Assessing socio-economic and environmental impacts of CO2 taxes with the econometric input-output model DYNK

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Research Aim

- How do reduce emissions in non-ETS sectors (transport, service sector, private heating & mobility)?
- Effort Sharing:
  - -16% until 2020 (vs. 2005) in Austria

- CO2 taxes?
  - Essential part of an policy instrument mix
  - How effective is the incentive?
  - What about **regressive** tax impacts on households?

THG nach Sektoren - AUT

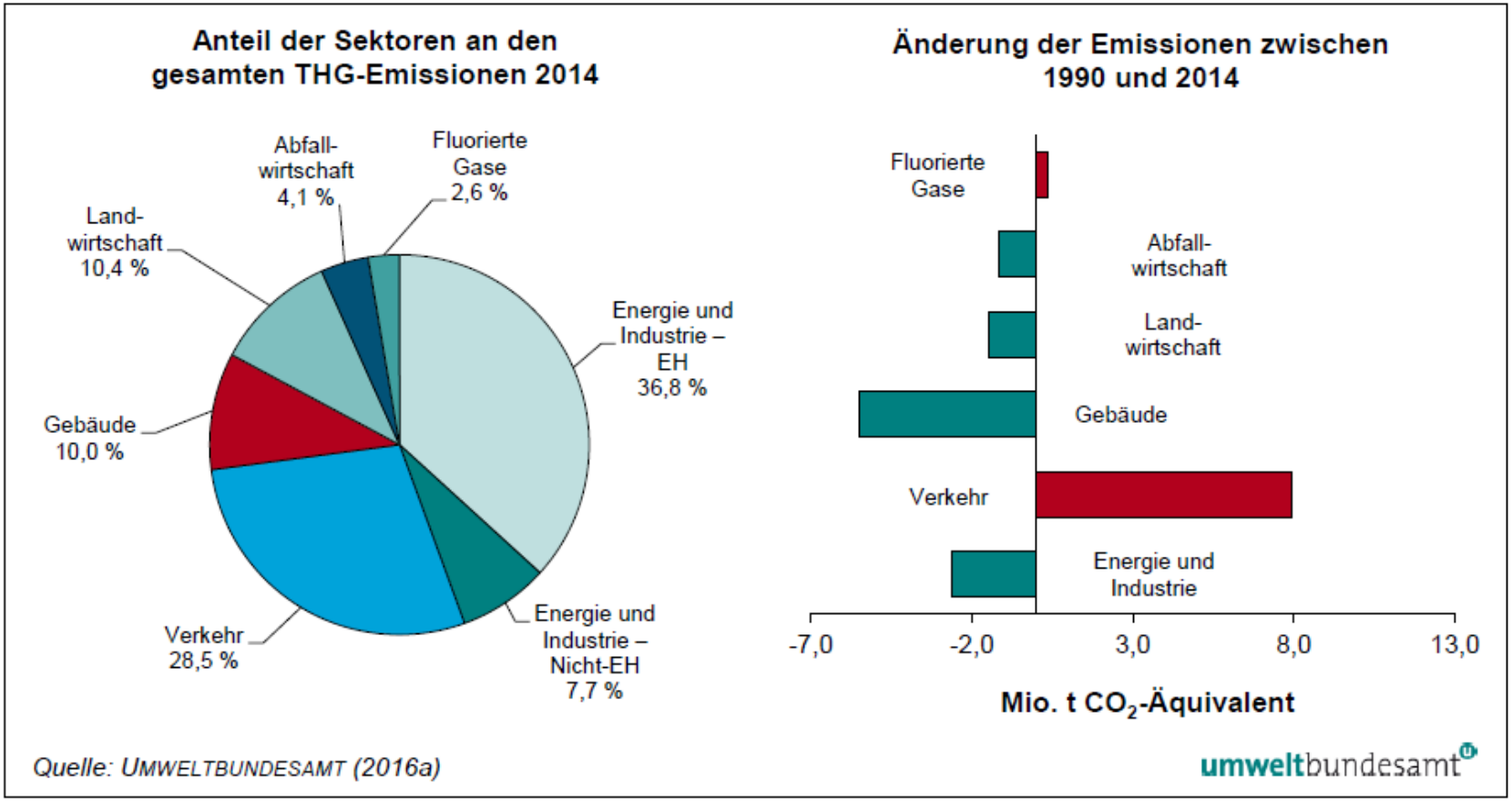


Abbildung 6: Anteil der Sektoren an den Treibhausgas-Emissionen 2014 und Änderung der Emissionen zwischen 1990 und 2014.

