# Green fiscal reforms, electricity generation and macroeconomic performance in the European Union. A model-based approach

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# Goal of the paper

- We assess a fiscal reform in Italy and rest of the European Union (REU) for
  - reducing $CO_2$ by private road transports (tax on fuel)
  - favoring renewable sources (RES) of electricity and households' consumption of electricity (subsidies)
- For the assessment, we develop a large-scale DGE model

# Motivation

## GHG emission target and road transport

- Road transport is the second largest $CO_2$ emitting sector
- Externalities of $CO_2$ emissions are estimated to be large
- Inadequate technological progress to achieve $CO_2$ target
- Taxes on fuel less regressive than those on electricity

# Motivation

## RES and electricity generation

- RES remain a minor source of energy (2008: 8.4% of total energy consumption in EU, 7.8% in Italy)
- According to European Commission (2011), by 2020:
  - **Electricity** should account for 45% of the RES increase
  - RES should be 37% of EU's electricity mix, 26% for Italy

# Motivation

## What is at stake

- Satisfy environmental targets
- Economic implications of achieving environmental targets
  - structural change of energy sector (fossil vs renewables)
  - households' consumption and economic activity

# Model: main features

- Model akin to DICE and WITCH
- A large-scale two-region dynamic GE model
- One "region" is calibrated to Italy, the other to REU
- Main features are:
  - detailed electricity generation sector
  - fuel for private (households and firms) road transport

# Model: other features

- Representative forward-looking household in each region
- She consumes and supplies $L$ and $K$ to domestic firms
- Each region specialized in one manufacturing good
- Regions trade in goods, electricity and a bond
- Fossils imported from rest of the world at an exogenous (before-tax) price

# Model: the electricity generation sector

- Eight sectors in each region, one for each source: oil, coal, gas, nuclear, hydro, biomass, solar, wind
- Each source is combined with domestic capital and labor
- Low substitutability btw fossil fuels and RES
- Electricity sold to domestic and foreign households/firms
- Low substitutability btw electricity and other goods

# Model: the electricity generation sector

$$EL_{ES,t} = \left[ \rho_{ES}^{\frac{1}{\theta_{ES}}} VA_{ES,t}^{\frac{\theta_{ES}-1}{\theta_{ES}}} + (1-\rho_{ES})^{\frac{1}{\theta_{ES}}} ES_t^{\frac{\theta_{ES}-1}{\theta_{ES}}} \right]^{\frac{\theta_{ES}}{\theta_{ES}-1}}$$

$$VA_{ES,t} = \left[ \rho_{K_{VA_{ES}}}^{\frac{1}{\theta_{VA_{ES}}}} K_{VA_{ES,t}}^{\frac{\theta_{VA_{ES}}-1}{\theta_{VA_{ES}}}} + \left(1-\rho_{K_{VA_{ES}}}\right)^{\frac{1}{\theta_{VA_{ES}}}} L_{VA_{ES,t}}^{\frac{\theta_{VA_{ES}}-1}{\theta_{VA_{ES}}}} \right]^{\frac{\theta_{VA_{ES}}}{\theta_{VA_{ES}}-1}}$$

# Model: the electricity generation sector

$$EL_{H,t}^{TOT} = \left[ \rho_{EL_{CON}}^{\frac{1}{\theta_H}} EL_{CON,t}^{\frac{\theta_H - 1}{\theta_H}} + (1 - \rho_{EL_{CON}})^{\frac{1}{\theta_H}} \, EL_{RES,t}^{\frac{\theta_H - 1}{\theta_H}} \right]^{\frac{\theta_H}{\theta_H - 1}}$$

$$EL_t = \left[ \rho_{EL_H}^{\frac{1}{\theta}} EL_{H,t}^{\frac{\theta - 1}{\theta}} + (1 - \rho_{EL_H})^{\frac{1}{\theta}} \, EL_{F,t}^{\frac{\theta - 1}{\theta}} \right]^{\frac{\theta}{\theta - 1}}$$

