Social, Environmental, and Macroeconomic Impacts of Introducing a CO_2 Tax for Non-ETS Sectors in Austria

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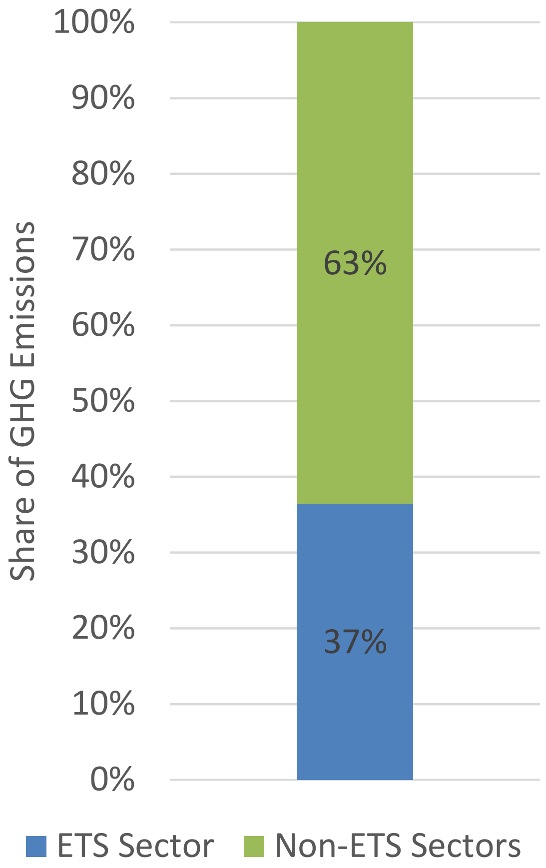
RESEARCH AIM & MOTIVATION

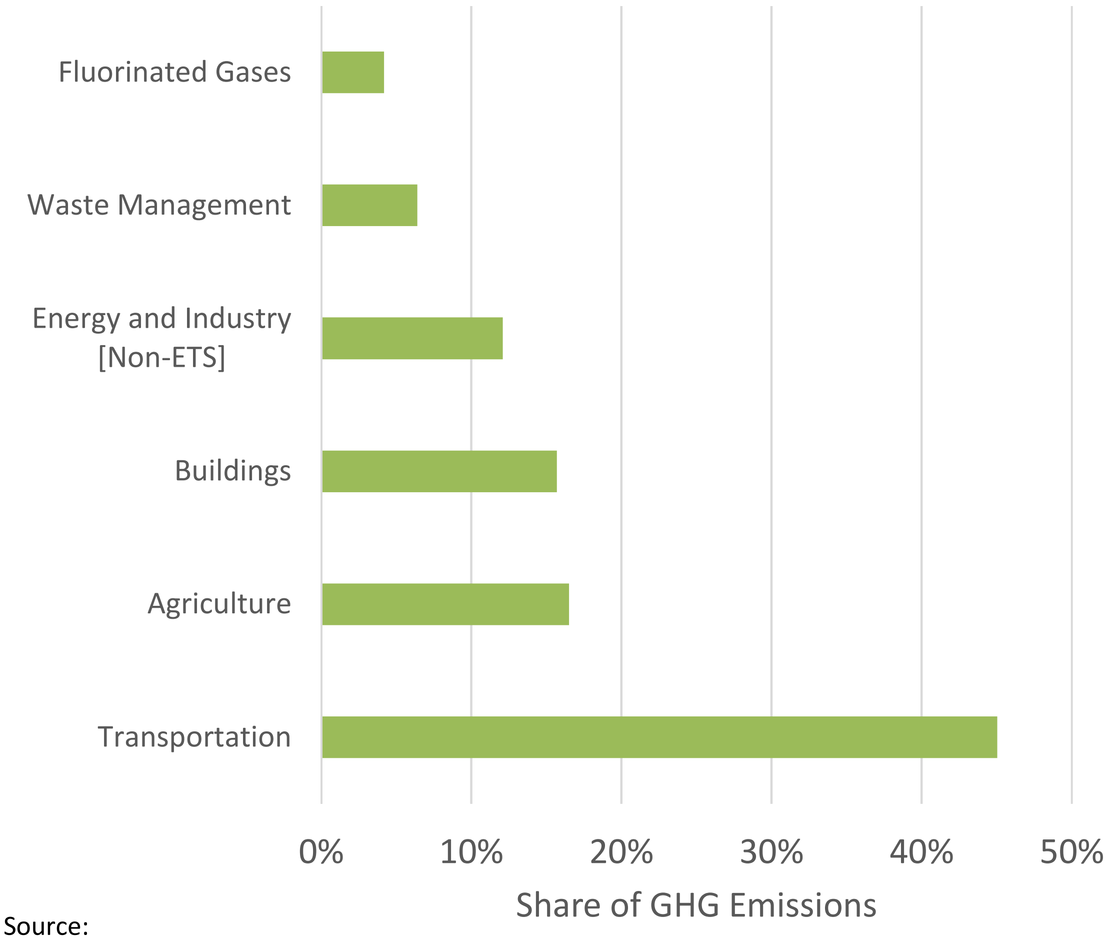
Research Aim

- 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)

- CO_2 taxes
  - How **effective** is the incentive?
  - What about **regressive** tax impacts on households?
  - What are the **macroeconomic** impacts?

GHG Emissions Austria 2014
Sectoral Shares





Source:
Austrian Environmental Agency

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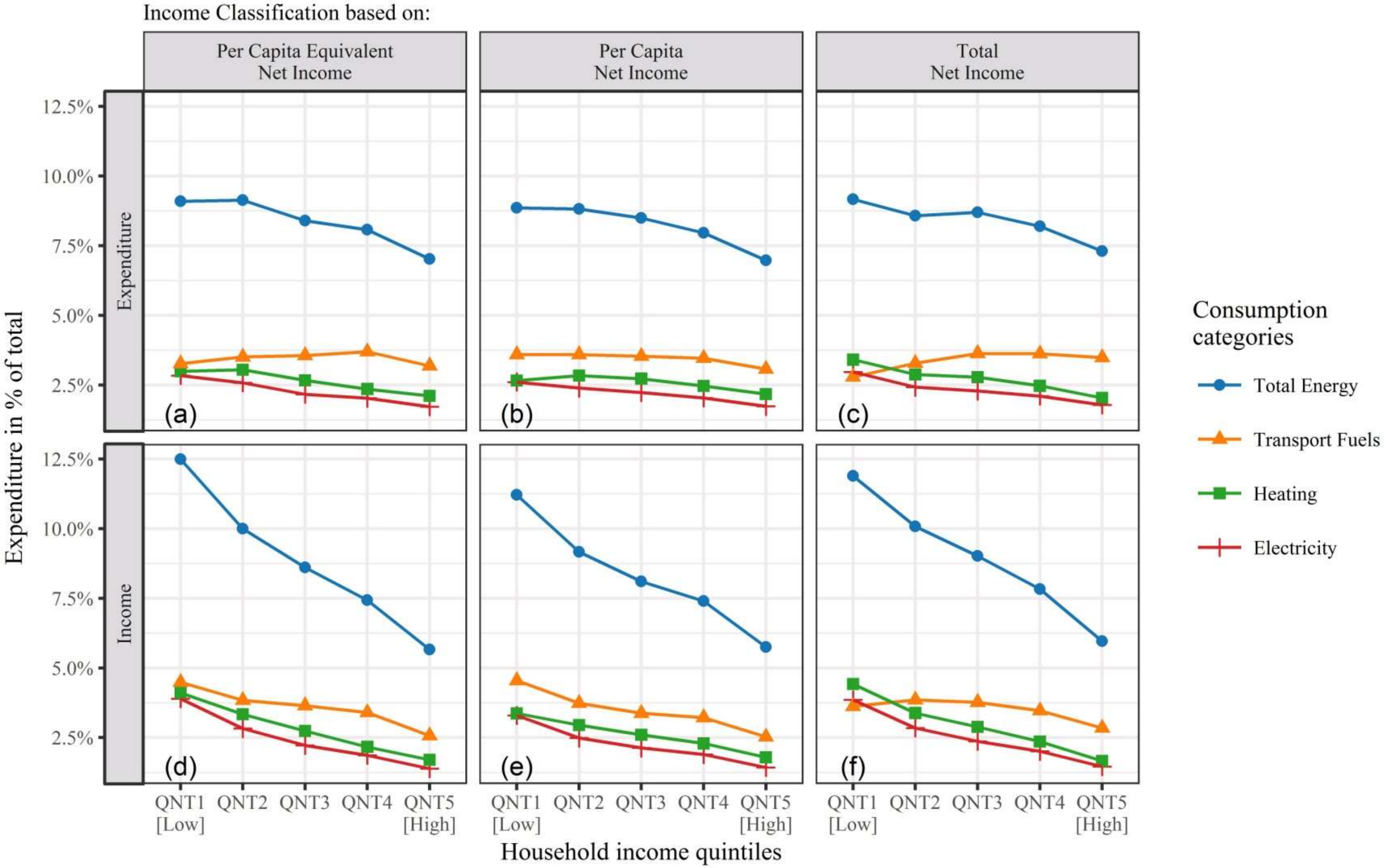
Household Income Quintiles Consumption Expenditure



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 → $KLEM^mM^d$ – 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 → 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**$M^m M^d$)
    - 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)
  - → considers rebound and income effects!
- **Household income quantiles**
  - Consideration of different income and consumption patterns

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SCENARIOS

Scenarios

- **What** will be taxed?
  - CO_2 content of **energy carriers**
    - diesel, gasoline, oil, gas and coal

- What will **NOT** be taxed?
  - Methane (CH_4), laughing gas (N_2O), other GHG & process related CO_2 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

Scenario Name	Explicit CO_2 tax (€/tCO_2)	Energy Tax	Implicit CO_2 tax rates for fossil fuels (€/tCO_2)				
			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

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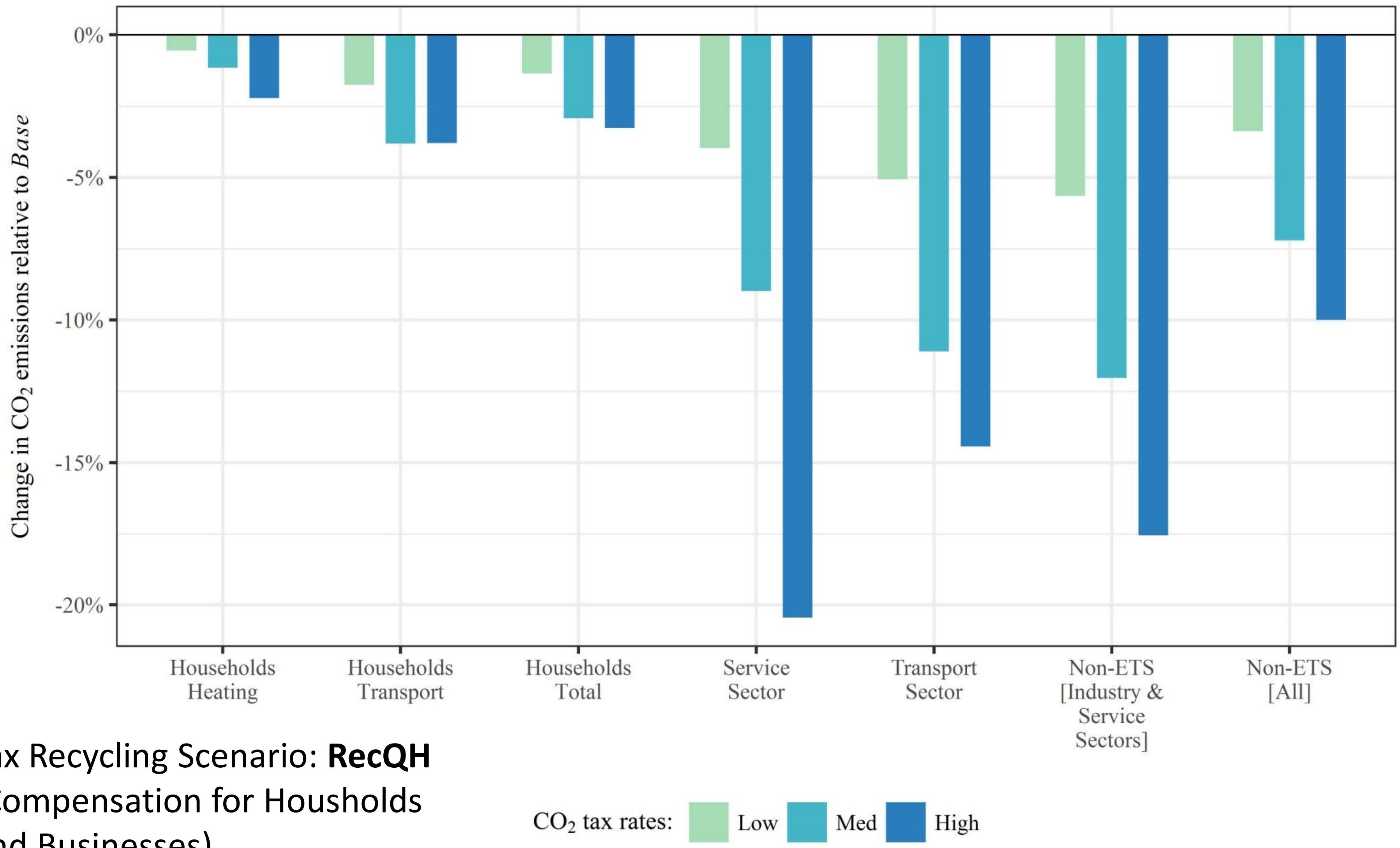
Scenarios
Compensation Schemes