Quelle: UBA (2016): Klimaschutzbericht 2016

THG nach Sektoren - AUT

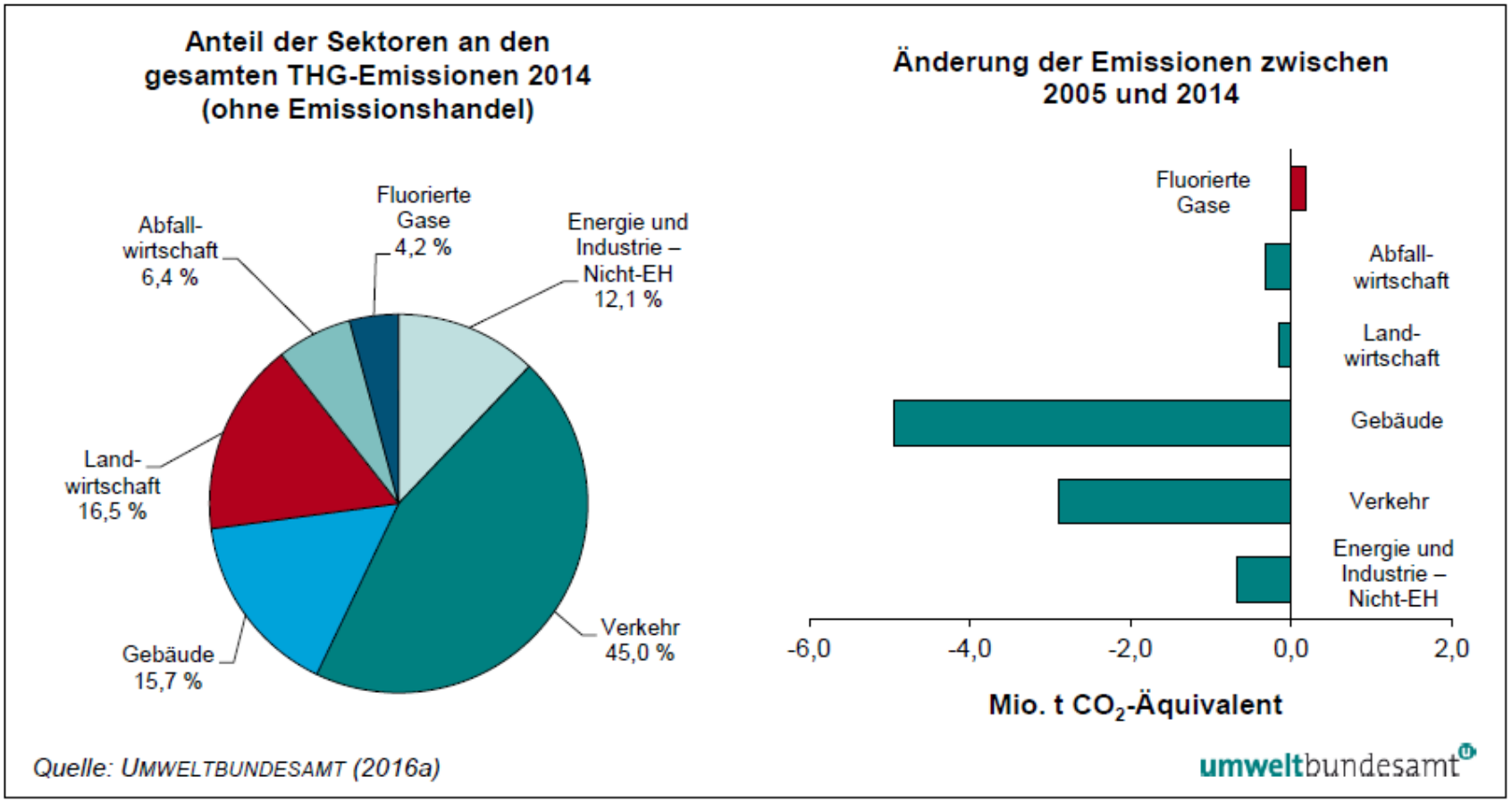
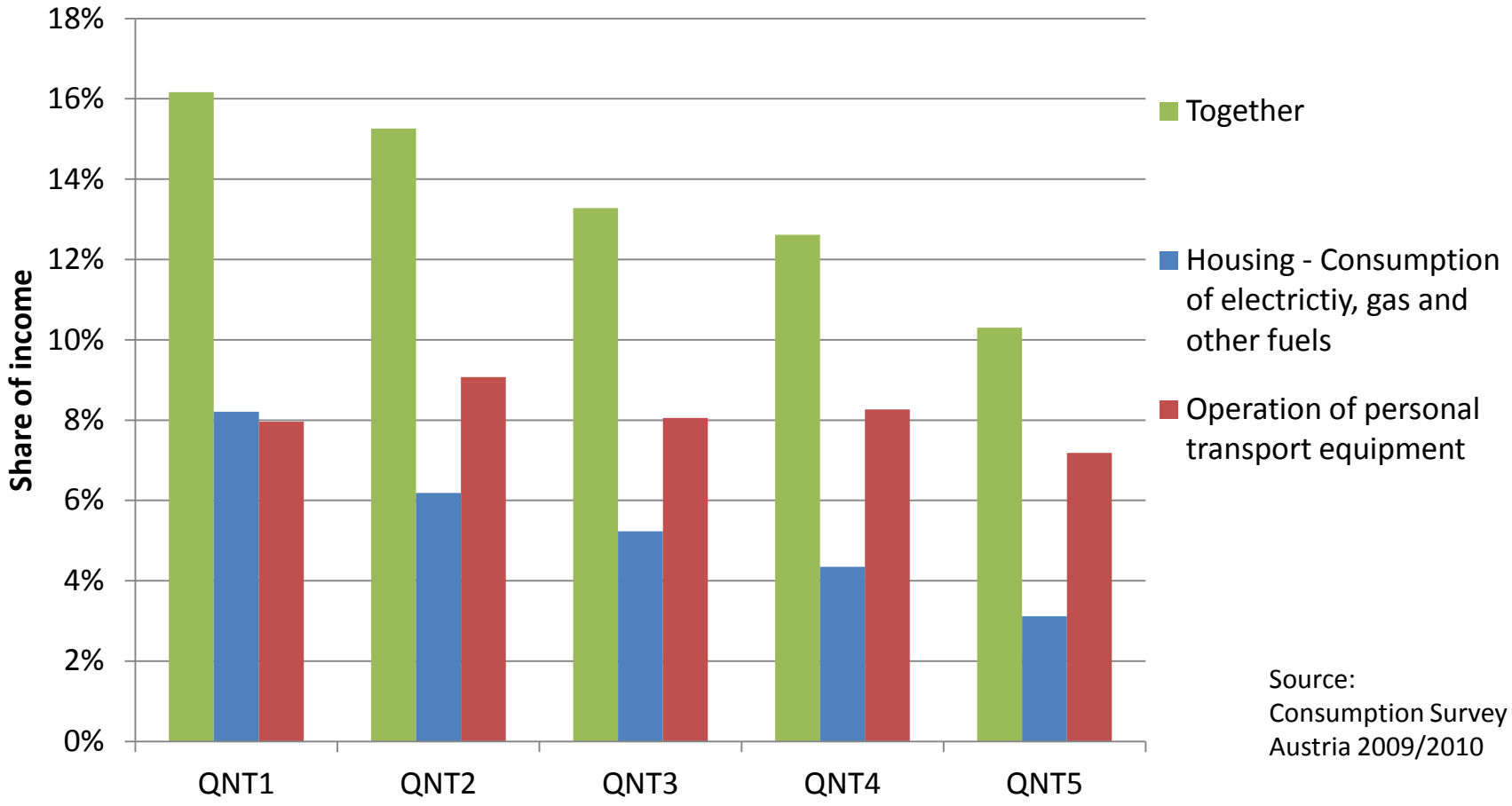


Abbildung 7: Anteil der Sektoren an den Treibhausgas-Emissionen 2014 (ohne Emissionshandel) und Änderung der Emissionen zwischen 2005 und 2014.