# Model: the transport sector

- Fuel for distributing manufacturing goods to retailers
- Fuel in the households' consumption (transport services)
- Low substitutability btw fuel and other goods

# Model: the transport sector

## From manufacturer to retailer

$$Q_{CM,t} = \left[ \rho_{C_H}^{\frac{1}{\theta_{CM}}} Q_{CH,t}^{\frac{\theta_{CM}-1}{\theta_{CM}}} + \left(1-\rho_{C_H}\right)^{\frac{1}{\theta_{CM}}} Q_{CF,t}^{\frac{\theta_{CM}-1}{\theta_{CM}}} \right]^{\frac{\theta_{CM}}{\theta_{CM}-1}}$$

$$Q_{CMFFU,t} = \left[ \rho_{C_{CM}}^{\frac{1}{\theta_{CMFFU}}} Q_{CM,t}^{\frac{\theta_{CMFFU}-1}{\theta_{CMFFU}}} + \left(1-\rho_{C_{CM}}\right)^{\frac{1}{\theta_{CMFFU}}} Q_{FFU,t}^{\frac{\theta_{CMFFU}-1}{\theta_{CMFFU}}} \right]^{\frac{\theta_{CMFFU}}{\theta_{CMFFU}-1}}$$

# Model: the transport sector

## Households' private transport services

$$Q_{CME,t} = \left[ \rho_{C_{CMFFU}}^{\frac{1}{\theta_{CME}}} Q_{CMFFU,t}^{\frac{\theta_{CME}-1}{\theta_{CME}}} + (1-\rho_{C_{CMFFU}})^{\frac{1}{\theta_{CME}}} Q_{CE,t}^{\frac{\theta_{CME}-1}{\theta_{CME}}} \right]^{\frac{\theta_{CME}}{\theta_{CME}-1}}$$

$$Q_{C,t} = \left[ \rho_{C_{CME}}^{\frac{1}{\theta_C}} Q_{CME,t}^{\frac{\theta_C-1}{\theta_C}} + (1-\rho_{CME})^{\frac{1}{\theta_C}} Q_{CHFU,t}^{\frac{\theta_C-1}{\theta_C}} \right]^{\frac{\theta_C}{\theta_C-1}}$$

# Simulations

- Permanent and gradual increase (9 years) in fuel tax by 10% of the initial fuel price in EU
- Revenues are used as follows:
  - 80% to low taxes on consumption of electricity
  - 20% to finance electricity generation by RES (biomass, solar and wind). We keep hydro at the baseline level

# Simulations

- The initial steady state is calibrated over 2005-2007
- $CO_2$ emissions are computed relatively to 2005 level

# RES in electricity and $CO_2$ in road transports

| | IT | REU |
|---|---|---|
| Share of RES (%) | 16.23 | 21.89 |
| Bio, Solar, Wind (% Change) | 65 | 103 |
| $CO_2$ emissions (% Change) | -4.82 | -4.89 |