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

SIMULATION RESULTS

(energy related) CO_2 Emissions

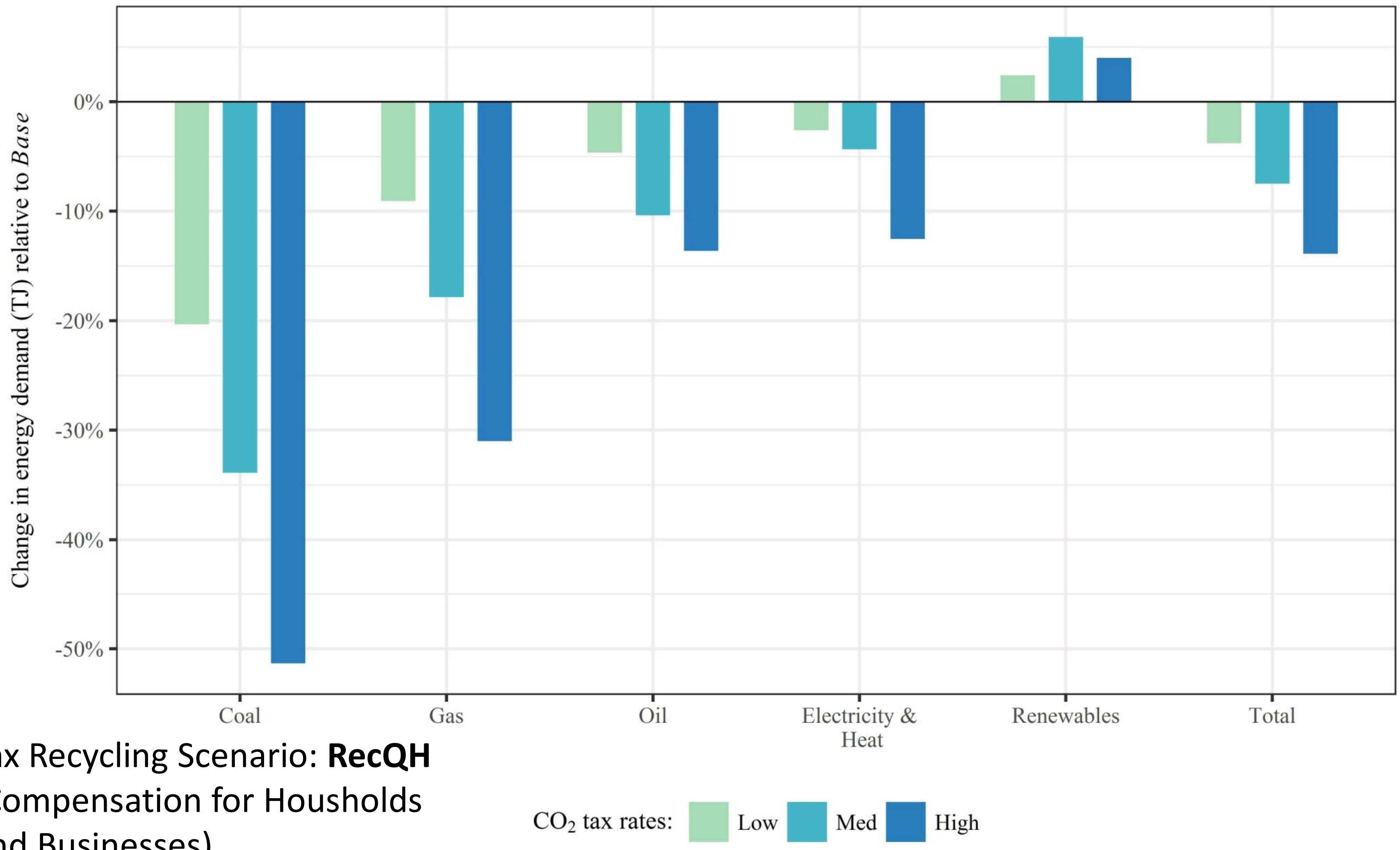
Short-Term Effects of CO_2 taxes



Tax Recycling Scenario: **RecQH** (Compensation for Housholds and Businesses)

Final Energy Consumption – Non-ETS

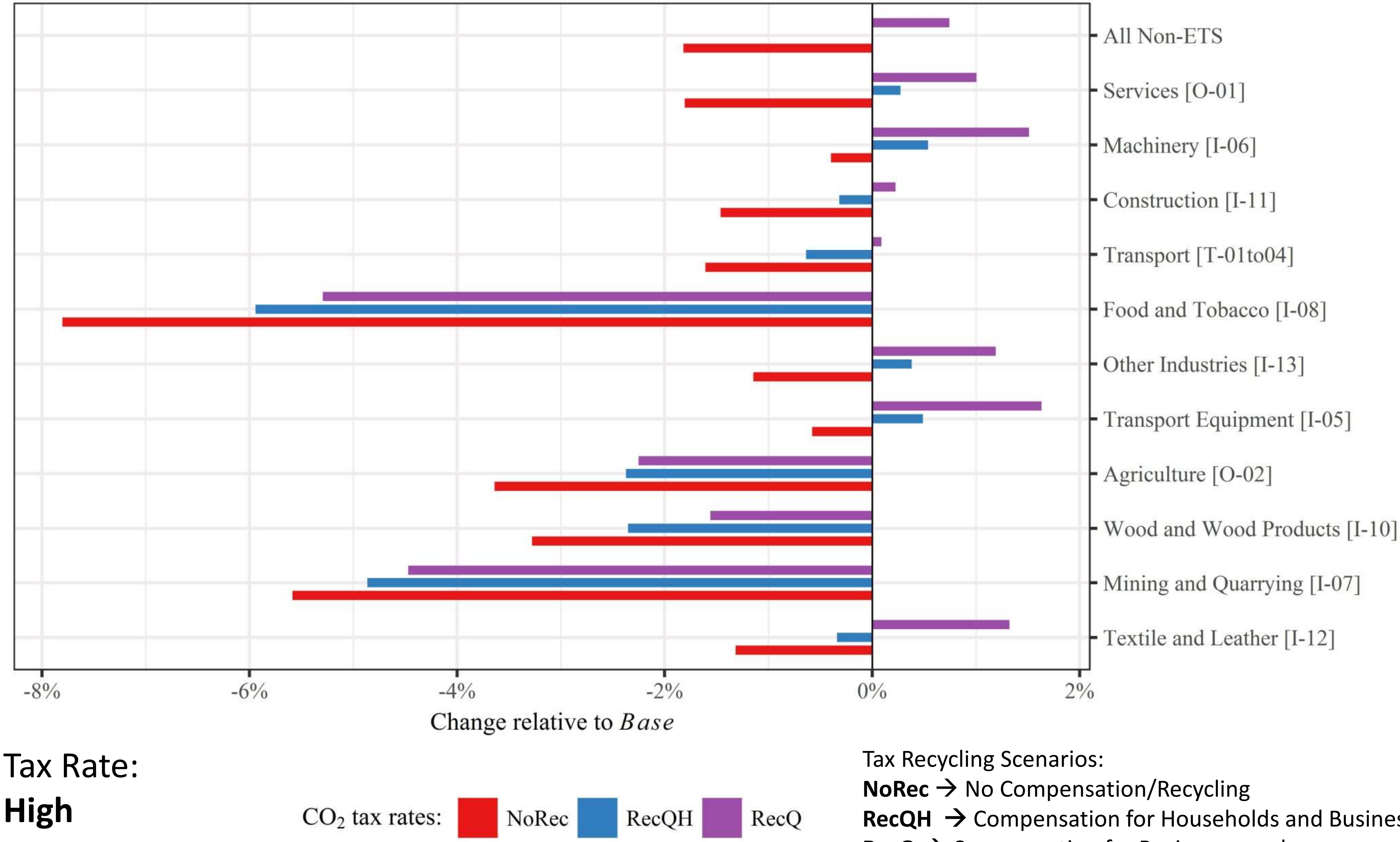
Short-Term Effects of CO_2 taxes



Tax Recycling Scenario: **RecQH**
(Compensation for Housholds
and Businesses)

Value Added – Non-ETS

Short-Term Effects of CO_2 taxes

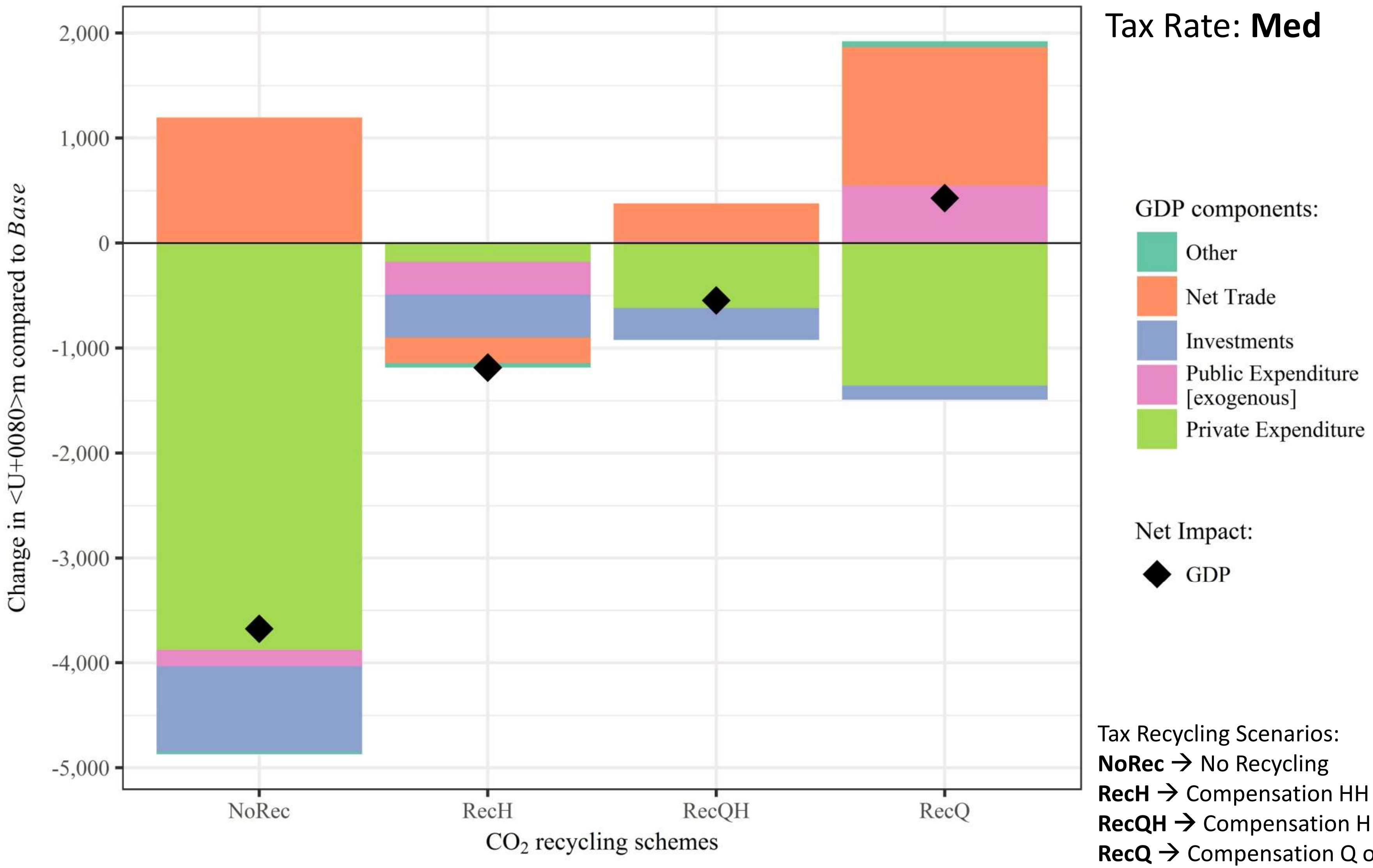


Tax Rate:
High

Tax Recycling Scenarios:
NoRec → No Compensation/Recycling
RecQH → Compensation for Households and Businesses
RecQ → Compensation for Businesses only