Quelle: UBA (2016): Klimaschutzbericht 2016

Household Income Quintiles Energy Consumption



Source:
Consumption Survey
Austria 2009/2010

Quantitative analysis of CO2 taxes

- Possible **Tax Variants**
  - Uniform tax on all energy sources for non-ETS emissions
    - On top of energy taxes
    - On top of uniform energy taxes
    - No energy taxes
  - Progressive tax (e.g. kilometers driven)
  - Tax on car purchases (NOVA)

- Possible **Rebate schemes**
  - VAT reduction on non-energy commodities
  - Lump-sum payments (e.g. for subsistence use)

- **Affected** (non-ETS)
  - Private mobility and heating
  - Transport and service sector

- Possible **Time Horizon**
  - Comparative static (one year)
  - Mid-Term (2020/2030)

Quantitative analysis of CO2 taxes

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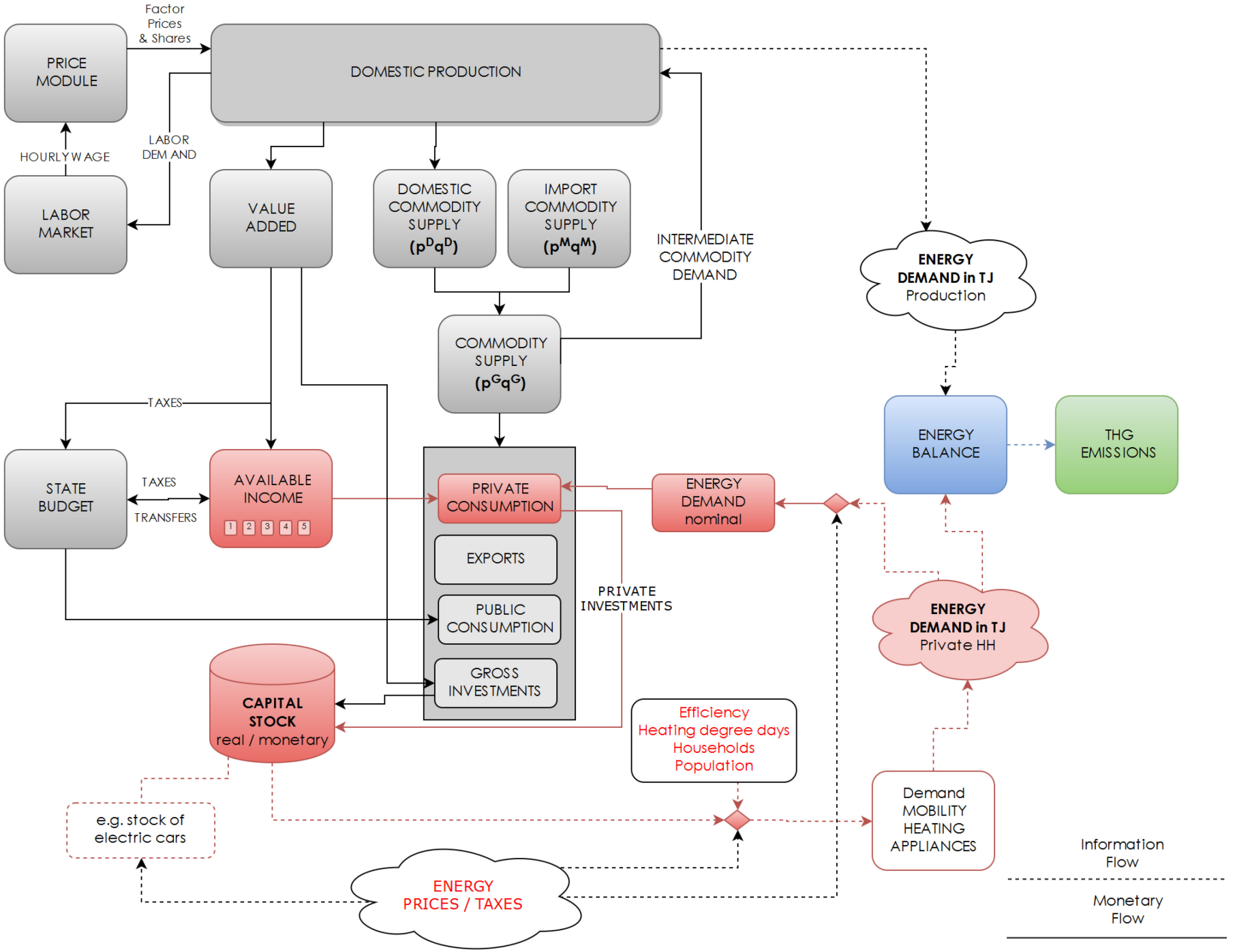
DYNK
A dynamic econometric IO model

- Input-Output (IO)
  - Macro-economic interlinkages between industry, value-added and final end users
- Econometric
  - Includes behavorial function estimations:
    - Production (Input of capital, labor, non-energy goods and energy goods)
    - Private consumption (Durable-, non-durable and energy commodities)
    - Wage curves
- Recursive Dynamic
  - Previous year‘s outcomes influence current year‘s outcomes, e.g.:
    - assets → household wealth and income
    - capital stock for durables (vehicles, appliances, housing, other)


Factor Prices & Shares
PRICE MODULE
DOMESTIC PRODUCTION
HOURLY WAGE
LABOR DEMAND
LABOR MARKET
VALUE ADDED
DOMESTIC COMMODITY SUPPLY (p^Dq^D)
IMPORT COMMODITY SUPPLY (p^Mq^M)
INTERMEDIATE COMMODITY DEMAND
COMMODITY SUPPLY (p^Gq^G)
ENERGY DEMAND in TJ Production
TAXES
STATE BUDGET
TAXES
TRANSFERS
AVAILABLE INCOME
1 2 3 4 5
PRIVATE CONSUMPTION
EXPORTS
PUBLIC CONSUMPTION
GROSS INVESTMENTS
PRIVATE INVESTMENTS
ENERGY DEMAND nominal
ENERGY BALANCE
THG EMISSIONS
ENERGY DEMAND in TJ Private HH
CAPITAL STOCK real / monetary
Efficiency
Heating degree days
Households
Population
e.g. stock of electric cars
Demand MOBILITY HEATING APPLIANCES
ENERGY PRICES / TAXES
Information Flow
Monetary Flow

DYNK
A dynamic econometric IO model

- Specific Consideration of
  - **Energy**(-commodities)
    - as input in the production process of commodities
    - during consumption, z.B.:
      - mobility
      - heating
      - household appliances
  - **Household income quintiles**

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 **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)

