



Gothenburg | Sweden 25-29 June 2018

CO₂ tax scenarios for Austria – impacts on households, CO₂ emissions, and the economy

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WCERE 2018





RESEARCH AIM & MOTIVATION







Carbon Taxes in Austria: Implementation Issues and Impacts cats.wifo.ac.at

 How do reduce emissions in non-ETS sectors (transport, service sector, private heating & mobility)?

• EU-Effort Sharing Decision in Austria:

- -16% until 2020 (vs. 2005)
- -36% until 2030 (vs. 2005)
- CO₂ taxes
 - How **effective** is the incentive?
 - What about **regressive** tax impacts on households?
 - What are the macroeconomic impacts?







GHG Emissions Austria 2014 Sectoral Shares





Household Income Quintiles Consumption Expenditure





METHODOLOGY – WIFO.DYNK

A recursive dynamic econometric Input-Output Model (Dynamic New Keynesian) for Austria with focus on energy and distributive impacts







WIFO.DYNK The Basis

- Input-Output core for Austria (62 sectors + final users)
- **Behavior** (Econometrics)
 - Sectors \rightarrow KLEM^mM^d translog production function
 - Capital (K), Labor (L), Energy (E), domestic (M^d) and imported (M^m) commodities
 - Private consumption:
 - Durable-, non-durable- and energy commodities
 - Labor market
 - New Keynesian \rightarrow long-term unemployment steady-state







WIFO.DYNK The Foci

• Energy

- **Sectors**: as essential production input
 - Share of energy **commodities** in production (**E** in KL**E**M^mM^d)
 - Share of energy **carriers** in E (nested production function)
 - oil, coal, gas, electricity&heat, renewables

• Private consumption:

- Energy Services for Mobility, Heating, Appliances
- ~f(Prices, Stocks, Efficiencies, Income)
- \rightarrow considers rebound and income effects!

Household income quantiles

• Consideration of different income and consumption patterns







SCENARIOS







Scenarios

- What will be taxed?
 - CO₂ content of **energy carriers**
 - diesel, gasoline, oil, gas and coal
- What will **NOT** be taxed?
 - Methane (CH₄), laughing gas (N₂O), other GHG & process related CO₂ emissions







Scenarios

- Who will be taxed?
 - Private consumption
 - Mobility and heating
 - Sectors, that do not participate in emission trading
 - e.g.: transport & services sectors
- Time frame of simulations
 - Comparative short-term (2012)







Scenarios Tax Rates

			Implicit CO_2 tax rates for fossil fuels (ε/tCO_2)				
Scenario Name	Explicit CO ₂ tax (€/tCO ₂)	Energy Tax	Petrol	Diesel	Oil ¹	Gas	Coal
Base	0	Current	195	147	40	31	18
Low	60	Current	255	207	100	91	78
Med	120	Equivalized	315	315	160	178	153
High	315	None	315	315	315	315	315







Scenarios Compensation Schemes

- **No**Rec
 - No tax recycling
- Rec**H**
 - Per-Capita eco-payments to households (total revenue)
- Rec**Q**
 - Reduction of employers' social contributions (total revenue)
 - Uniform for all Non-ETS sectors
- Rec**QH**
 - Combination of RecH and RecQ
 - Taxes paid by HH \rightarrow eco-payments
 - Taxes paid by businesses \rightarrow labor tax reduction









SIMULATION RESULTS















Value Added – Non-ETS

Short-Term Effects of CO₂ taxes



RecQ \rightarrow Compensation for Businesses only

GDP impact (real) - Composition Short-Term Effects of CO₂ taxes





Employment Short-Term Effects of CO₂ taxes





CO₂ Tax Burden Relative to Expenditure and Income

Short-Term Effects of CO₂ taxes





CO₂ Tax Burden Change in income and expenditure (real) Short-Term Effects of CO₂ taxes





CONCLUSIONS







Conclusions

- A carefully designed CO₂ tax can contribute to both
 - a strong **double dividend** in the short term, i.e.:
 - $CO_2 \downarrow + GDP \uparrow \leftrightarrow + employment \uparrow$
 - more equity across household income groups.
- Possible trade-off between efficiency & equity:
 - Implement both lump-sum eco payments and labor tax cuts for businesses?
- Equity impacts without compensation:
 - depend on indicator used







THANKS!