GDP impact (real) - Composition

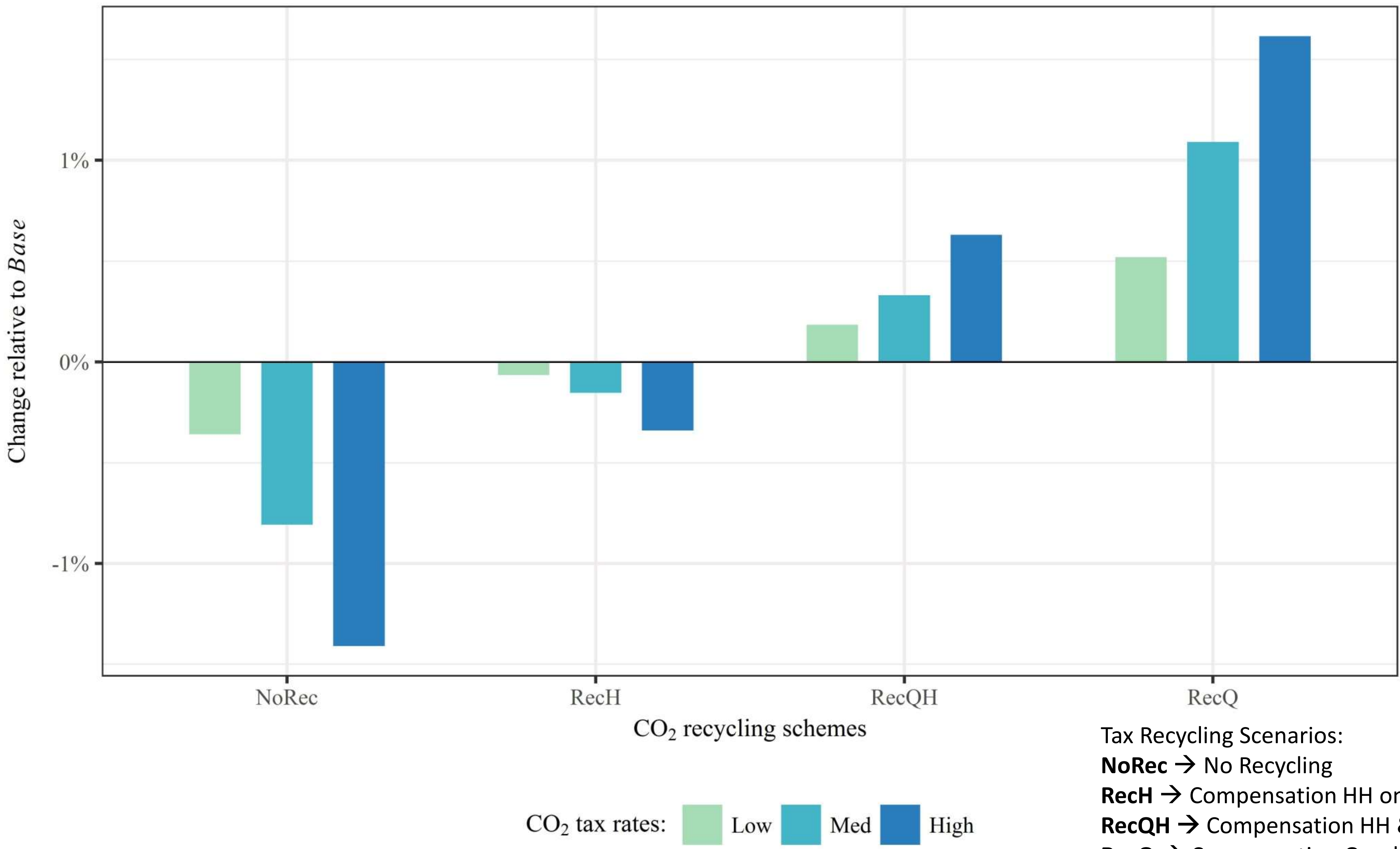
Short-Term Effects of CO_2 taxes



Tax Recycling Scenarios:
NoRec → No Recycling
RecH → Compensation HH only
RecQH → Compensation HH & Q
RecQ → Compensation Q only

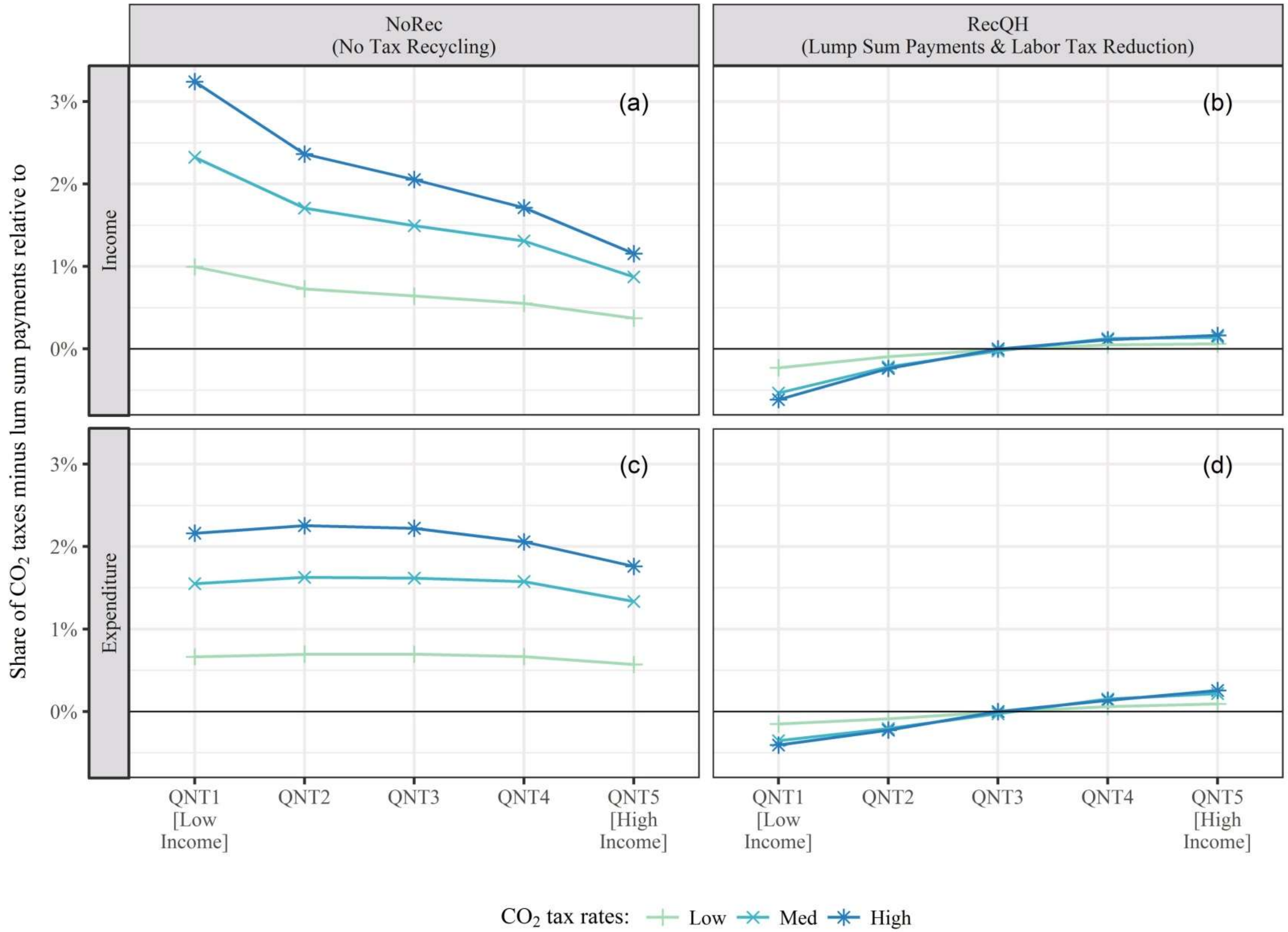
Employment

Short-Term Effects of CO_2 taxes

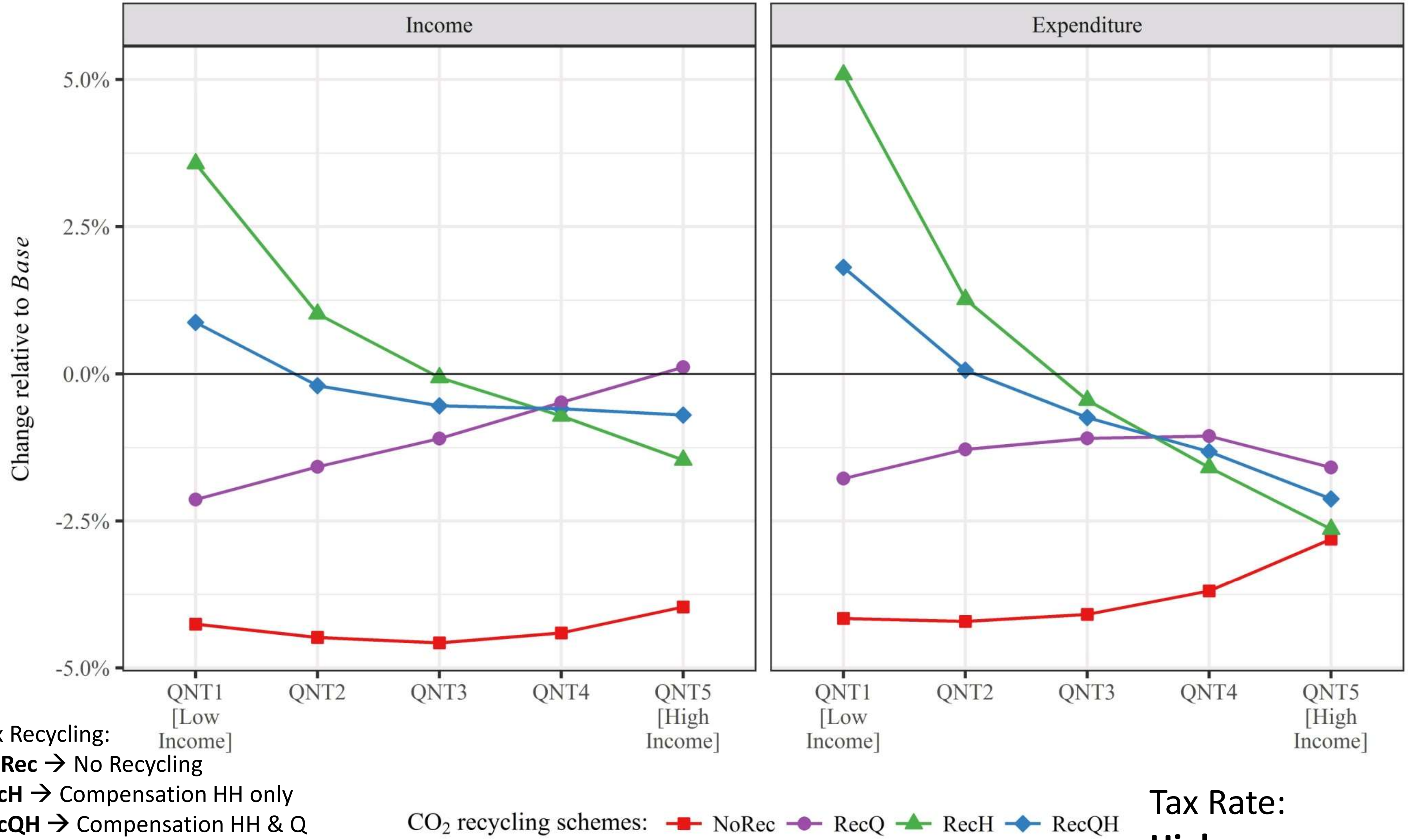


Tax Recycling Scenarios:
NoRec → No Recycling
RecH → Compensation HH only
RecQH → Compensation HH & Q
RecQ → Compensation Q only

CO_2 Tax Burden
Relative to Expenditure and Income
Short-Term Effects of CO_2 taxes



CO_2 Tax Burden
Change in income and expenditure (real)
Short-Term Effects of CO_2 taxes



Tax Recycling:
NoRec → No Recycling
RecH → Compensation HH only
RecQH → Compensation HH & Q
RecQ → Compensation Q only

Tax Rate:
High

CONCLUSIONS

Summary

- Energy related CO_2-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

Summary

- Tax Burden depends on indicator:
  - Regressive (tax/income, Δ real expenditure)
  - Proportional (tax/expenditure)
  - U-Shaped (Δ 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

Conclusions

- A carefully designed CO_2 tax can contribute to both
  - a strong **double dividend**, i.e.:
    - considerable reductions in CO_2 in the short term
    - positive/non-negative impacts on GDP
    - increases in employment
  - more **equity** across household income groups.

- Possible **trade-off** between **efficiency & equity**:
  - Implement both lump-sum eco payments and labor tax cuts for businesses?

THANKS!