Modelling private energy consumption

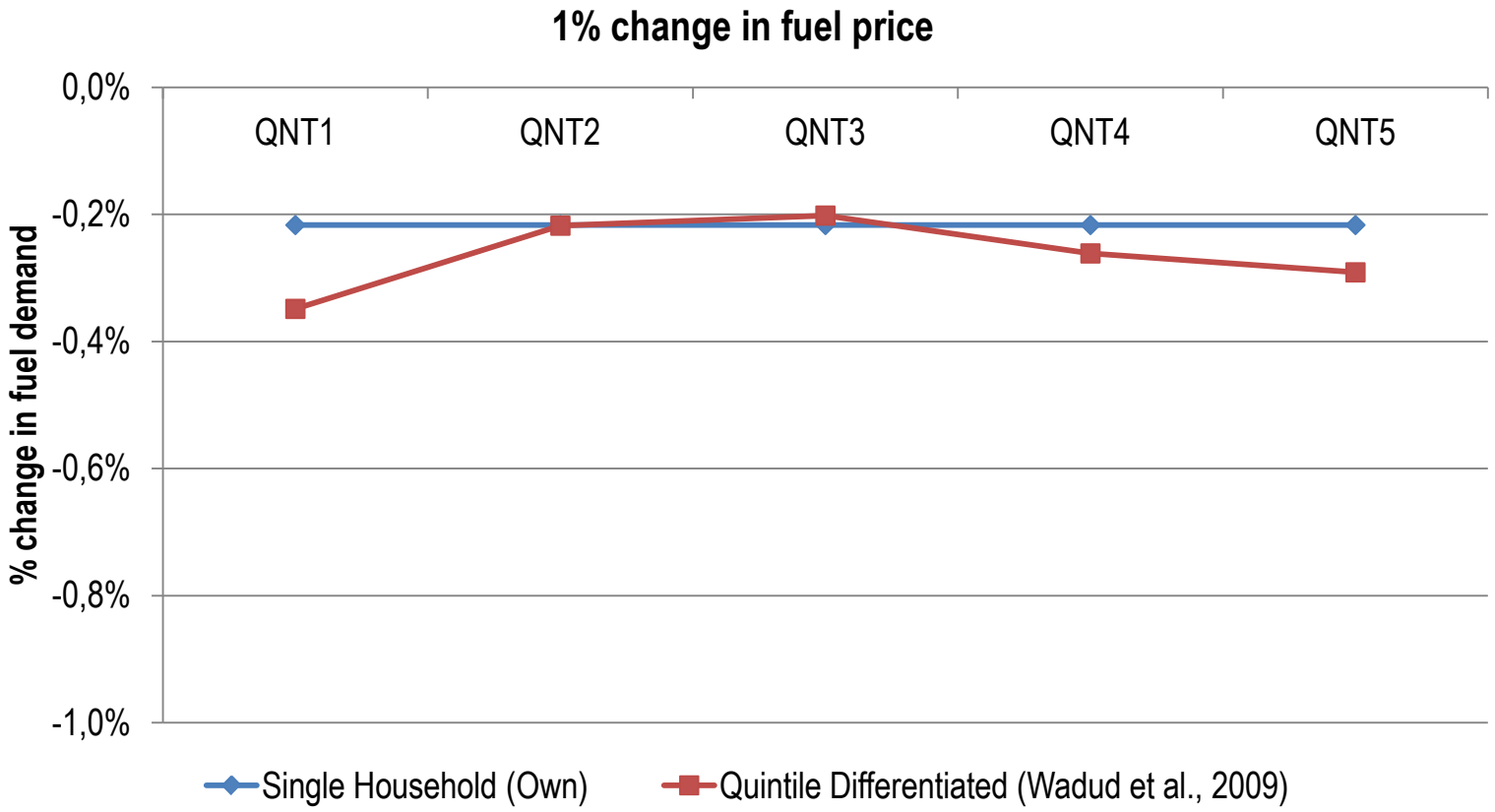
- Demand for **fuel** (in TJ) per person as a function of price, efficiency & stock:

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

  - 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 private energy consumption



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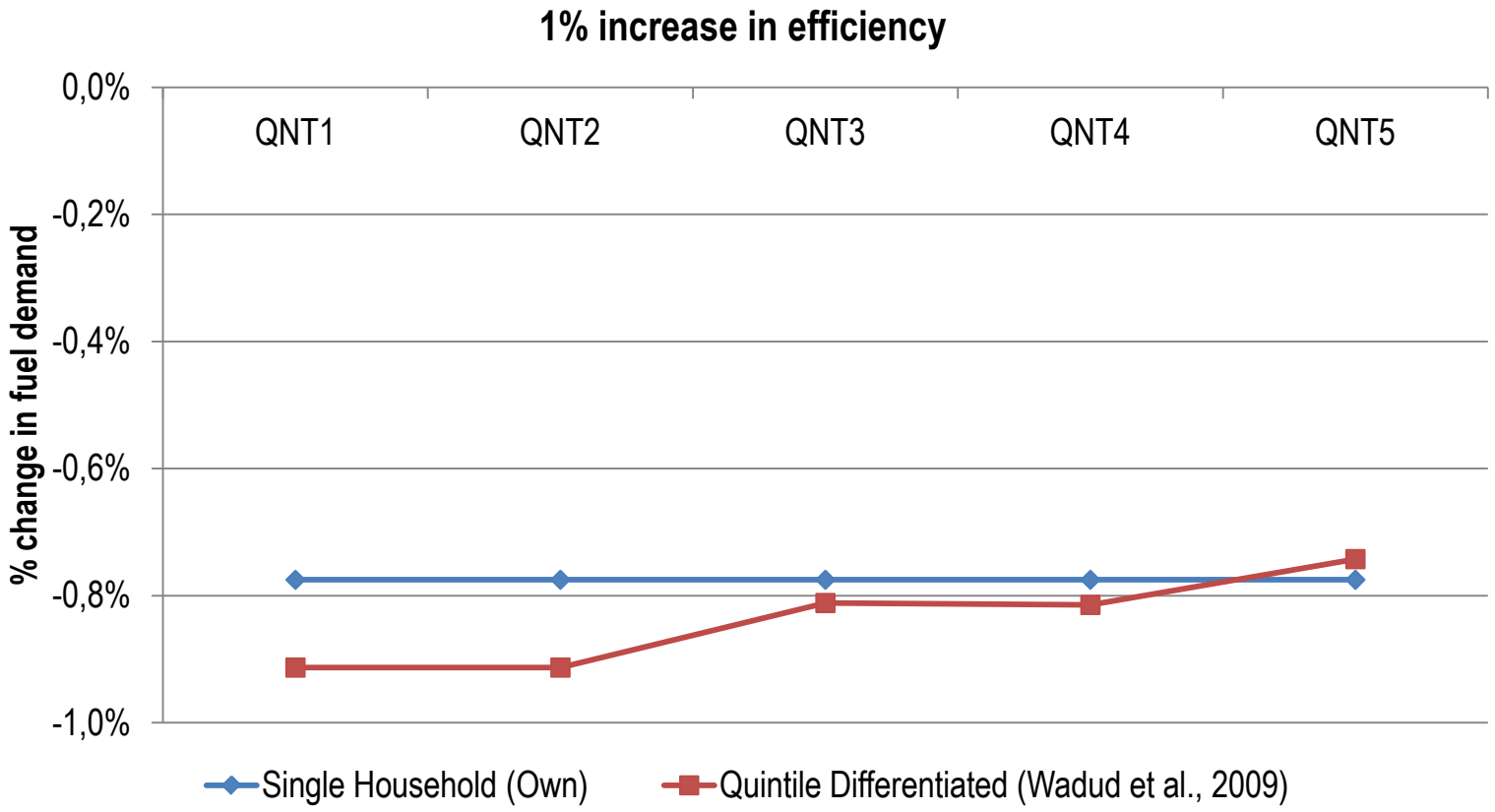