APPENDIX







- Short-term impacts \rightarrow probably overestimated
- Long-term impacts \rightarrow probably higher
 - Trends, investment decisions
- Very likely: different (service energy) price elasticities for household income groups
- Marginal Propensity to Consume
- Macromodel \rightarrow black-box for technical changes
 - How does the fuel switch / energy reduction occur?
- Everything outside our modelling boundaries...







- Energy related CO₂-Reductions in non-ETS:
 - Households reactions are small in the short-term
 - Industry & Service sectors react more significantly
 - Slightly higher share of renewables but mostly less energy demand
- Macro-economic impacts
 - Impacts rather small
 - Decisive for a double dividend (DD): tax revenue recycling!
 - Strong DD with labor cost reductions
 - Weak DD → labor cost reductions more efficient than lump-sum payments









- Tax Burden depends on indicator:
 - Regressive (tax/income, ∆ real expenditure)
 - Proportional (tax/expenditure)
 - U-Shaped (∆ real income)
- Tax Burden depends on recycling/compensation:
 - Labor cost reductions → may exaggerate regressive impacts on income
 - Lump-Sum payments → impacts become less regressive for all indicators









RESULTS







(energy related) CO₂ Emissions **Rebound Effects of Tax Recycling**

Short-Term Effects of CO₂ taxes



CO₂ recycling schemes: RecH RecQH



Change in energy carriers Non-ETS







High



CO₂ Tax Burden Change in Consumer Price Index (CPI) Short-Term Effects of CO₂ taxes

CO2 tax rates:



CO₂ recycling schemes: ➡ NoRec ➡ RecQ ➡ RecH ➡ RecQH





SENSITIVITY SCENARIOS







CO₂ Emissions – ETS Short-Term Effects of CO₂ taxes





Value Added – ETS Short-Term Effects of CO₂ taxes









GDP impact (real) - Range Short-Term Effects of CO₂ taxes





Wadud et al. (2009) Differentiated price elasticities

Short-Term Effects of CO₂ taxes

Difference in CO₂ emissions from transport fuels if household income quintiles react differently to changes in fuel prices for the scenario *Med* & *NoRec*.



Price elasticities: 🗠 Own 🔶 Wadud et al. (2009)



Wadud et al. (2009) Differentiated price elasticities

Short-Term Effects of CO₂ taxes

Tax burden impact for quintile differentiated fuel price elasticities and our CO₂ tax rate scenarios (Tax recycling scenario: *NoRec*).



Price elasticities: 🐨 Own 🔶 Wadud et al. (2009)



MODEL











WIFO.DYNK Data Sources

- Statistic Austria
 - IO-Core (SUT), Employment, Consumption Survey, Energy Prices
- WIOD (World Input-Output Database)
 - Esimtations for Production Function (IO, SEA, PYP)
- EUROSTAT
 - Employment, State Budget, SILC, long-term interest rates, Consumption
- IEA
 - Energy Prices
- Odyssee
 - Aplliances: Efficiency
- Project data
 - Heating (EEG) & Mobility (TU Wien): Stocks & Efficiency







WIFO.DYNK Applications (Past and Current)

- Energy Scenarios
 - Monitoring Mechanism Projekt (UBA)
 - Energieszenarien 2030/2050 (BMWFW)
- Circular Economy
 - Recycling-Study (BMLFUW)
- Multiplier
 - Investments in Flood Protection (BMVIT)
- Labor Market Forecast
- CATs project (ACRP)
 - CO₂-taxes for Non-Emission Trading Sectors (non-ETS)
 - Focus on distributional aspects
- UncertProp (ACRP)
 - Uncertainty analysis for IMFs with focus on climate change & land use









DYNK CO₂ Tax Impact Chains



Price System & Input Shares



Household Consumption

Modelling Production Factor Input Shares

• Example: Energy

$$= \alpha_{e} + \gamma_{ek,j} \log\left(\frac{PK_{j}}{PD_{j}}\right) + \gamma_{el,j} \log\left(\frac{PL_{j}}{PD_{j}}\right) + \gamma_{ee,j} \log\left(\frac{PE_{j}}{PD_{j}}\right) + \gamma_{em,j} \log\left(\frac{PM_{j}}{PD_{j}}\right) + \rho_{k,j}t$$

