Catching the macroeconomic rebound-effect of energy efficiency improvements in Austrian households

Sensitivities and uncertainties

Veronika Kulmer, Sebastian Seebauer, Judith Köberl

GCET, Groningen 2016

Motivation and objectives

- Rebound effect **contradicts the projected energy reduction**
  - Channels: direct, indirect and economy-wide
- Rebound effects are a **severe risk for national climate strategies**

Literature Review

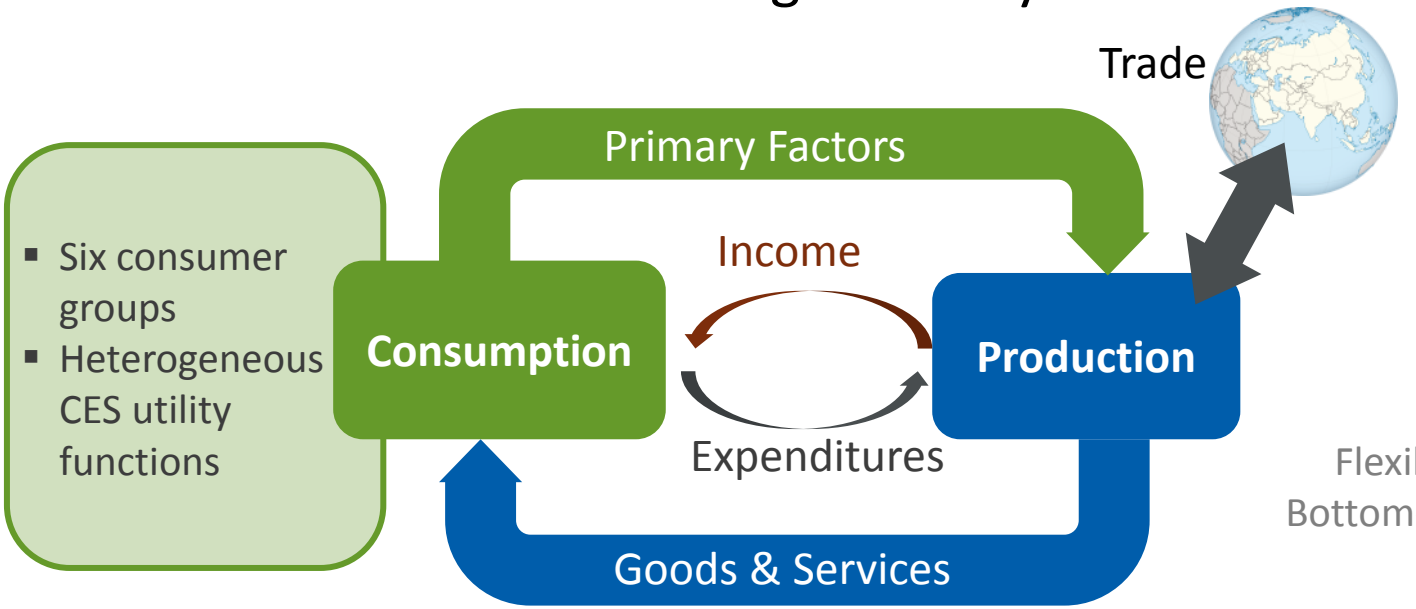
- **Direct rebound effect** is already well studied and estimated to be 5% to 35% (e.g. Sorrell 2010, Chitnis et al. 2013, IEA 2014)
- Only a few studies estimate **indirect** and **economy-wide rebound effect** (e.g. Lecca et al. 2014, Hanley et al. 2010)
  - Great variations: **25 to 120%**

Motivation and objectives

- Majority of studies focus on production sectors
- Few macroeconomic studies analyze energy efficiency in households
- No discussion on importance of parameter assumptions
- Objectives:
  - Estimate the macroeconomic rebound effect of a 10% efficiency improvement in private households
  - How do **household characteristics** influence the result?
  - Identify the tax rate which neutralizes the rebound effect and how the stringency of this rate is influenced by key assumptions

Methodology and data

- Computable general equilibrium model (CGE) of the Austrian economy (Kulmer and Steininger 2016)
- Calibrated to the Austrian input-output table (2010) and Austrian Household Budget Survey



Model Features

Multiple households
Flexible production sectors
Bottom-up technology details
Small open economy