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Modelling private energy consumption

- 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

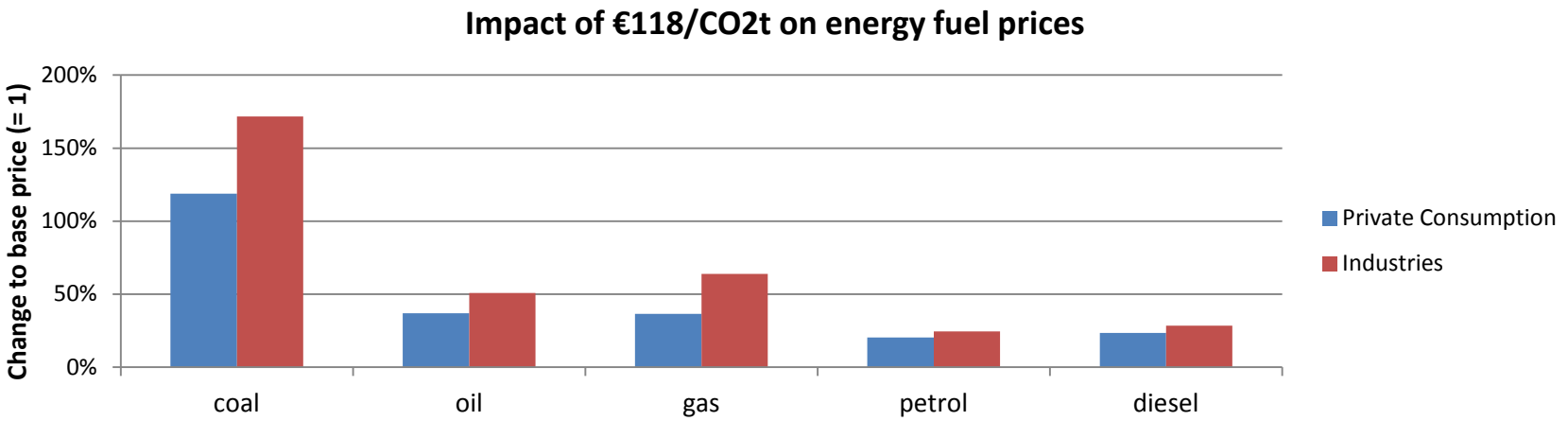
- Demand for **heating** (as service energy) as a function of price & heating degree days

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

  - 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)

Preliminary results

- Scenario
  - Uniform €118/CO2t tax (= Sweden) on energy fuels for private consumption, transport & service sector + VAT reduction on non-energy commodities



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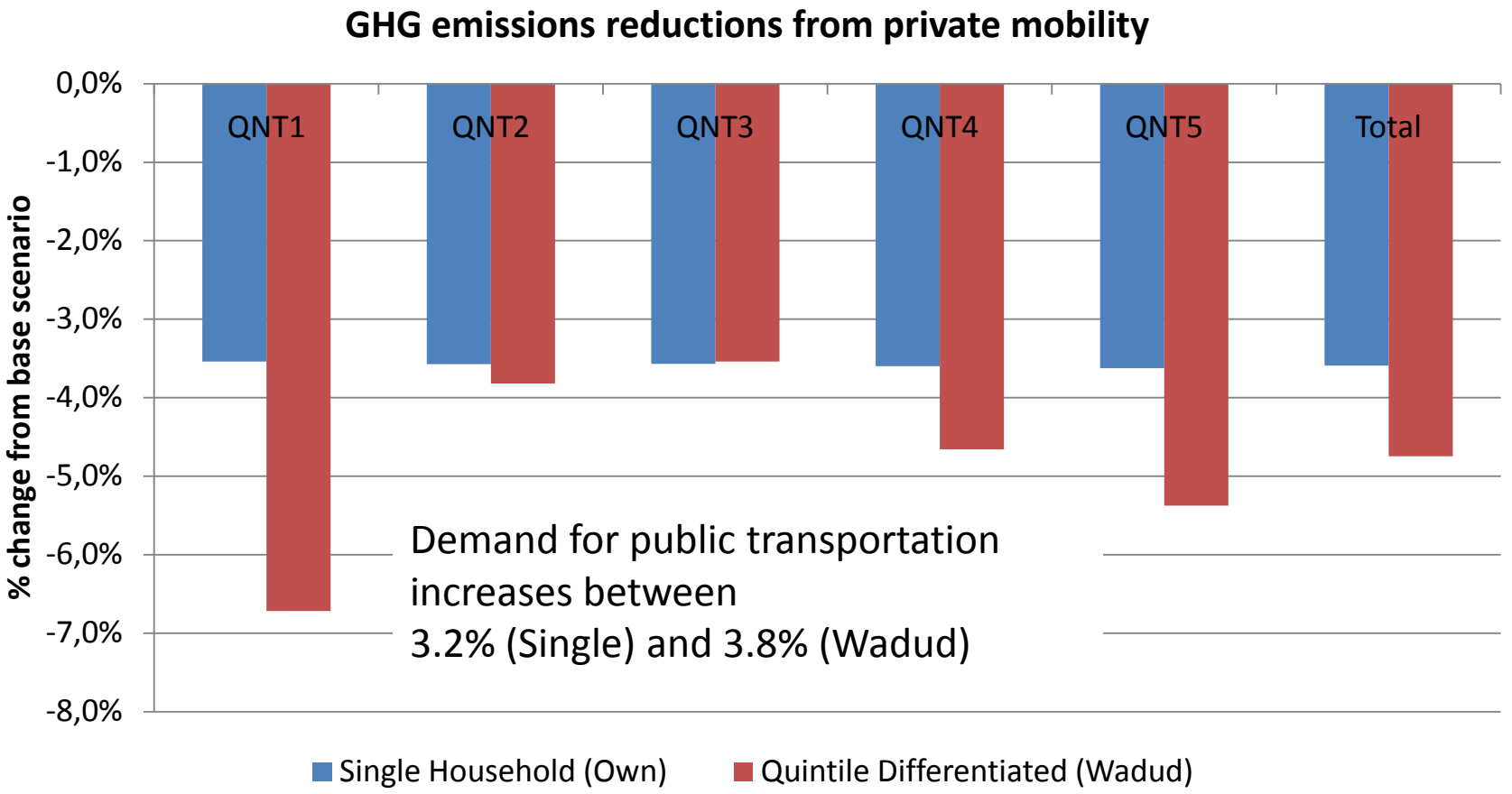