APPENDIX

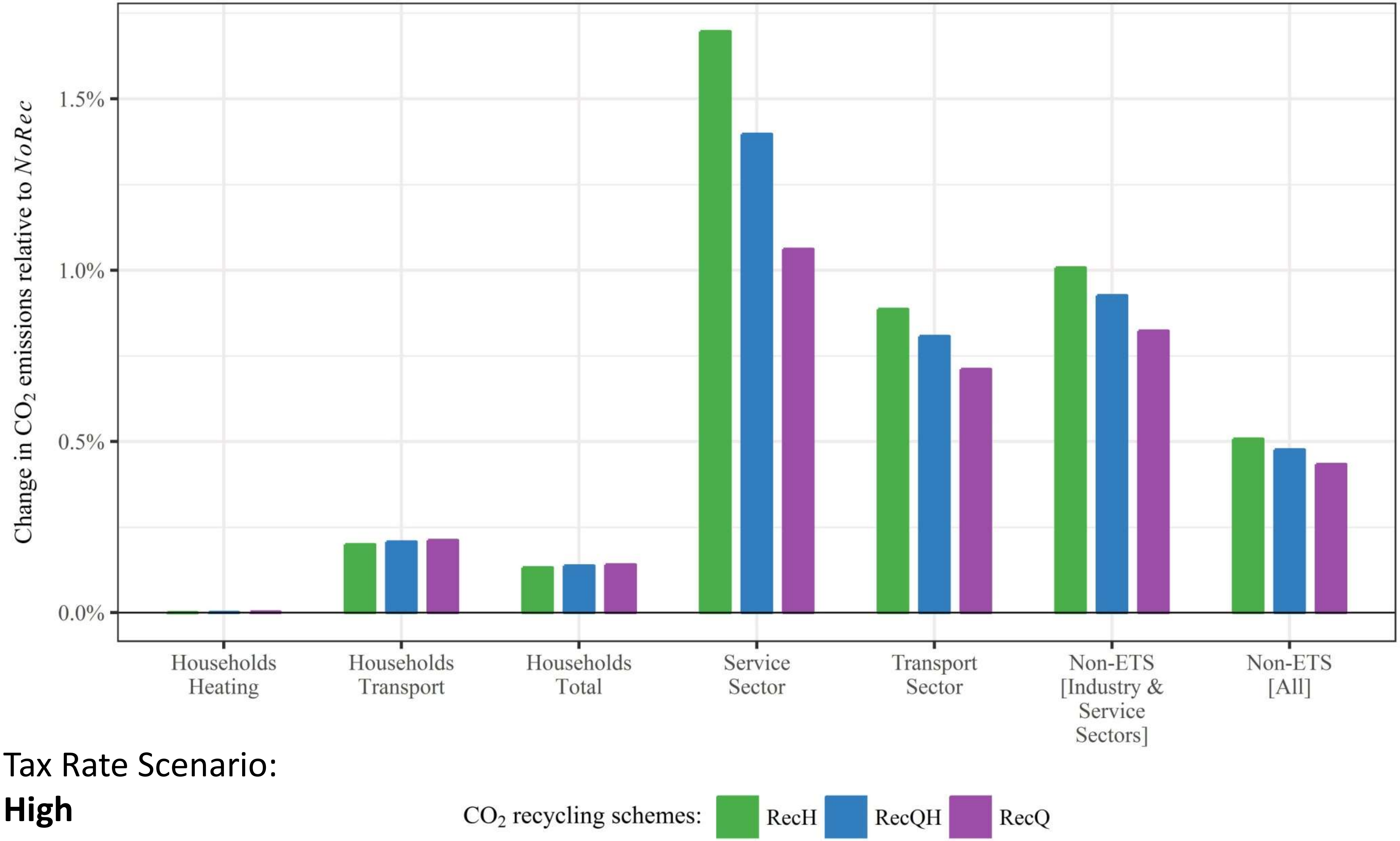
Caveats

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

RESULTS

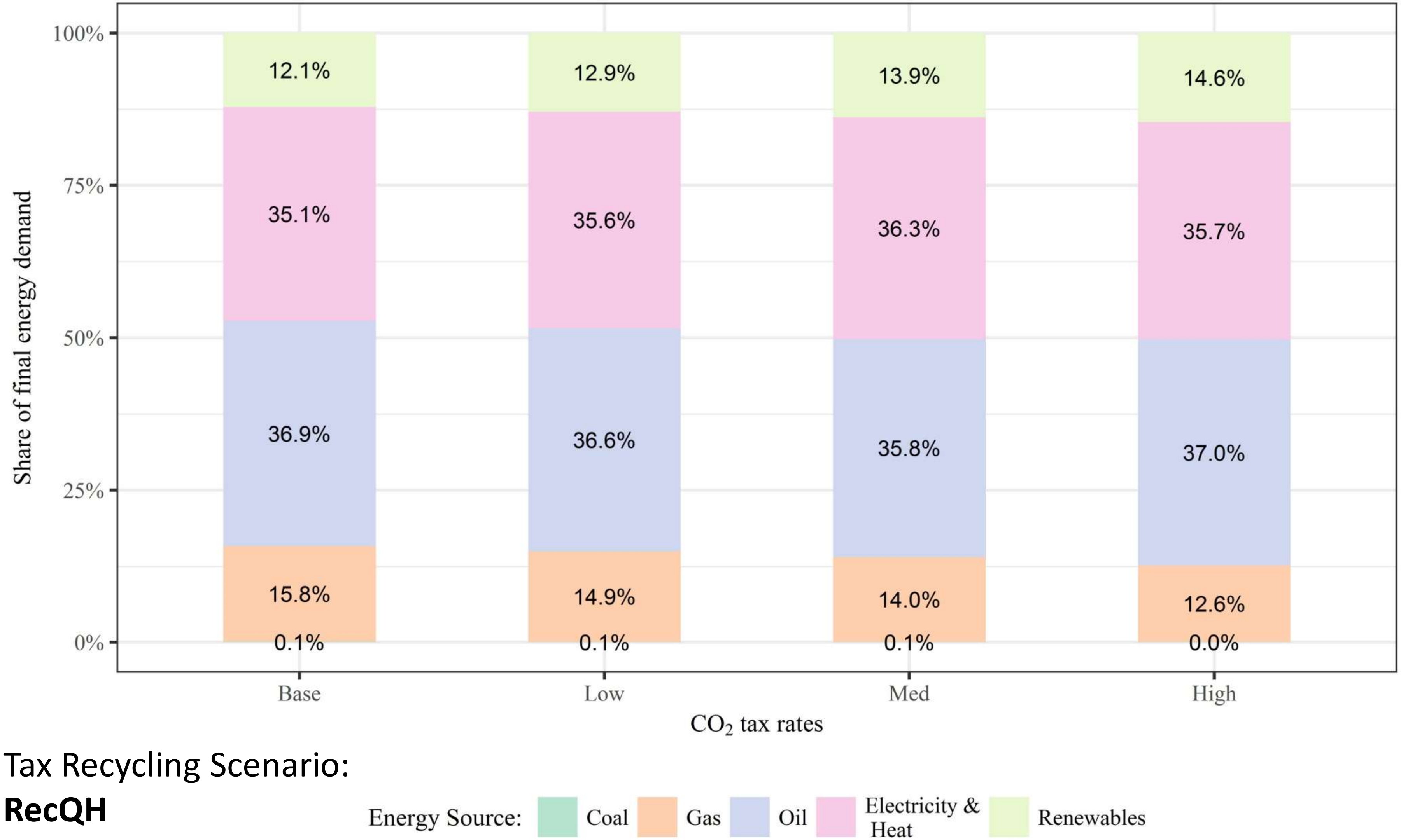
(energy related) CO_2 Emissions Rebound Effects of Tax Recycling