Methodology and data

- Six consumer groups significantly differ in their energy and mobility behavior
  - Parameter specifications follow recent CGE models (e.g. Bosetti et al. 2006, 2015; Paltsev et al. 2008, Lecca et al. 2014)
  - Elasticity of substitution between energy goods: 0.4 - 0.7
  - Top-level elasticity of substitution: 0.2 - 0.4
- Empirical estimations of elasticities of substitution in private consumption are scarce

Scenarios

10% efficiency improvement in fuel consumption across all consumer groups (FEI Scenario)

- 10% less fuels (coal, oil and gas), while shifting household consumption towards non-fossil fuel goods
- Monte- Carlo based sensitivity analysis to identify drivers of the Rebound effect

Fuel tax to offset the macroeconomic rebound effect of the fuel efficiency improvement in consumption (FEI_tax Scenario)

- Identify level of fuel tax which is able to offset the macroeconomic rebound effect
- Sensitivity analysis on how the tax rate is influenced by key assumptions

Results – FEI Scenario

Economic Impacts: Changes in %	
GDP	+0.11%
Fossil Fuel Output	-0.29%
Electricity Output	+0.04%
Real wages	+0.03% to +0.06%
Households consumption	+0.12% to +0.17%
Households fuel consumption	-8.9% to -9.4%

Total Rebound (R^T)	**66%**

$$R^T = \left(1 + \frac{\Delta FFC_{actual}}{\Delta FFC_{potential} * \alpha}\right) * 100$$

Rebound in consumption (R^C)	**6 to 9%**

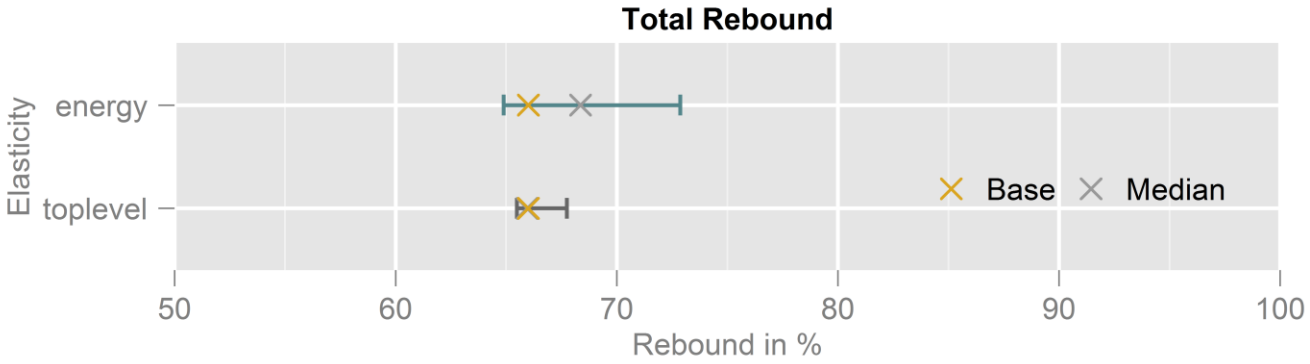
$$R^C = \left(1 + \frac{\Delta FFC_{actual}}{\Delta FFC_{potential}}\right) * 100$$

FEI Scenario – Sensitivity analysis (1)