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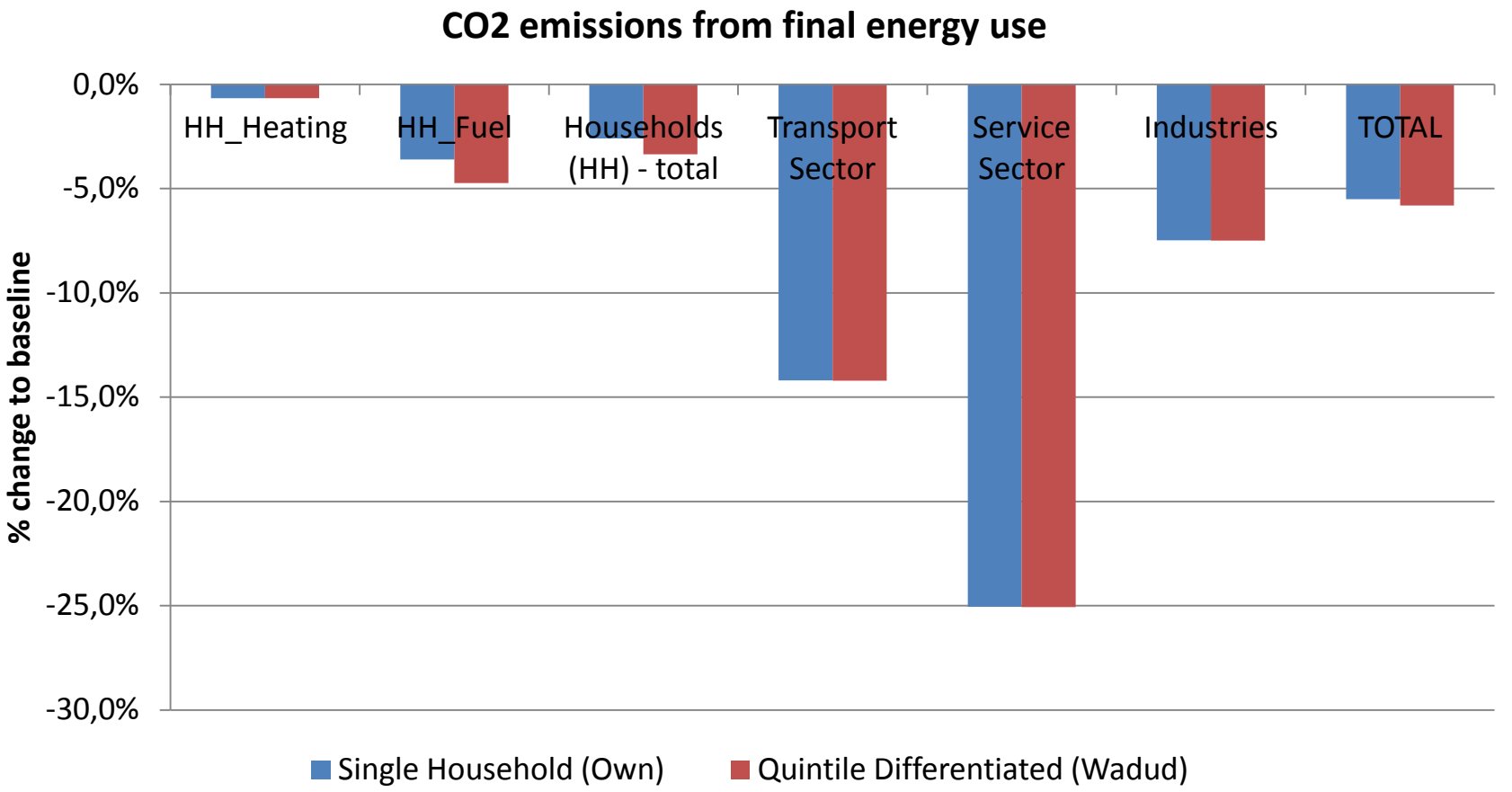

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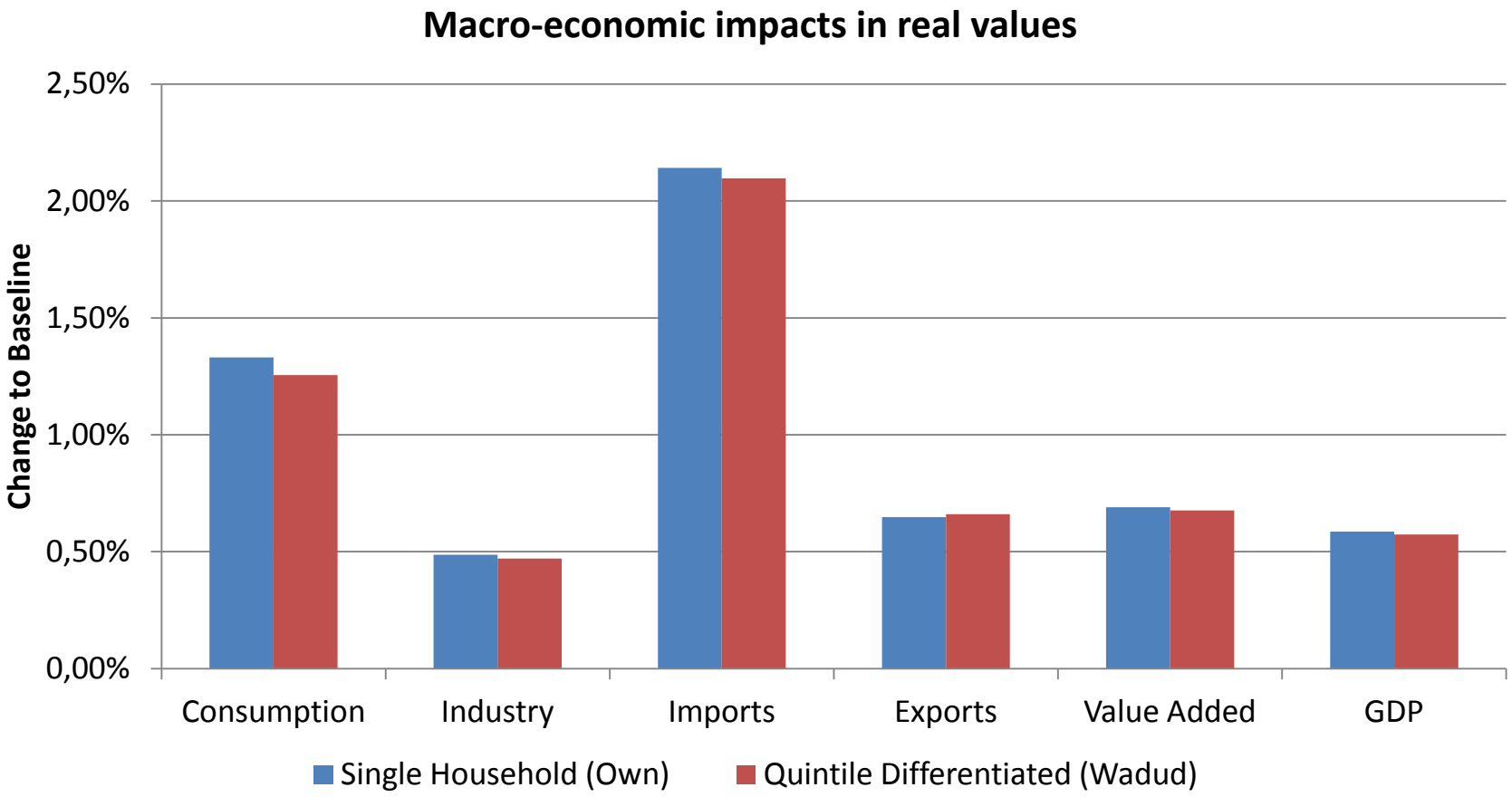