Short-Term Effects of CO_2 taxes



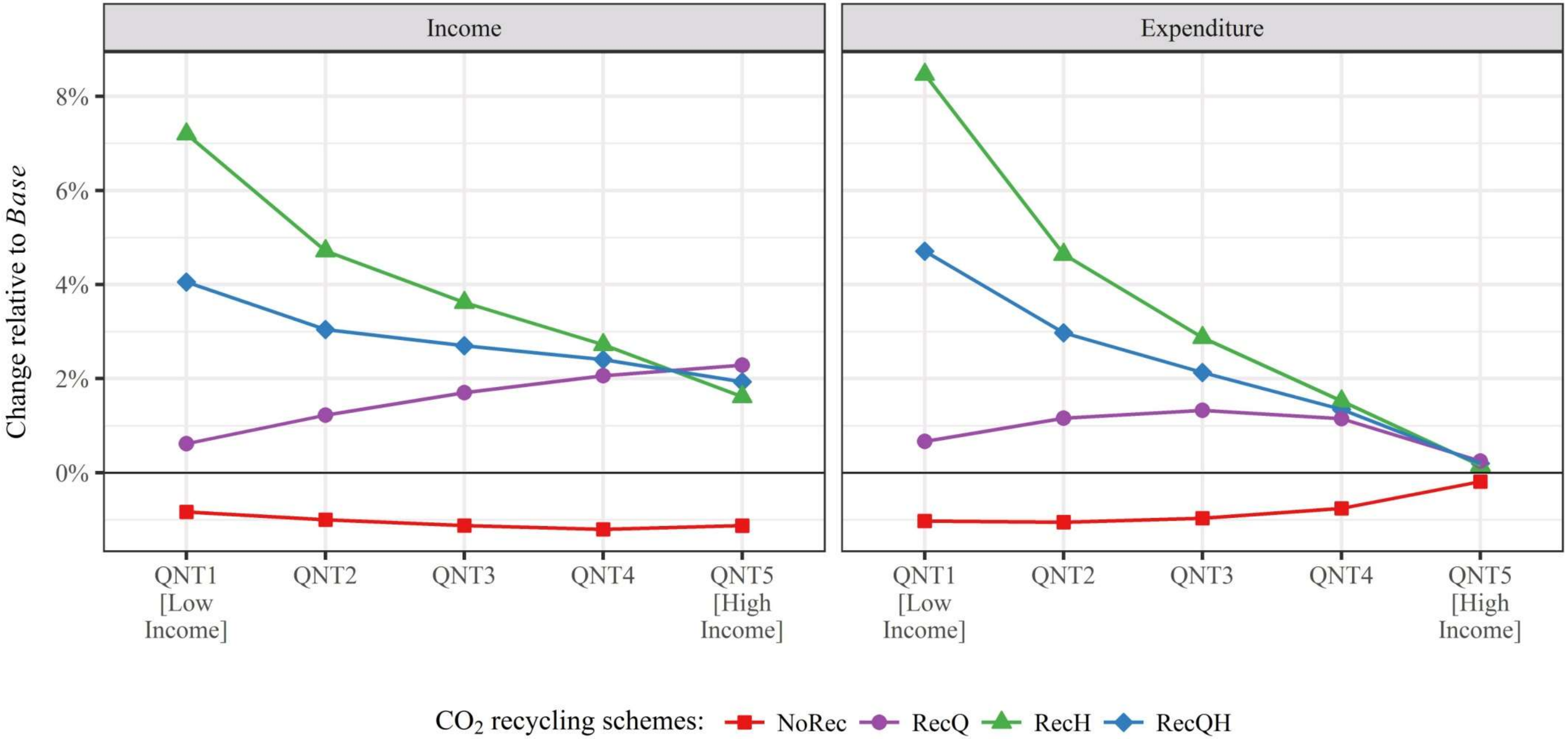
Tax Rate Scenario:
High

Change in energy carriers
Non-ETS



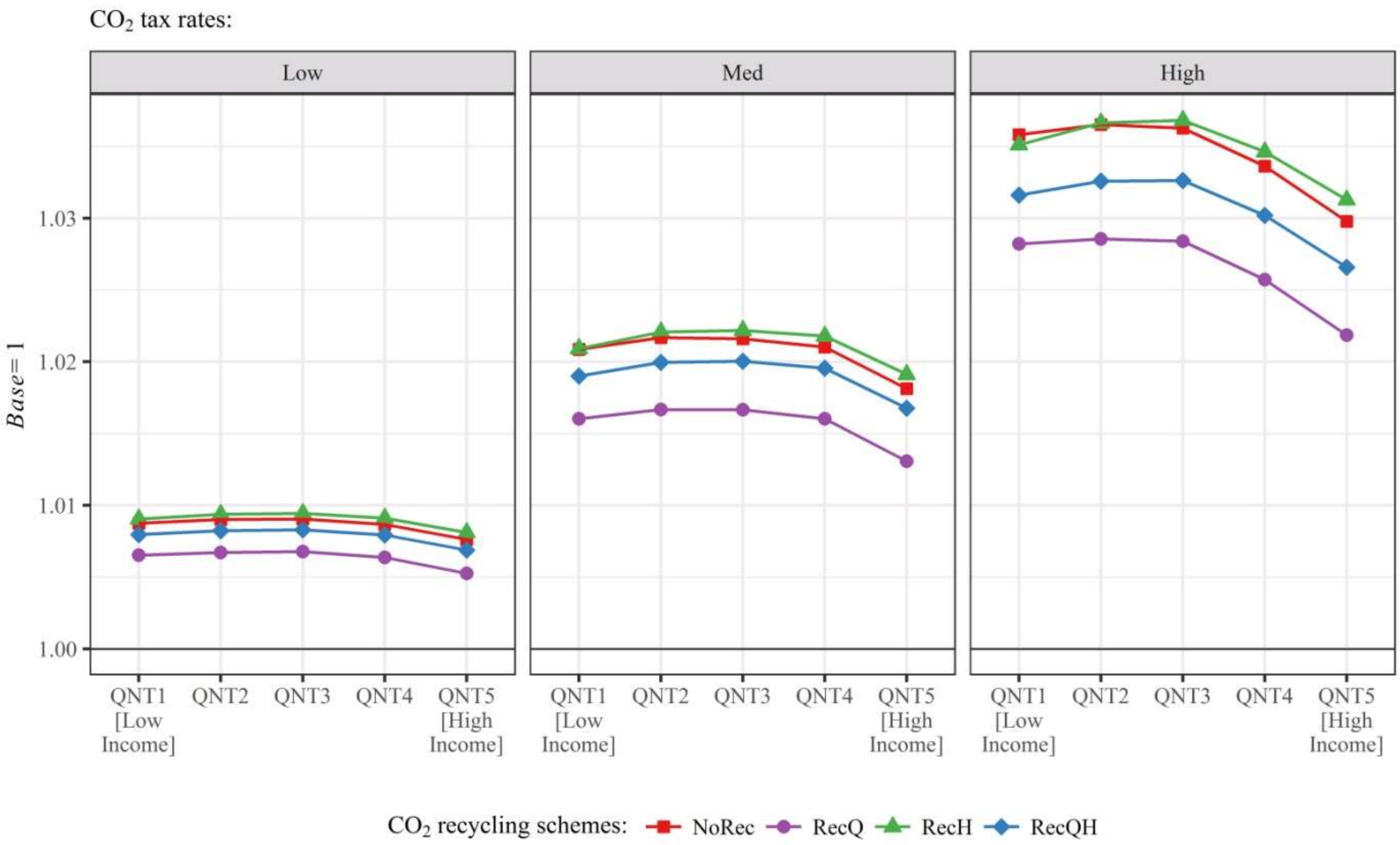
Tax Recycling Scenario:
RecQH

CO_2 Tax Burden
Change in income and expenditure (nominal)
Short-Term Effects of CO_2 taxes



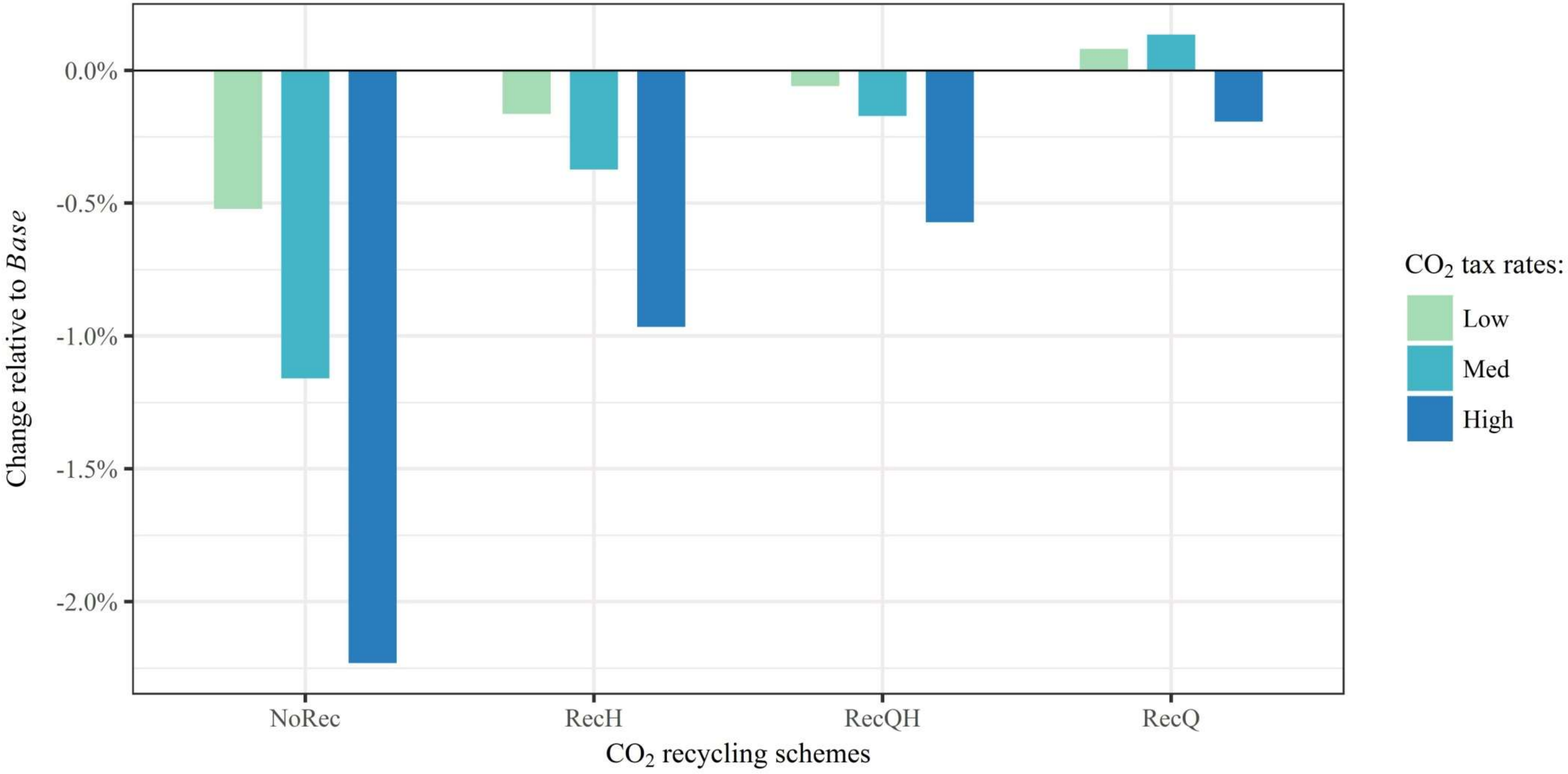
Tax Rate:
High

CO_2 Tax Burden
Change in Consumer Price Index (CPI)
Short-Term Effects of CO_2 taxes



GDP impact (real) - Range

Short-Term Effects of CO_2 taxes



SENSITIVITY SCENARIOS

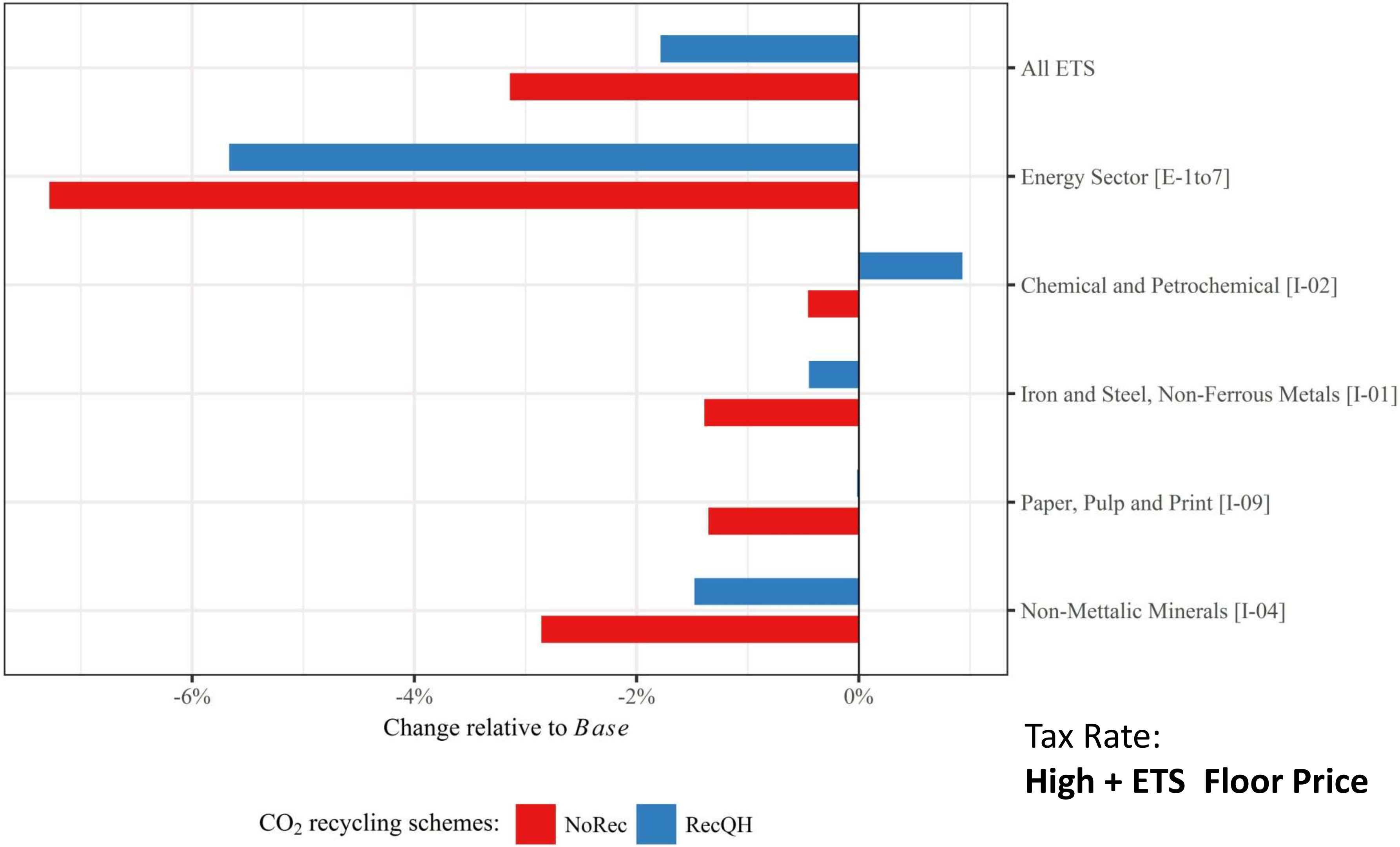
CO_2 Emissions – ETS

Short-Term Effects of CO_2 taxes

Tax Scenario:
Rate: **Med + ETS Floor Price**
Recycling: **RecQ**

Value Added – ETS

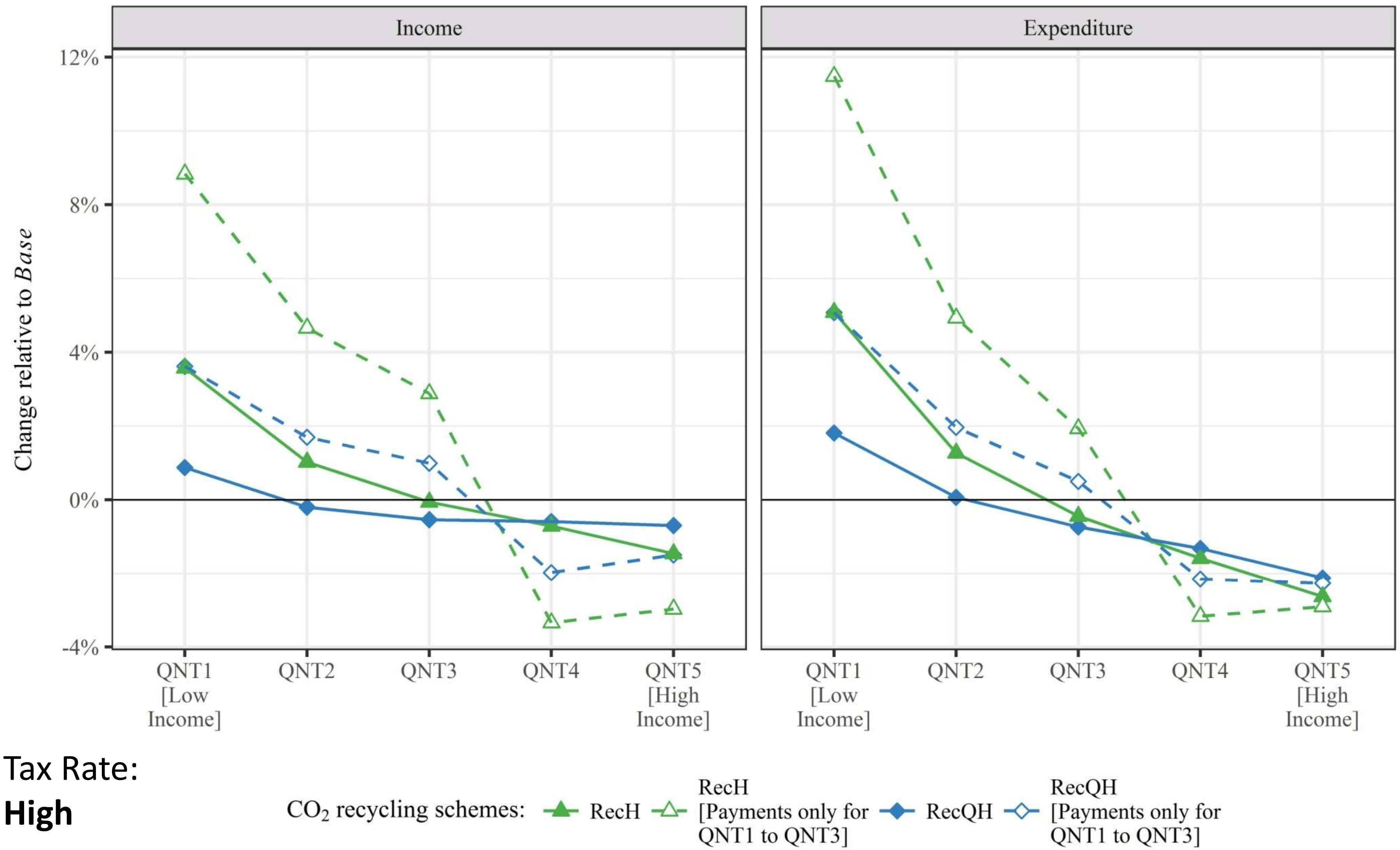
Short-Term Effects of CO_2 taxes



Tax Rate:

High + ETS Floor Price

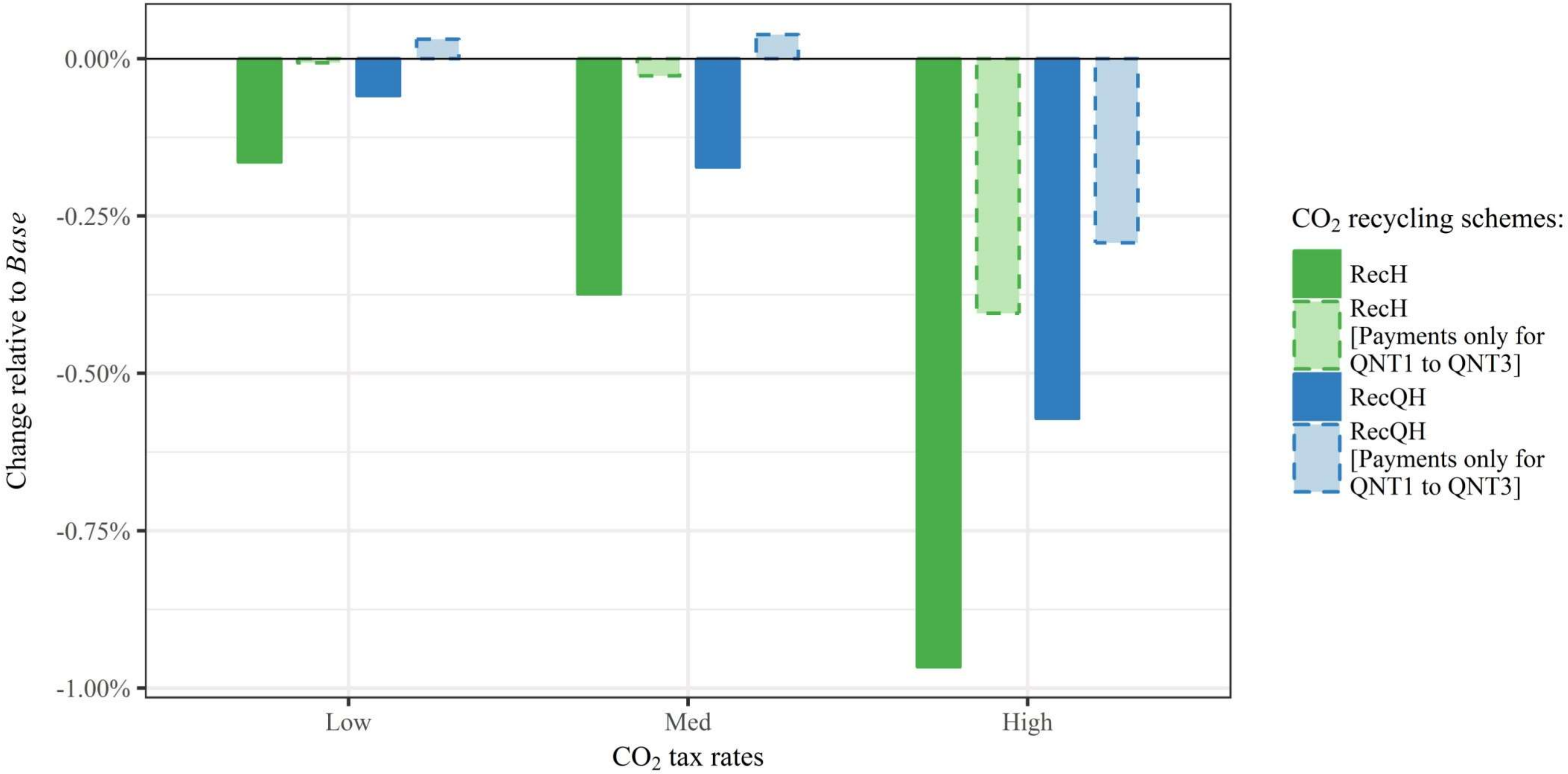
CO_2 Tax Burden
Relative to Expenditure and Income
Short-Term Effects of CO_2 taxes



Tax Rate:
High

GDP impact (real) - Range

Short-Term Effects of CO_2 taxes



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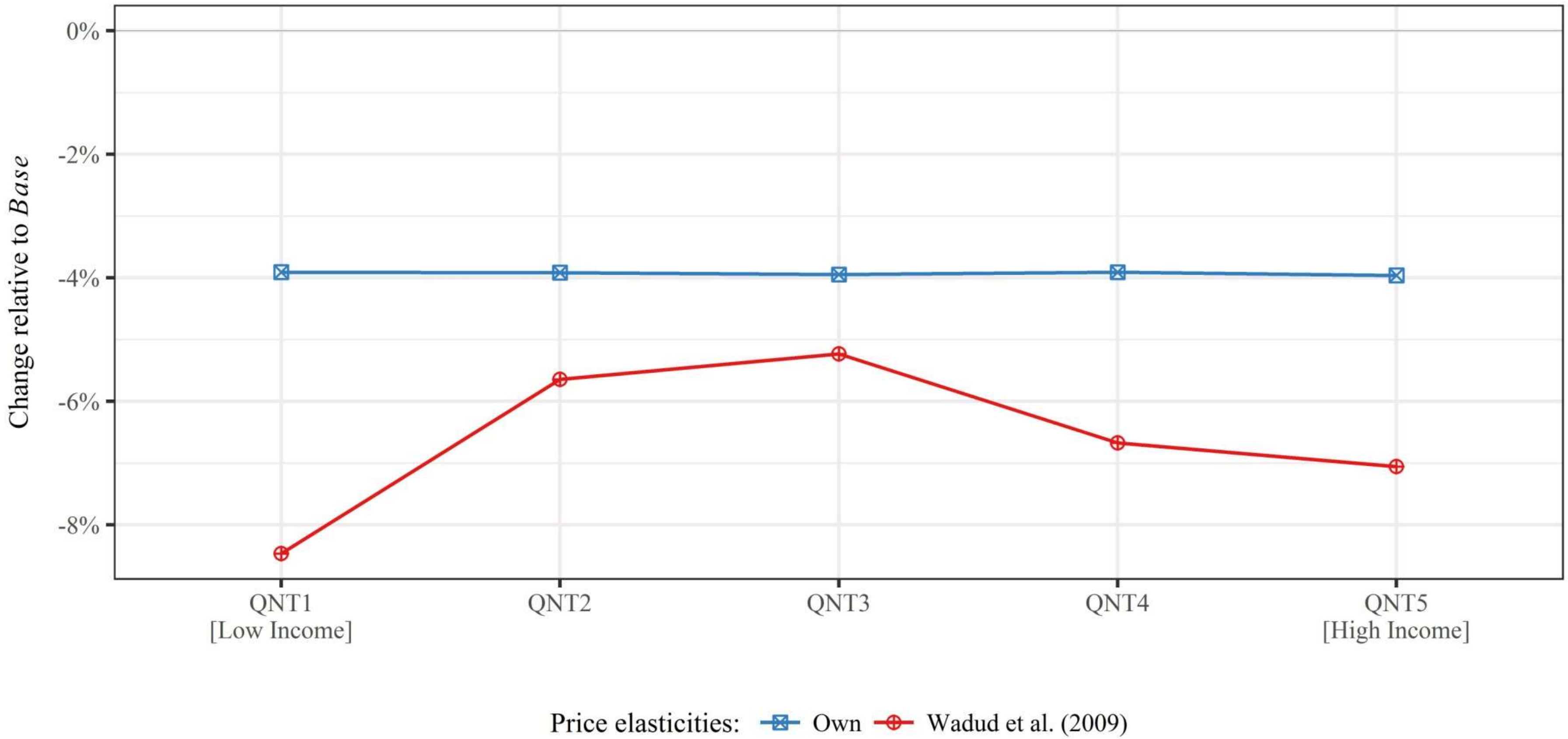
Wadud et al. (2009)
Differentiated price elasticities

Short-Term Effects of CO_2 taxes

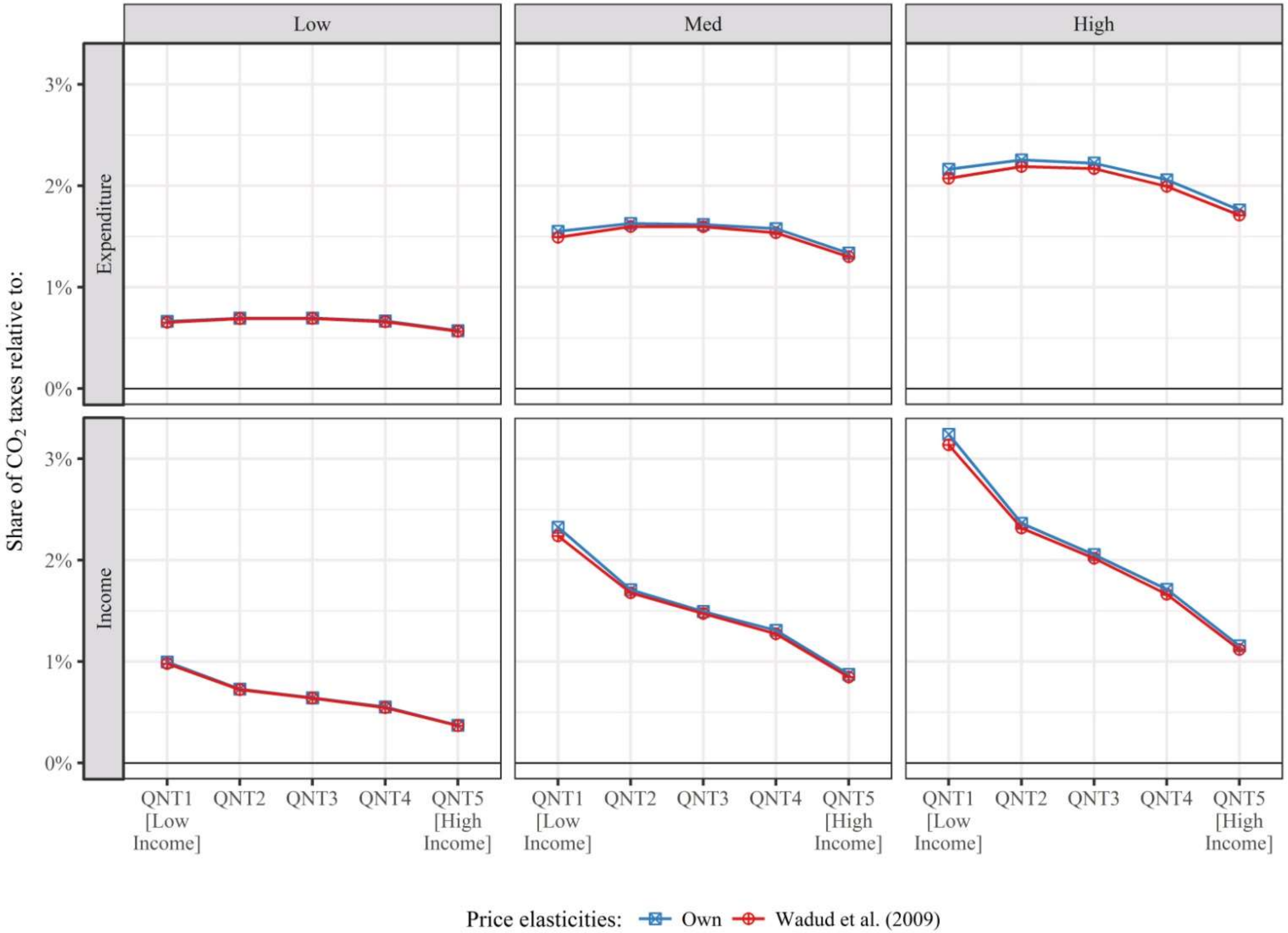
Difference in CO_2 emissions from transport fuels if household income quintiles react differently to changes in fuel prices for the scenario *Med* & *NoRec*.



