} price of passenger transport
p_i^{G} price of Armington aggregate (G) of sector *i*
$\theta_{tec,i}^{G}$ share parameter of sector *i* in production of technology *tec*
A_{tec} level of technological knowledge of technology *tec*
$t_i^{C,PT}$ commodity tax of input sector *i*

- Development of technological knowledge

$$A_{t+1,tec} = \left(1 - \gamma_{tec} \cdot \left(\frac{\frac{LS_{t+1}}{LS0}}{\frac{L_{t+1}}{L0}} \right) \cdot \mu_{tec} \right) \cdot A_{t,tec}$$

$A_{t+1,tec}$ level of technological knowledge of technology *tec* in period *t+1*
μ_{tec} probability of success of an innovation of technology *tec*
γ_{tec} cost improvement (learning rate) of technology *tec*
LS_{t+1} economy-wide skilled labor in period *t+1*
$LS0$ economy-wide skilled labor in the base year
L_{t+1} total employment in period *t+1*
$L0$ total employment in the base year
$A_{t,tec}$ level of technological knowledge of technology *tec* in period *t*

- Calibrated to Input-Output table Austria 2007 and Austrian Households' Consumption Survey 2004-05
- Passenger transport technologies
  - 1 dirty technology: conventional fossil fuel based (ICE)
  - 3 clean technologies: Plug-in hybrid electric (PGEV), pure electric (EV), fuel cell electric (FCEV)

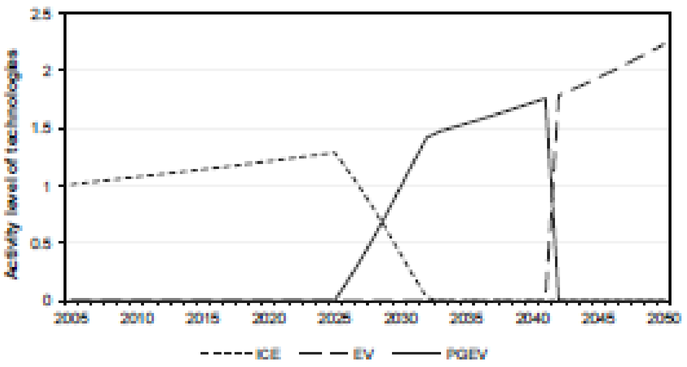


Basic model structure

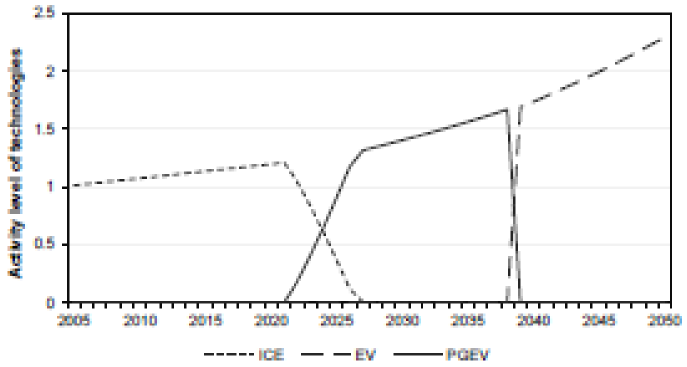
- Reference scenario 2050 (REF)
  - Endogenous technological change, but no policy intervention
- Policy simulation
  - Phase out of ICE and subsidy in Research and Development of alternative passenger technologies (PhaseOut)
  - Fuel tax and subsidy in Research and Development of alternative passenger technologies (FT_SubsRD)
  - Output subsidy on FCEV (SubsFCEV_FT)