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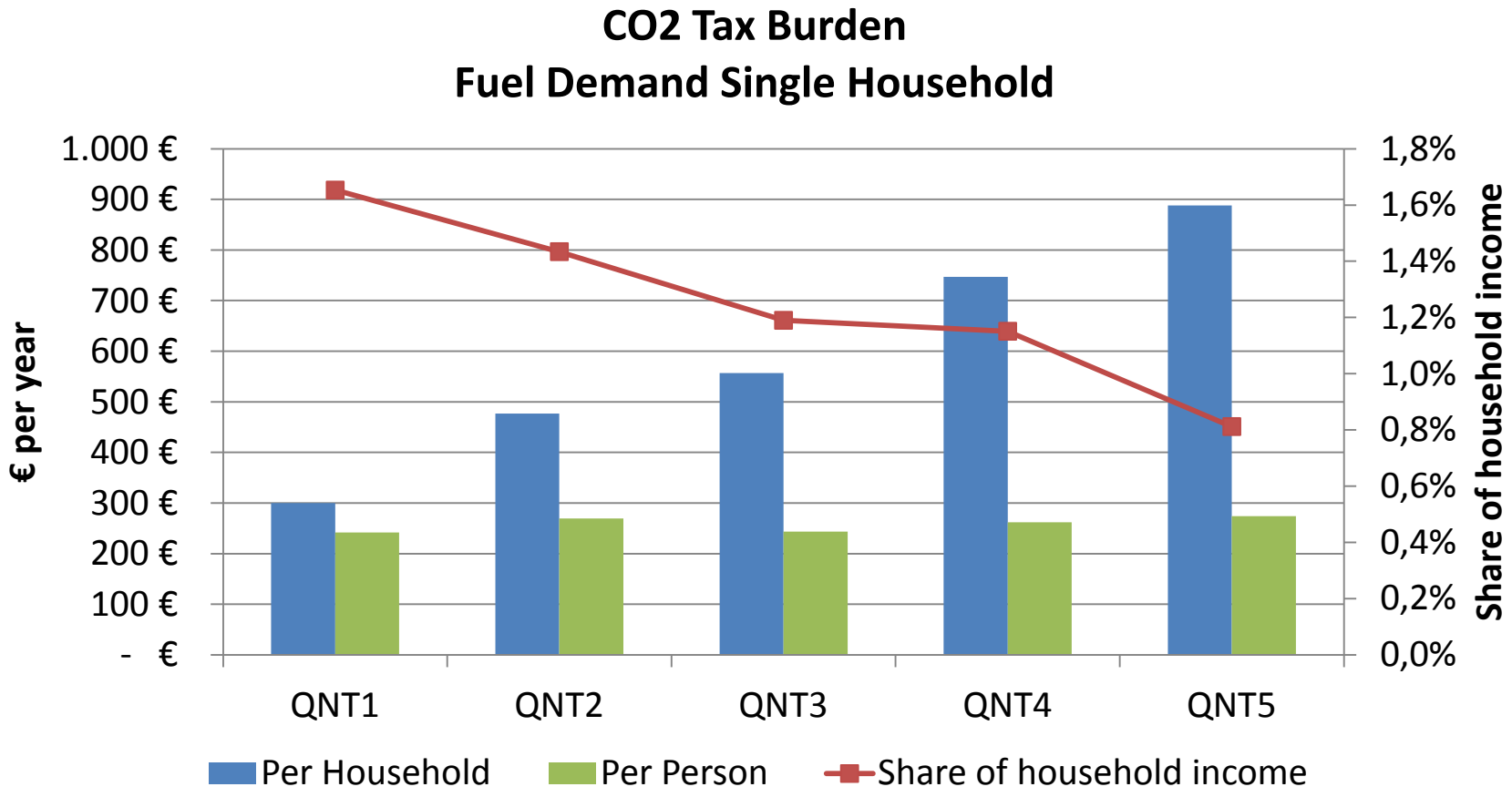