Monte Carlo based sensitivity analysis of elasticities in private consumption

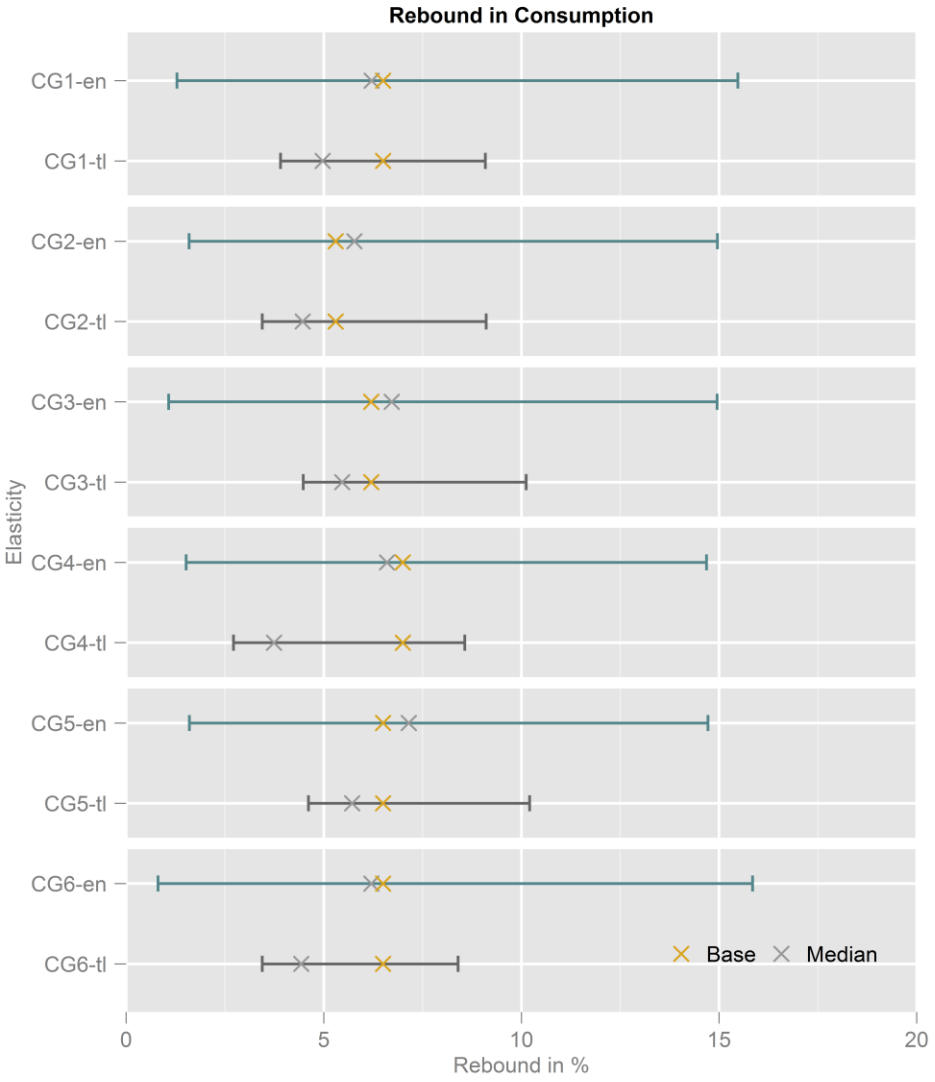
- "*energy elasticity*" between energy goods
- "*top level elasticity*" between material and energy goods

Randomized selection of values for each CG - [0.2 to 1.2]



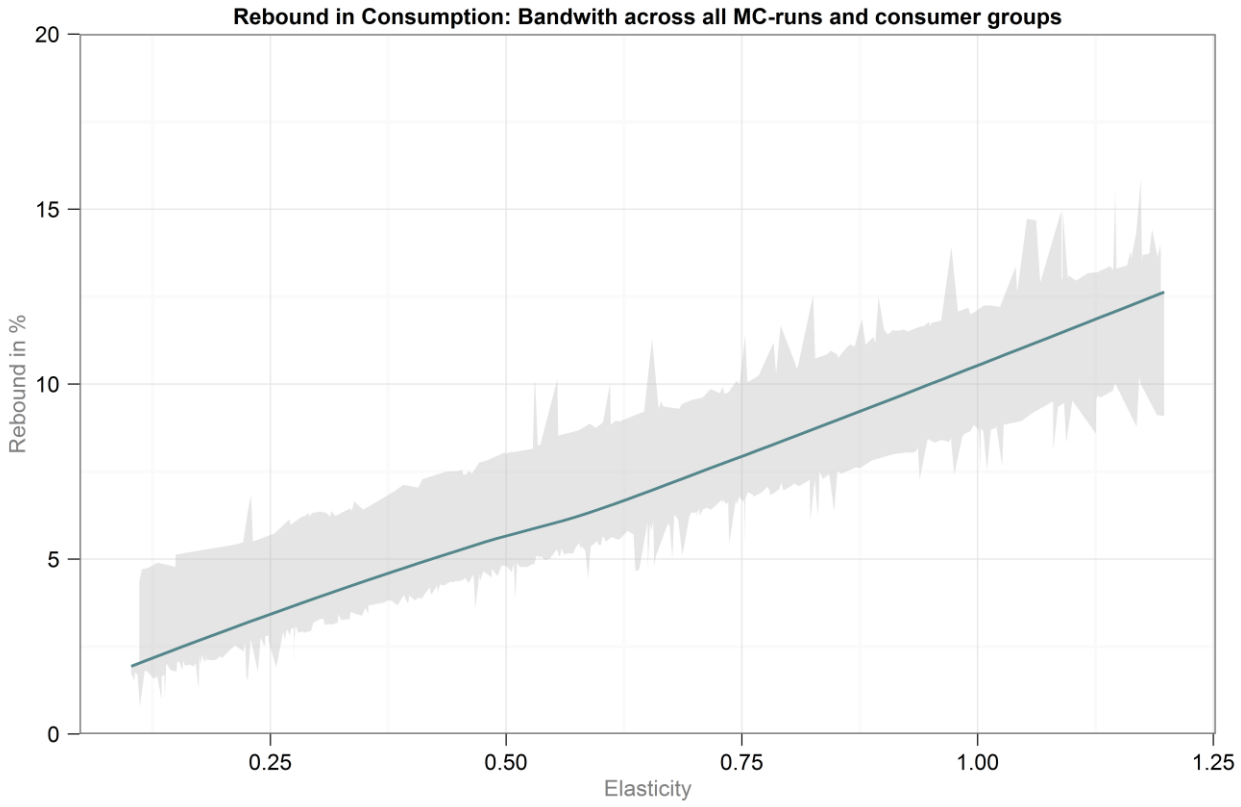
- **R^T is stable** and not strongly influenced by elasticity assumptions
- Household heterogeneity slightly affects economy-wide demand