- Passenger transport supply of technologies

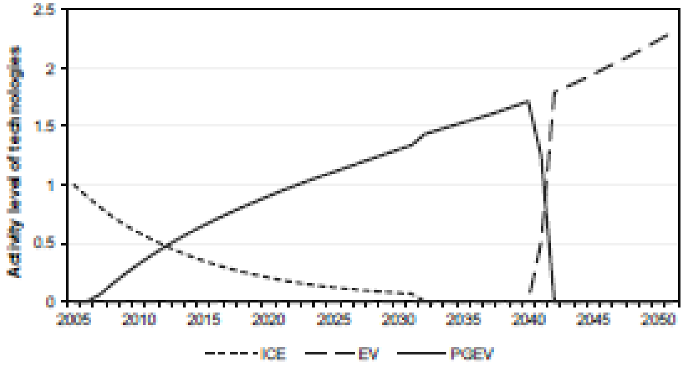
Reference



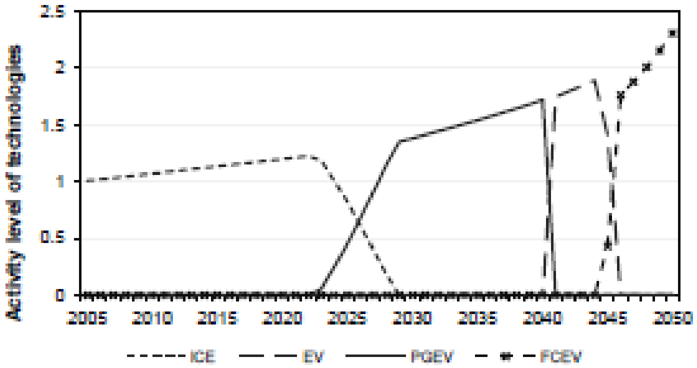
FT_SubsRD



Phase_Out



SubsFCEV_FT



CO2 emissions

Table 6.1: CO_2 coefficients of passenger transport technologies

	CO_2 coefficients [gCO_2/km]			
	ICE	**EV**	**PHEV**	**FCEV**
2005	210	84	112	42
2025	157	54	77	32
2050	122	36	55	25

- Environmental impacts (CO2 emission reduction relative to REF scenario)