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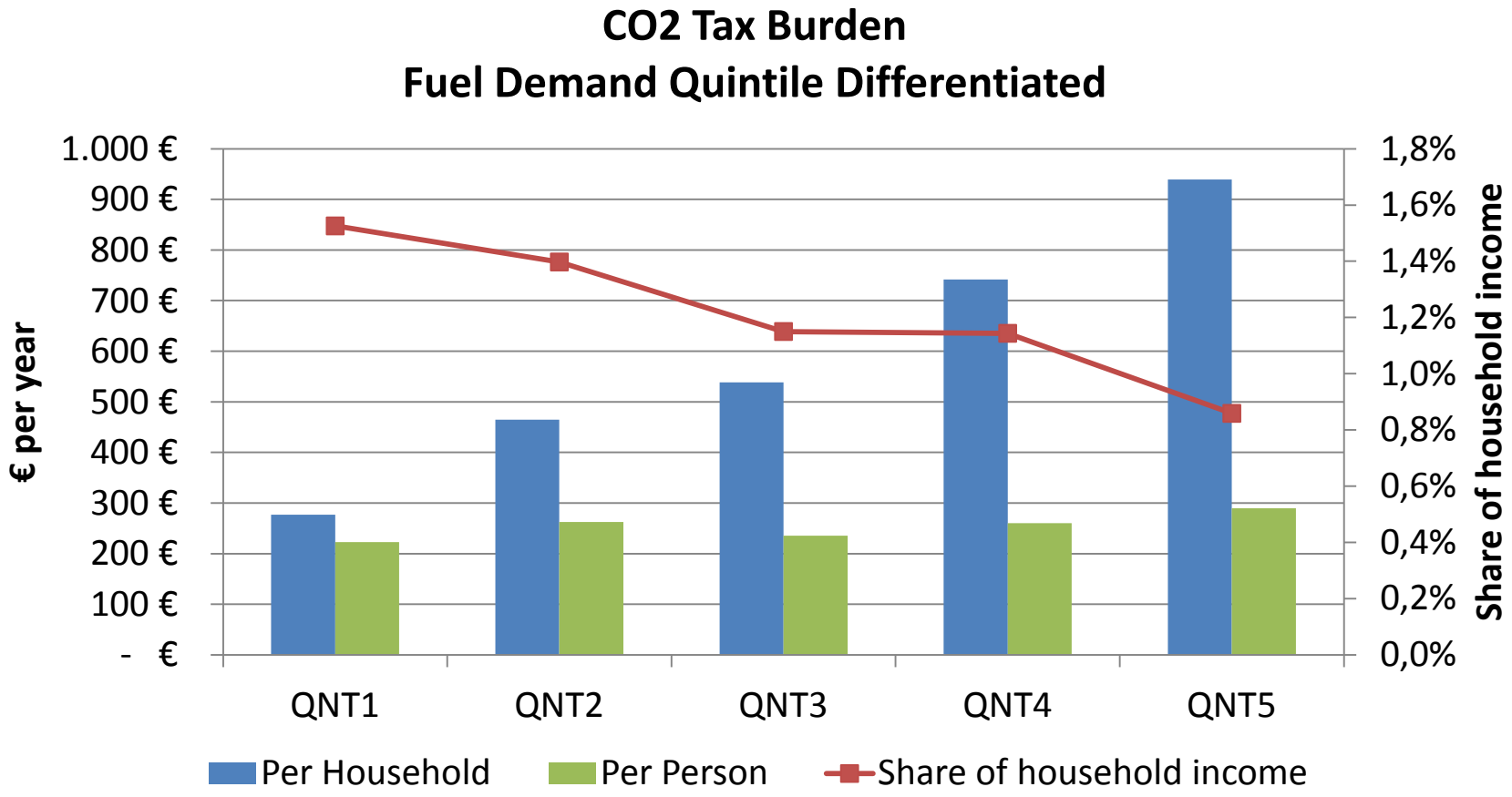
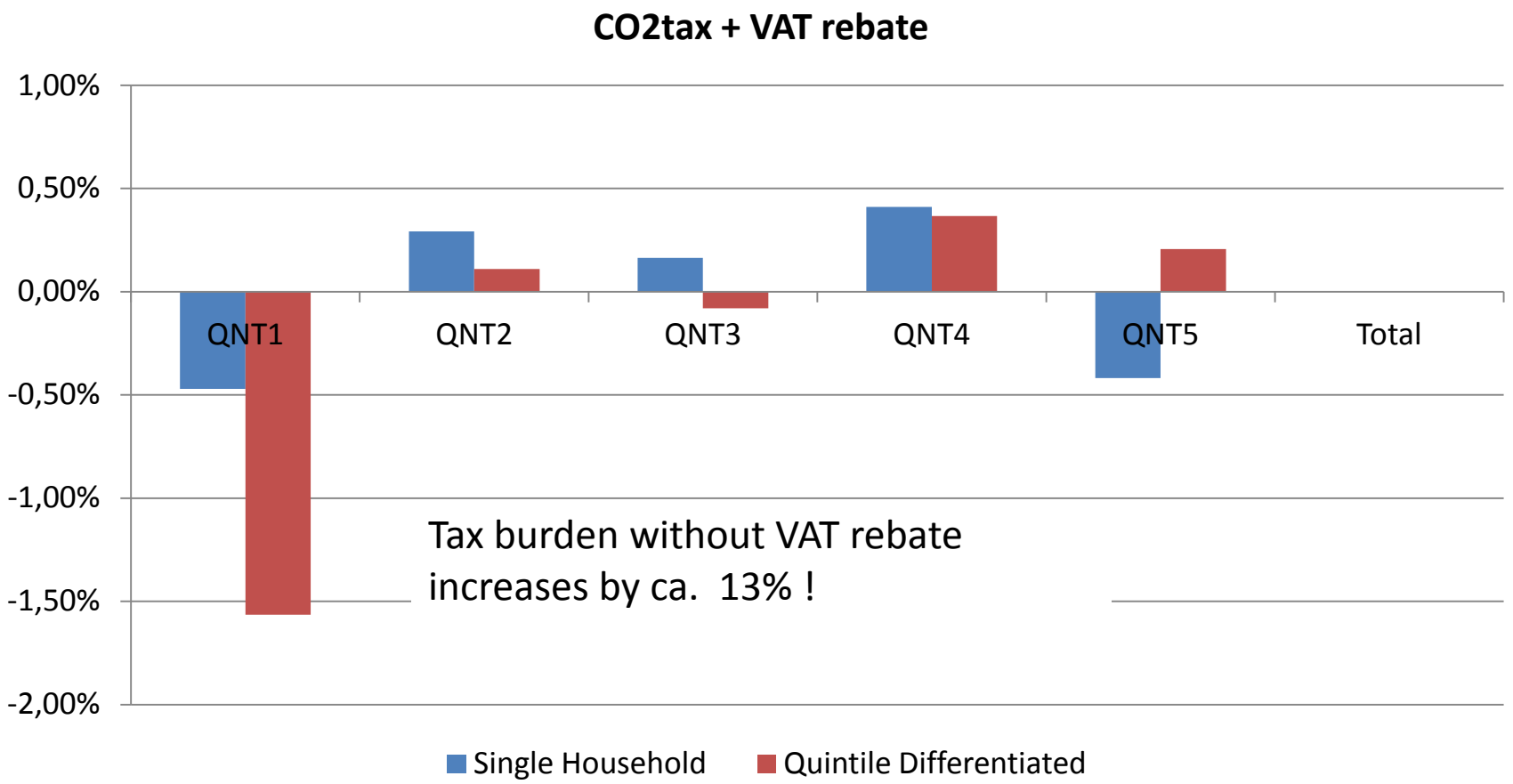


Change in total tax burden Household income quintiles



Concluding remarks

- Work in progress
- To do
  - CO2 tax on NOVA → vehicle purchases (adds time dimension)
  - Progressive tax rates (e.g. km driven, gas consumption for heating)
  - CO2 tax rate without energy tax rates)
  - Recycling methods:
    - lump sum payments for subsistence use

Thoughts? Feedback?

DANKE