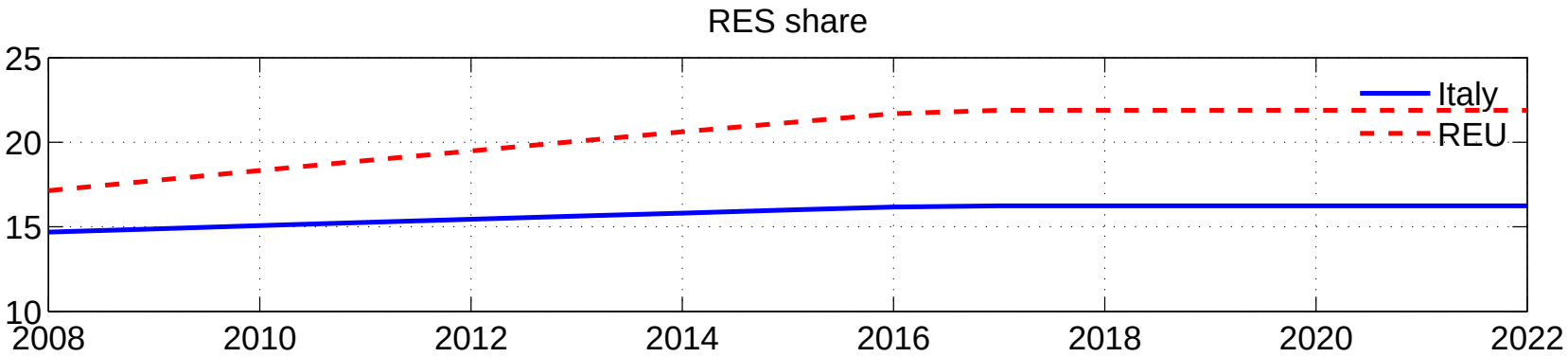
Share of RES in 2007: IT 14.41%; EU 15.82%