FEI Scenario – Sensitivity analysis (2)



- **Energy elasticity** (en) impacts R^C across all CG
- Impact of top-level (tl) is clearly smaller
- Is there a relationship between R^C and energy elasticity?

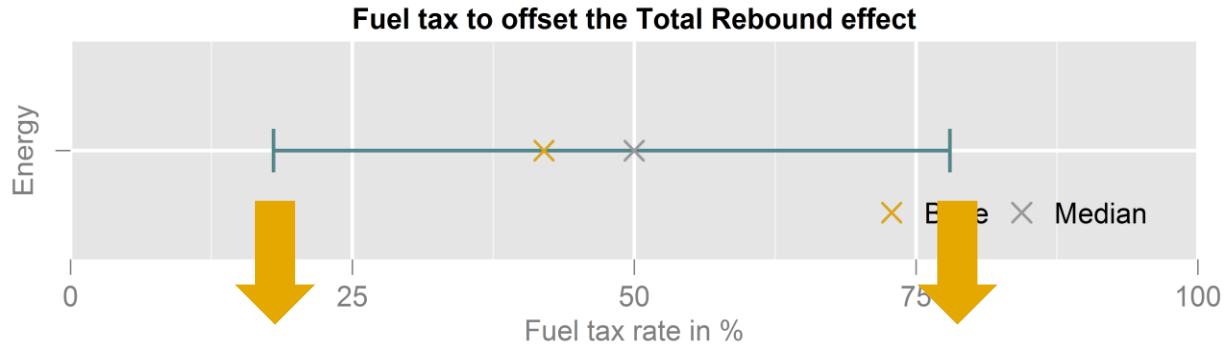
FEI Scenario – Sensitivity analysis (3)



- Trend: **Strong positive relationship**
- R^C depends on the mix of assumptions of all CG

Results FEI_tax Scenario

- 43% fuel tax to offset the Total Rebound of 66%
- However, tax rate depends highly on the assumption of the **energy elasticity of substitution** in private consumption



All CG: en > 1.1

All CG: en < 0.25

Negative relationship: Tax rate is lower in case of higher substitution possibilities between energy goods

Implications and outlook

- Macroeconomic rebound effect is rather high with 66%
  - R^T is quite stable and not strongly influenced by parameter assumptions
- Great variations in rebound neutralizing tax rate
- Two major shortcomings in macroeconomic impact analysis:
  I. Unreliable deviation of concrete policy measures
  II. No consideration of multiple household's with diverse market responses and preferences
- **Empirical observations** of critical parameters and robustness checks
- Next step: Derive empirical observations **from consumer survey** and improve quality of results on policy options that counteract rebound effect

CONTACT:

Veronika Kulmer
JOANNEUM RESEARCH
veronika.kulmer@joannem.at