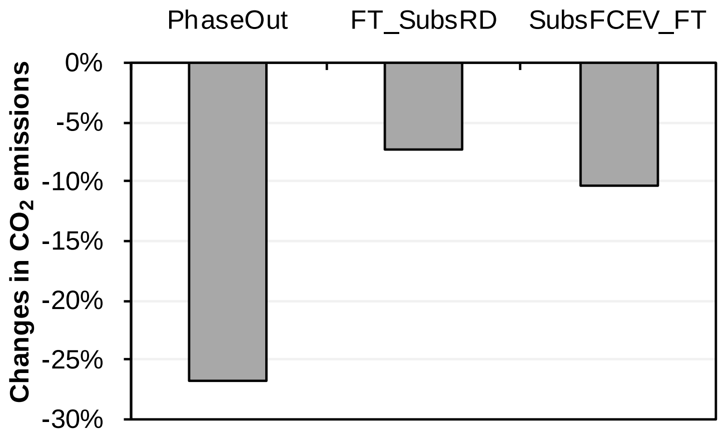
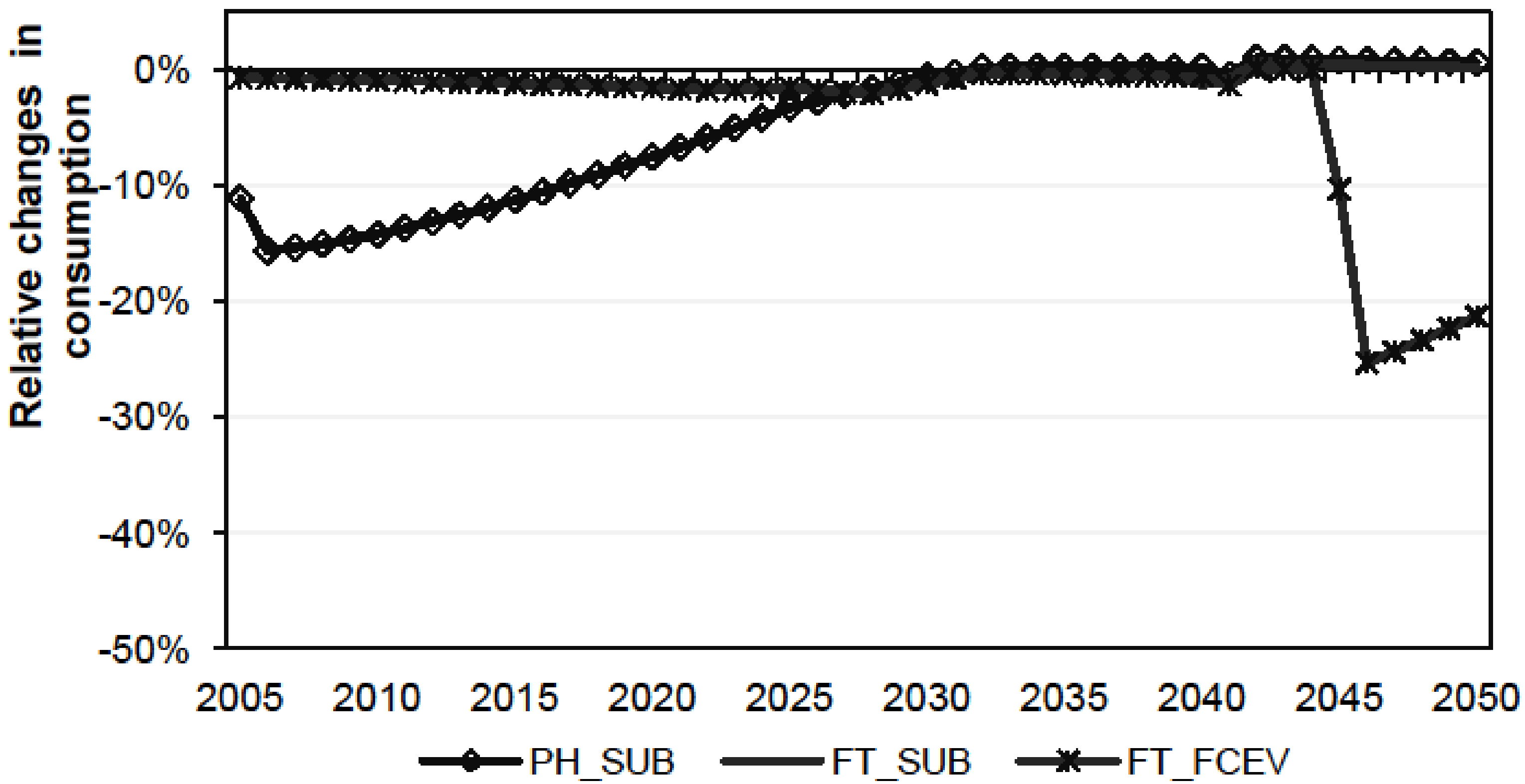


Fig: Cumulative emission reduction (2005-2050) for policy scenarios compared to REF

- *PhaseOut* achieves by far the highest emission reduction
- Due to FCEV emission reduction in *SubsFCEV_FT* is higher than in *FT_SubsRD*

- Changes in consumption of private goods (relative to Reference scenario up to 2050)



Conclusions

- Phase Out
  - Early environmental progress, pushes prices substantially
- FuelTax and Subsidy R&D
  - Lowest environmental progress, low costs
- Subsidy FCEV and FuelTax
  - Cleanest technology FCEV, high costs when subsidized (=> future generations)

- Environmental benefit
  - At low cost
  - At higher costs – initially or later

Sensitivity analysis

Table 7.1: Sensitivity values for γ_{tec}

Parameter setting		PHEV	EV	FCEV
LOW	$\gamma_{tec} \cdot 0.95$	0.01045	0.01805	0.019
REF[a]	γ_{tec}	0.011	0.019	0.02
HIGH	$\gamma_{tec} \cdot 1.05$	0 .01155	0.01995	0.021

[a] REF denotes γ_{tec} of the reference scenario.