Wadud et al. (2009)
Differentiated price elasticities

Short-Term Effects of CO_2 taxes

Tax burden impact for quintile differentiated fuel price elasticities and our CO_2 tax rate scenarios (Tax recycling scenario: *NoRec*).



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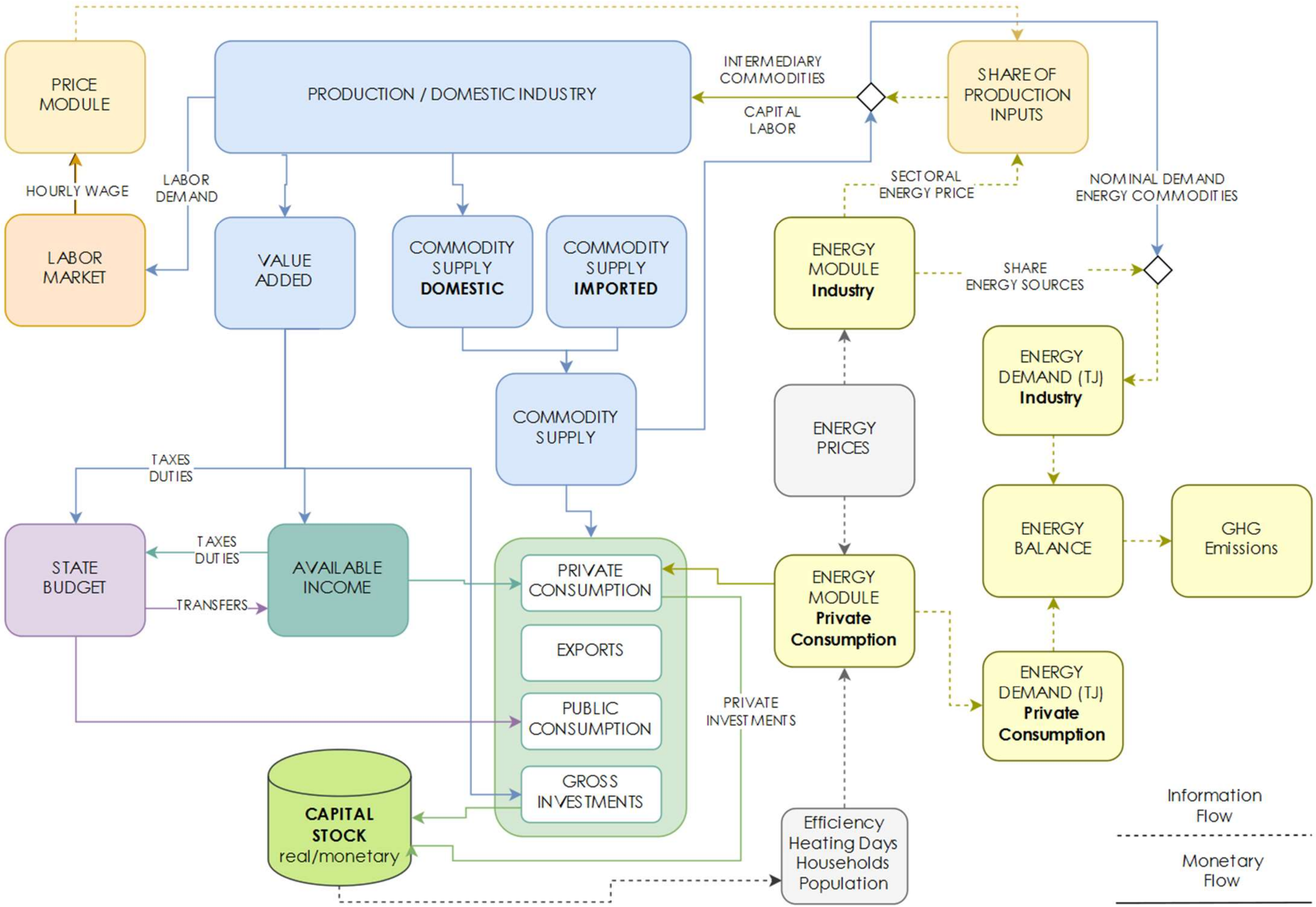
MODEL

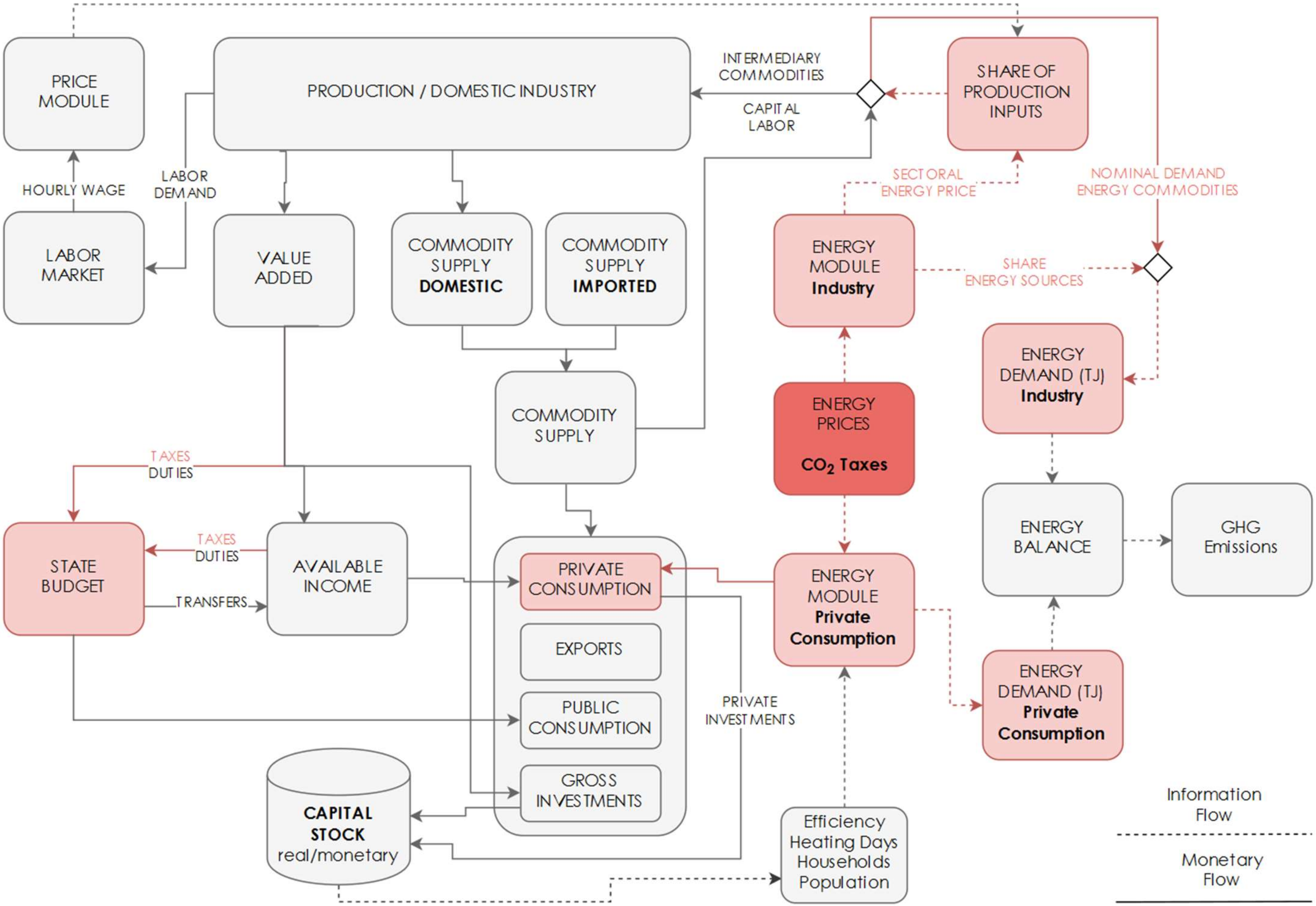

PRICE MODULE
HOURLY WAGE
LABOR MARKET
LABOR DEMAND
PRODUCTION / DOMESTIC INDUSTRY
INTERMEDIARY COMMODITIES
CAPITAL LABOR
SHARE OF PRODUCTION INPUTS
SECTORAL ENERGY PRICE
NOMINAL DEMAND ENERGY COMMODITIES
VALUE ADDED
COMMODITY SUPPLY DOMESTIC
COMMODITY SUPPLY IMPORTED
ENERGY MODULE Industry
SHARE ENERGY SOURCES
ENERGY DEMAND (TJ) Industry
COMMODITY SUPPLY
ENERGY PRICES
TAXES DUTIES
STATE BUDGET
TAXES DUTIES
AVAILABLE INCOME
TRANSFERS
PRIVATE CONSUMPTION
EXPORTS
PUBLIC CONSUMPTION
GROSS INVESTMENTS
PRIVATE INVESTMENTS
ENERGY MODULE Private Consumption
ENERGY BALANCE
GHG Emissions
ENERGY DEMAND (TJ) Private Consumption
CAPITAL STOCK real/monetary
Efficiency Heating Days Households Population
Information Flow
Monetary Flow

