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# ***Gdyn-E*: a dynamic CGE model for the economic assessment of long run climate policy alternatives**

A. Antimiani • *National Institute of Agricultural economic (INEA)*

V. Costantini • *University of Rome "RomaTre"*

C. Martini, M.C. Tommasino • *Italian National Agency for New Technologies, Energy and  
Sustainable Economic Development (ENEA)*

# **A tool to assess jointly environmental and economics issues**

Nowadays the assessment of policy interventions in environmental issues should include economic impact.

However while economic interventions are thought and applied in a short run context, environmental policies go for long run period.




A model should have an explicit representation of environmental variables as well as economic variables.

# A tool to assess jointly environmental and economics issues: GTAP-E and Gdyn-E (1)

Our work started with the **GTAP-E model** (Burniaux and Truong, 2002; McDougall and Golub, 2007) which include:

- Explicit treatment of energy demand [inter-factor and inter-fuel substitution, in production function and consumption]
- Representation of emissions (CO<sub>2</sub>) from fuel combustion
- Possibility of introducing market-based policy instruments such as Carbon Tax or Emission Trading



We already used an improved version of the model to deal with environmental issue (Kyoto Protocol) and economic competitive analysis [*Assessing alternative solutions to carbon leakage*, Energy Economics 36, 2013, 299–311]

However, the standard GTAP-E, since static, it not perfectly suitable to deal with long-term environmental-economics issue.

# A tool to assess jointly environmental and economics issues: GTAP-E and Gdyn-E (2)

To overcome such limit we develop a dynamic version of GTAP-E:

## Gdyn-E model



We merge the GTAP Dynamic model GDyn (Ianchovichina and McDougall, 2001)

- *Time path of the global economy,*
- *Endogenous capital accumulation,*
- *Adaptive expectations theory of investments,*
- *International capital mobility.*

with the last version of the GTAP-E model (McDougall and Golub, 2007)

- *refined energy nest in Private and Government consumption, share of carbon tax payments/permits revenue*
- *CO2 data for the **Gtap Database 8** (Base year **2007**).*

# Gdyn-E model - New Features included

We include some further adjustments in the model:

- ❑ **Energy Parameters**
    - ❑ Substitution Elasticities in the Energy Nest by Literature Review (Hertel 2010)
    - ❑ Substitution Elasticities between Capital - Energy in Energy Intensive Manufacturing Industry based on Econometric estimations.
  - ❑ **Additional Coefficient** to allow changes in regions of the Elasticity between Capital and Energy
  - ❑ **Armington Elasticities** for energy commodities by literature review (Hertel 2007)
  - ❑ Substitution Elasticities in **Household** energy sub-consumption based on the energy mix consumption at country level
  - ❑ **Adjustment Rigidity Parameters** RWQH, RWQF
- 
- **Additional Coefficient** showing the *carbon intensity*, relationship between changes in CO2 emission and GDP.
  - New Header **National Energy Consumption and Production in Mtoe**

# Regional – Sectoral Aggregation -Baseline

Regions	Sectors
Italy	Coal
France	Oil
Germany	Gas
Spain	Refined oil products
United Kingdom	Electricity
Rest of Europe	Energy Intensive Industry
United States	Other Industry
Japan	<b>Land Transport</b>
China	<b>Air Transport</b>
India	<b>Water Transport</b>
Brasil	
Rest of the World	

## Baseline

The Baseline Scenario, up to 2020, has been **calibrated to the emissions projections:** for EU member countries from Energy Roadmap 2050; for others countries from the World Energy Outlook (WEO) - IEA; both Reference Scenario.

To adjust the response of the model in terms of emissions we have modified:

- the Productivity of Energy Inputs;
- the capital accumulation;
- the substitution elasticities between capital and energy.

# **“Green” policy vs economic: defining the cost and the needs**

- ✓ Emission reduction targets affects the economic system of a country by different ways, GDP, high energy intensive sectors, trade competitiveness, ecc,
- ✓ Once we decide the “target” of the policy intervention, since resource are scarce, we should look at “how much it costs”
- ✓ Starting from the idea that nowadays, while trade is global, environmental policies are more like “local”. From an economic point of view, it could be the case that a competitiveness issue arise.
- ✓ We choose the land transport sector as a case studio since it provides a good representation of the situation above.