- y ... elasticities
- k ... capital
- I ... labor
- e ... energy commodities
- m ... non-energy imported commodities
- t ... time

$$-\rho$$
 ... factor bias

Source: WIOD

Modelling Production Fuel Input Shares

• Example: Oil

$$\begin{split} &= \alpha_{o} + \gamma_{og,j} \log \left(\frac{Pgas_{j}}{Pelecheat_{j}} \right) + \gamma_{or,j} \log \left(\frac{Prenwa_{j}}{Pelecheat_{j}} \right) + \gamma_{oc,j} \log \left(\frac{Pcoal_{j}}{Pelecheat_{j}} \right) \\ &+ \gamma_{oo,j} \log \left(\frac{Poil_{j}}{Pelecheat_{j}} \right) + \rho_{k,j} t \end{split}$$

- y ... elasticities
- o ... oil
- g ... gas
- r ... renwa
- c... coal
- t ... time
- ρ ... factor bias

Source: WIOD, IEA

Modelling private energy consumption

 Demand for **public transportation** (nominell) as a function of income, fare price and fuel price

 $\ln(Pub_q) = c_q + \gamma_{yd} * \ln(YD_q) + \gamma_{pf} * \ln(pp) + \gamma_{pf} * \ln(pf)$

- yd.. Household income
- pp... fare price for public transportation
- pf.. fuel price
- Elasticities (Holmgren et al. 2007) :
 - $\gamma_{yd} = -0.62$ (income)
 - $\gamma_{pp} = -0.75$ (own price)
 - $\gamma_{pf} = 0.4$ (cross price)

J. Holmgren, Meta-analysis of public transport demand, Transp. Res. Part Policy Pract. 41 (2007) 1021–1035. doi:10.1016/j.tra.2007.06.003.

Modelling private energy consumption

 Demand for heating (as service energy) as a function of price & heating degree days

$$\ln(Heat_SE_q) = c_q + \gamma_{ps} * \ln\left(\frac{ph}{eff}\right) + \gamma_{hgt} * \ln(hgt)$$

- Service energy (SE) = energy (in TJ) / efficiency
- ph/eff .. service price (=price for heating / efficiency)
- hgt... heating degree days
- Elasticities (own):
 - $\gamma_{ps} = -0.04$ (own-price)
 - $\gamma_{hgt} = 0.56$ (heating degree days)

Modelling private energy consumption

 Demand for **fuel** (in Service TJ) per vehicle as a function of price, efficiency, stock & time:

 $\ln(VEH_ServTJ) = c + \gamma_{ps} * \ln\left(\frac{pf}{eff}\right) + \gamma_{stock} * \ln\left(\frac{stock}{pop}\right) + \gamma_{time} * \ln(time)$

- yd/pop .. income per person
- pf/eff ... fuel price by efficiency (= service price)
- stock/pop ... vehicles per person
- Elasticities (own estimates) :
 - $\gamma_{ps} = -0.218$ (own service-price)
 - γ_{stock} = -3.34 (stock)
 - $\gamma_{time} = 0.0278$ (time)

Modelling private energy consumption - Quintiles

 Demand for **fuel** (in TJ) per person as a function of price, efficiency & stock:

$$\ln(Fuel_TJ_q) = c_q + \gamma_{yd,q} * \ln\left(\frac{yd_q}{pop_q}\right) + \gamma_{pf,q} * \ln(pf) + \gamma_{eff,q} * \ln(eff) + \gamma_{stock,q} * \ln\left(\frac{stock_q}{pop_q}\right)$$

- yd/pop .. income per person
- pf ... fuel price
- eff.. efficiency
- stock/pop ... vehicles per person

WIFO

Z. Wadud, D.J. Graham, R.B. Noland, Modelling fuel demand for different socio-economic groups, Appl. Energy. 86 (2009) 2740–2749. doi:10.1016/j.apenergy.2009.04.011.

- Hourly Wage depends on
 - Previous year's:
 - Consumer Price Index
 - Total or sectoral labor productivity
 - Hourly Wage
 - Current year's:
 - Distance to natural unemployment rate

Validierung DYNK

Zeitraum

Basisjahre: 2008-2012

Simulation: 2013-2015/2016

Überblick – DYNK vs. VGR

Überblick – DYNK vs. Energiebilanz