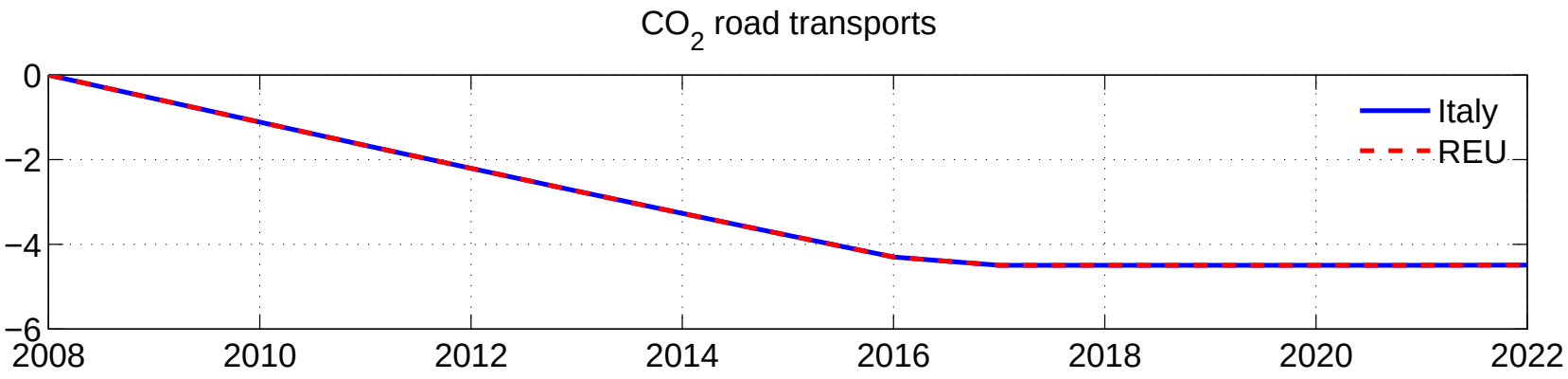
RES Target: IT 17%; EU 20%

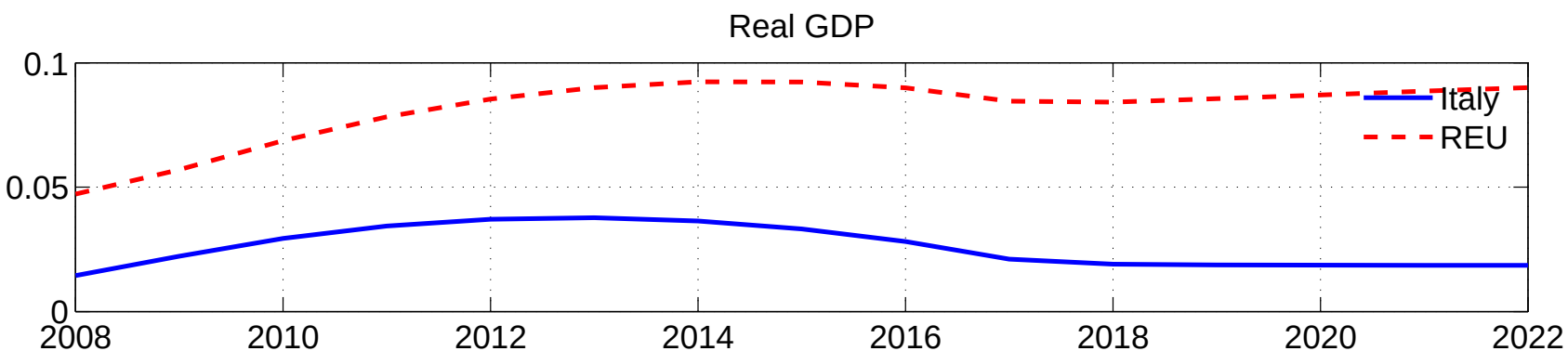
$CO_2$ Target: IT -10%, EU: -16%

# Macroeconomic effects

| | IT | REU |
|---|---|---|
| % Change in: | | |
| GDP | 0.02 | 0.11 |
| Consumption | -0.20 | -0.27 |
| Investment | 0.07 | 0.25 |
| Consumption of electric. | 7.44 | 9.97 |


RES share
25
20
15
10
2008
2010
2012
2014
2016
2018
2020
2022
Italy
REU


$CO_2$ road transports
0
−2
−4
−6
2008
2010
2012
2014
2016
2018
2020
2022
Italy
REU


Real GDP
0.1
0.05
0
2008
2010
2012
2014
2016
2018
2020
2022
Italy
REU

# RES in electricity and $CO_2$ in road transports

| | benchmark | | no subsidies to RES | |
|---|---|---|---|---|
| | IT | REU | IT | REU |
| Share of RES (%) | 16.23 | 21.89 | 14.41 | 15.82 |
| % Change in: | | | | |
| Bio, Solar, Wind | 65 | 103 | 5 | 6 |
| $CO_2$ emissions | -4.82 | -4.89 | -4.78 | -4.83 |

# Macroeconomic effects

| | benchmark | | no subsidies to RES | |
|---|---|---|---|---|
| | IT | REU | IT | REU |
| % Change in: | | | | |
| GDP | 0.02 | 0.11 | 0.05 | 0.12 |
| Consumption | -0.20 | -0.27 | -0.15 | -0.21 |
| Investment | 0.07 | 0.25 | 0.14 | 0.25 |
| Consumption of electric. | 7.44 | 9.97 | 8.46 | 11.61 |

# RES in electricity and $CO_2$ in road transports

| | benchmark | | no subsidies | |
|---|---|---|---|---|
| | IT | REU | IT | REU |
| Share of RES (%) | 16.23 | 21.89 | 14.41 | 15.82 |
| % Change in: | | | | |
| Bio, Solar, Wind | 65 | 103 | -0.25 | -0.59 |
| $CO_2$ emissions | -4.82 | -4.89 | -5.30 | -5.35 |

# Macroeconomic effects

| | benchmark | | no subsidies | |
|---|---|---|---|---|
| | IT | REU | IT | REU |
| % Change in: | | | | |
| GDP | 0.02 | 0.11 | -0.62 | -0.54 |
| Consumption | -0.20 | -0.27 | -0.69 | -0.72 |
| Investment | 0.07 | 0.25 | -1.11 | -1.05 |
| Consumption of electricity | 7.44 | 9.97 | -0.51 | -0.55 |

# Conclusions

- We have evaluated the impact of a green fiscal reform in Italy and REU by developing a DGE model
- We find that a mix of tax and subsidies could help to achieve EU targets
- The economic impact would be positive but small
- On going work on inserting ETS permits