# Baseline, policy and scenarios

## **BASELINE**

**2007-2010** updated on historical data

**2010-2015 and 2015-2020** (using forecast for GDP, population, labor force and the WEO reference scenarios in terms of emissions reduction)

## **POLICY**

(Equal to Baseline but the target, in terms of emissions reduction, is the WEO efficiency scenario)

### **SCENARIO 1 (Policy\_1)**

The output level of land transport sector is fixed (in the period 2015-2020)

### **SCENARIO 2 (Policy\_2)**

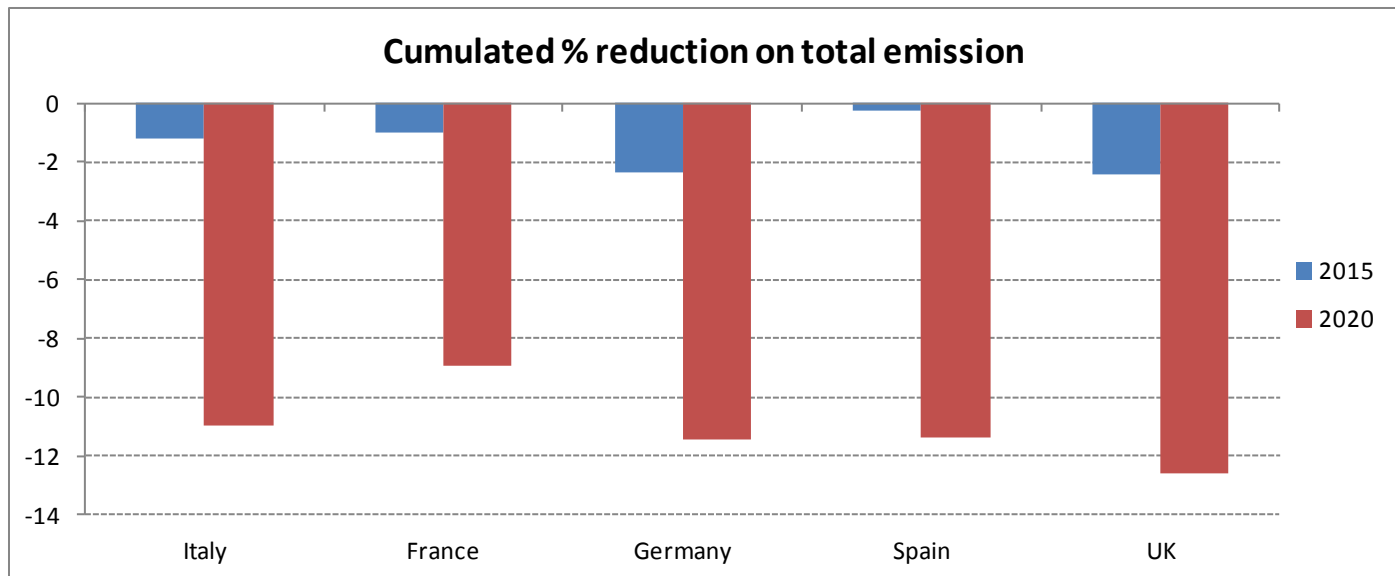
The trade balance is fixed (in the period 2015-2020)

# “Green” policy vs economic: defining the cost and the needs

The model features allow us to focus on EU energy strategy, evaluating the impact of the CO<sub>2</sub> emission reduction policy described in the Energy Roadmap 2050 as “Energy efficiency scenario”



At the 2020, we model a CO<sub>2</sub> reduction equal to -24% for the EU as a whole with respect to the 1990 historical level (-11.2% with respect to baseline)