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)
  - CO_2-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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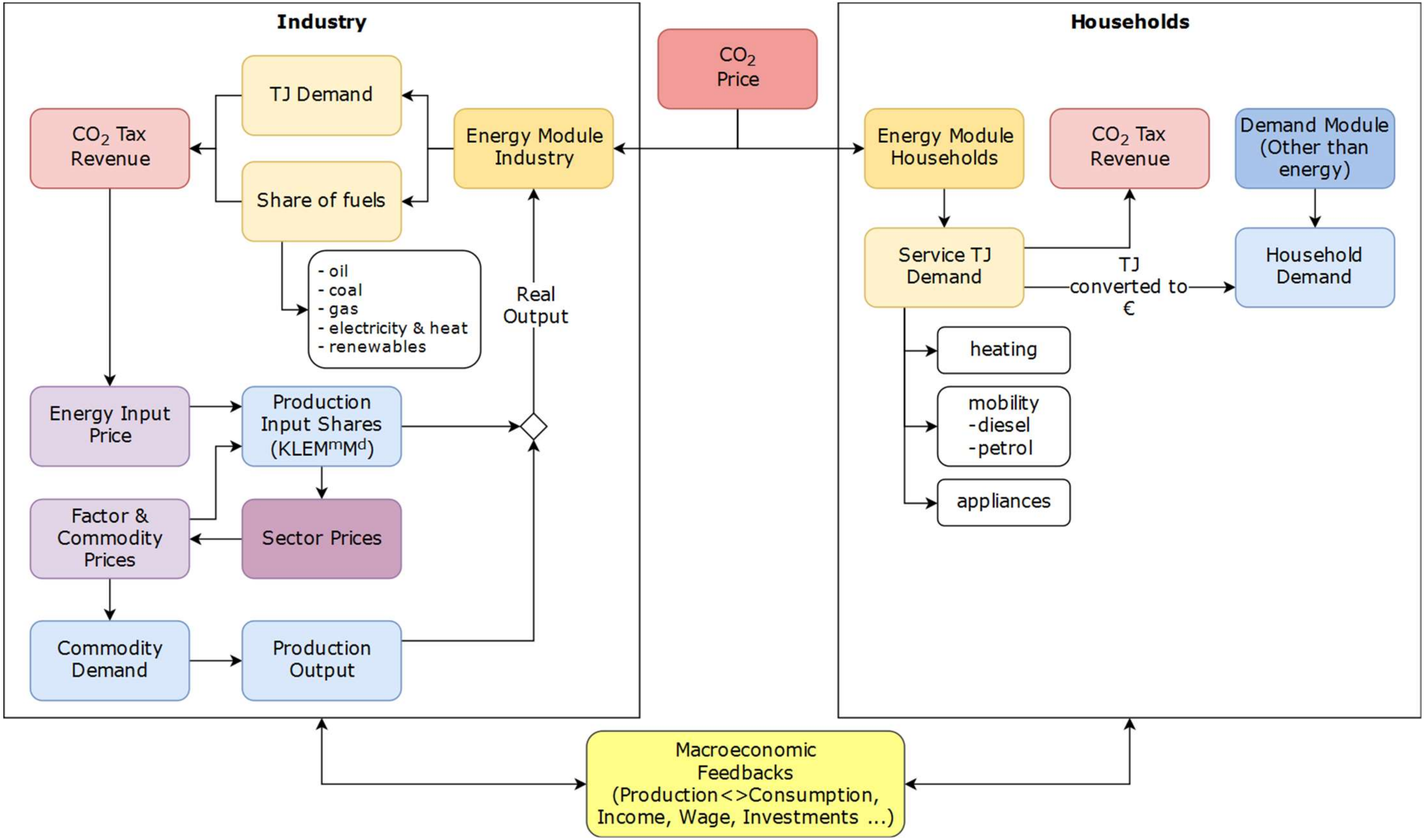
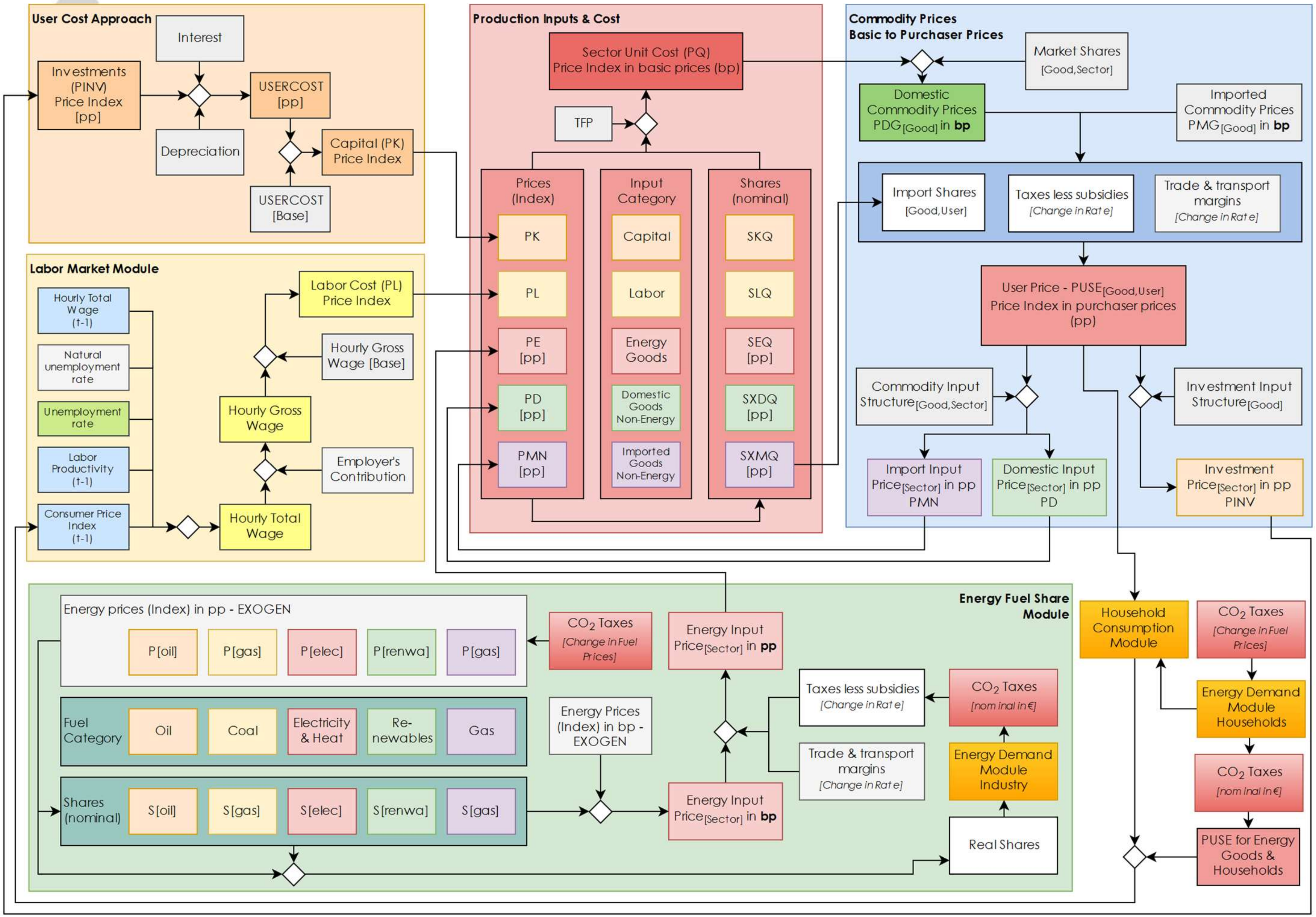
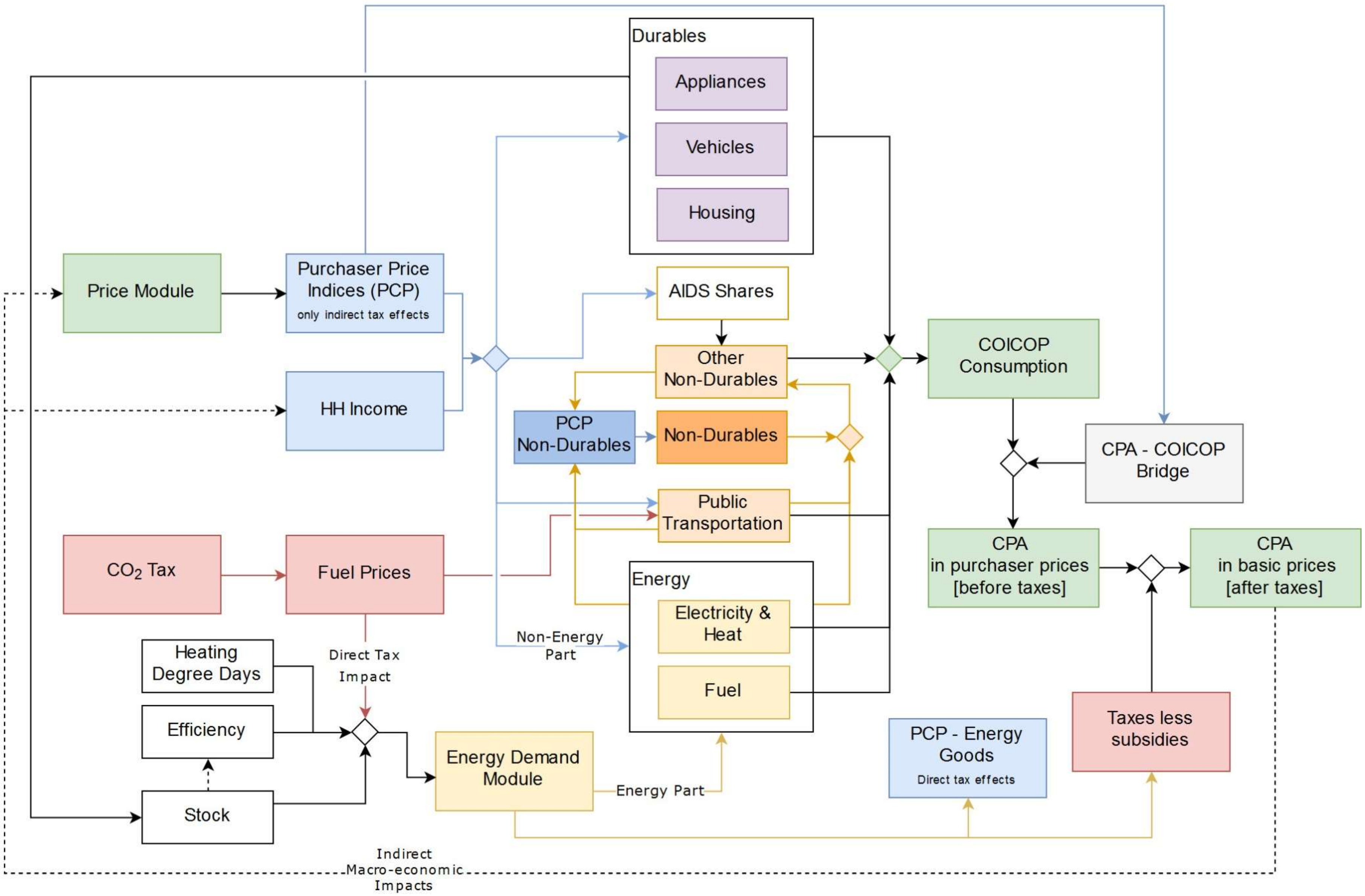
DYNK
CO_2 Tax Impact Chains



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
  - l … labor
  - e … energy commodities
  - m … non-energy imported commodities
  - t … time
  - ρ … factor bias

Source: WIOD

Modelling Production Fuel Input Shares

- Example: Oil

$$= \alpha_o + \gamma_{og,j} \log\left(\frac{Pgas_j}{Pelecheat_j}\right) + \gamma_{or,j} \log\left(\frac{Prenwa_j}{Pelecheat_j}\right) + \gamma_{oc,j} \log\left(\frac{Pcoal_j}{Pelecheat_j}\right)$$

$$+ \gamma_{oo,j} \log\left(\frac{Poil_j}{Pelecheat_j}\right) + \rho_{k,j} t$$

  - 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) :
    - γ_{yd} = -0.62 (income)
    - γ_{pp} = -0.75 (own price)
    - γ_{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):
    - γ_{ps} = -0.04 (own-price)
    - γ_{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) :
    - γ_{ps} = -0.218 (own service-price)
    - γ_{stock}= -3.34 (stock)
    - γ_{time}= 0.0278 (time)

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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

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.

Modelling Hourly Wage

- 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

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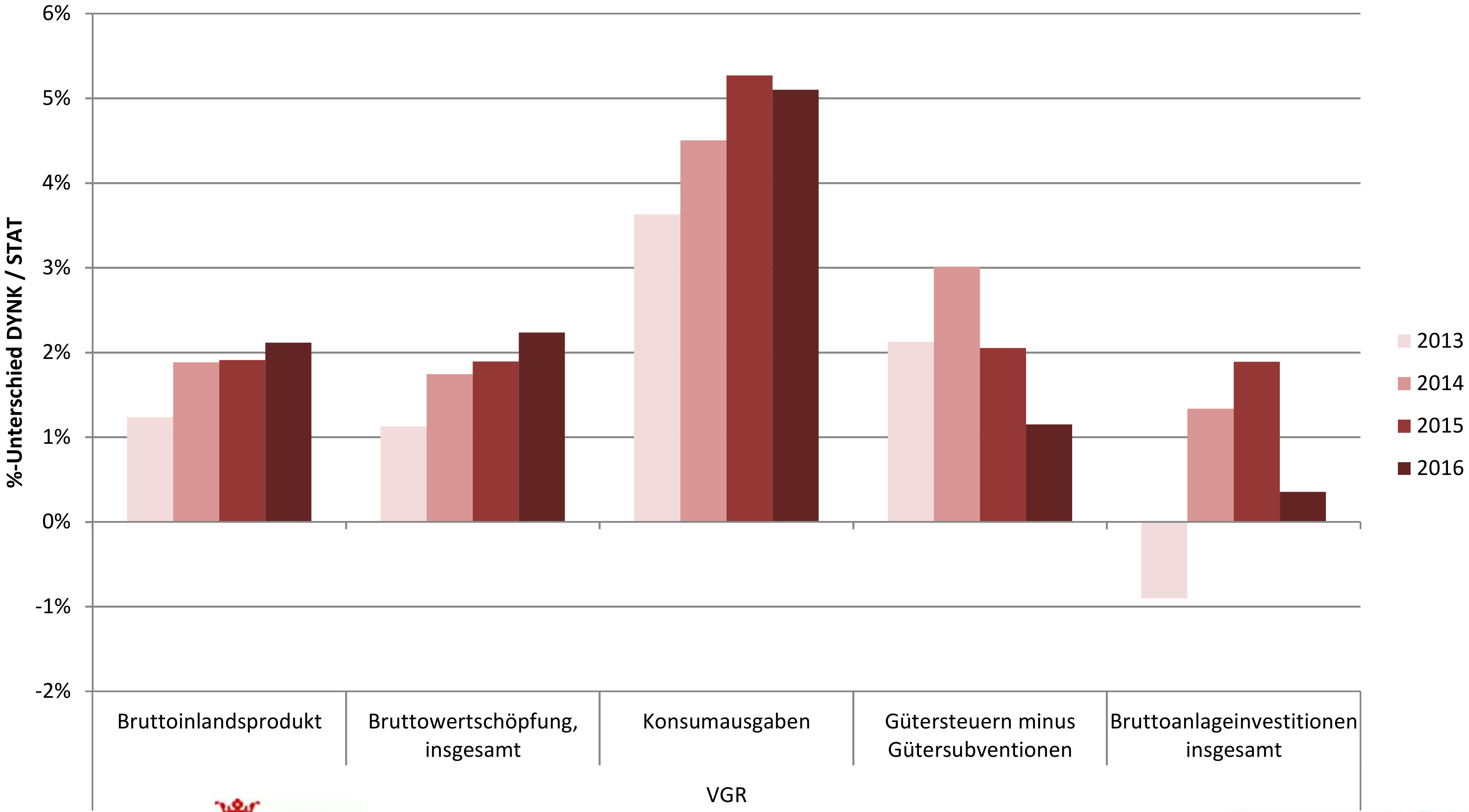
Überblick – DYNK vs. VGR



Überblick – DYNK vs. Energiebilanz