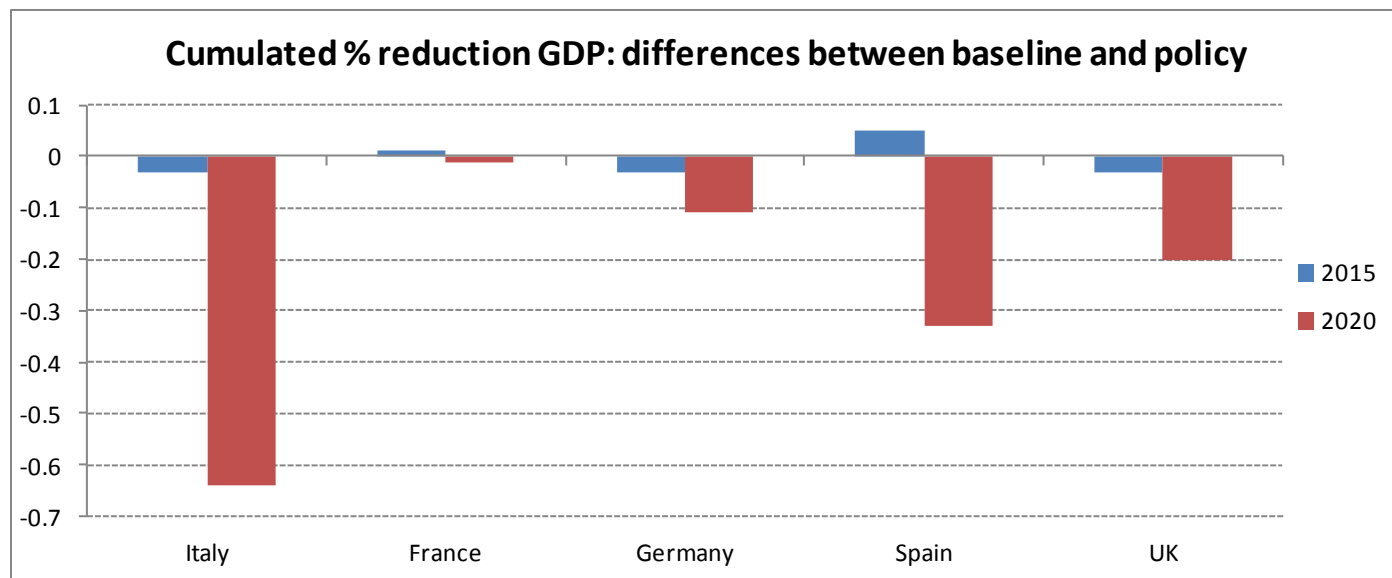


# “Green” policy vs economic: defining the cost and the needs

Reducing CO2 could impact GDP, and some of “higher” energy intensive sectors, like transport sectors (land or water or air)

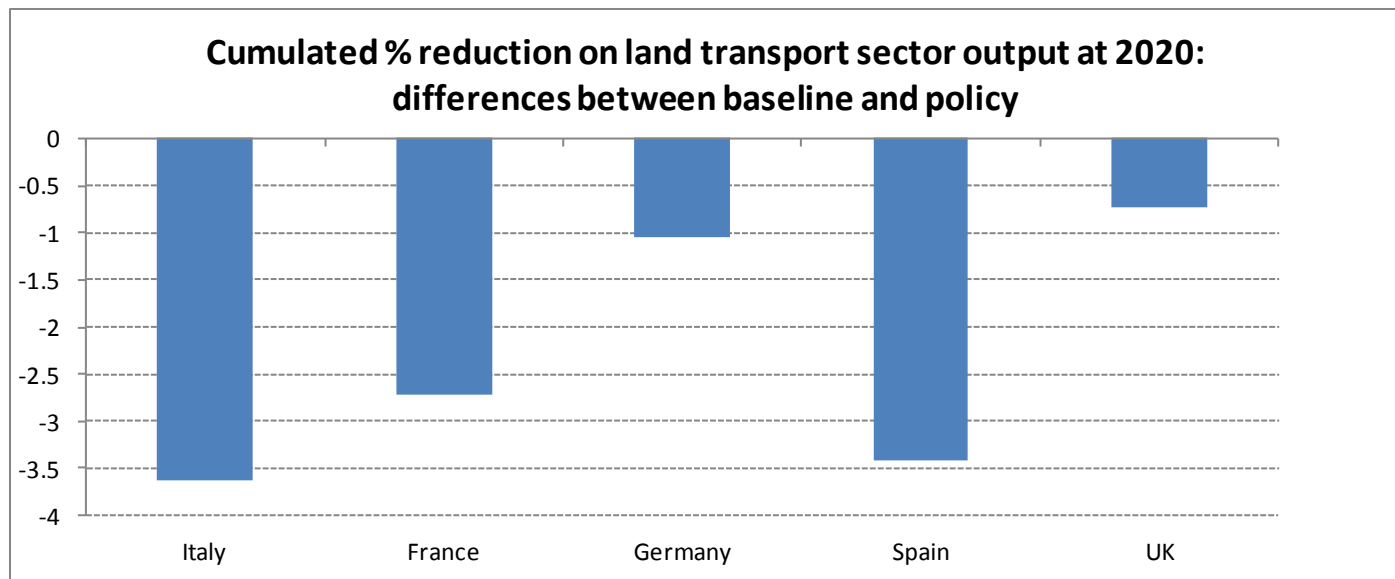


At the 2020, with the emission reduction modeled, we have a negative impact on GDP at the end of the period (2020)



# “Green” policy vs economic: defining the cost and the needs

We focus, as a case studio, on the land transport sector, since at the same time it is affected by the “green policy” and it has a relevant impact both on imports and export



However, even if the impact on GDP is univocal, and negative, the impact of the CO<sub>2</sub> reduction policy is not straightforward on the trade balance.

# “Green” policy vs economic: defining the cost and the needs

Impact on trade balance is differentiated among countries

Impact on trade balance, US million: baseline and policy and 2020		
	Baseline	Policy
Italy	-99,456	-78,723
France	5,644	-3,261
Germany	417,930	415,263
Spain	-321,615	-314,541
UK	114,454	113,227

While for Italy the impact is negative, for France it is positive; it is almost neutral on UK, Germany and Spain.

# Two counterfactual scenarios

We use the model for a counterfactual analysis which seeks to capture, in a single figure, the uniform productivity growth we should reach for land transport as input, given a specific target the political economy intervention would like to reach:

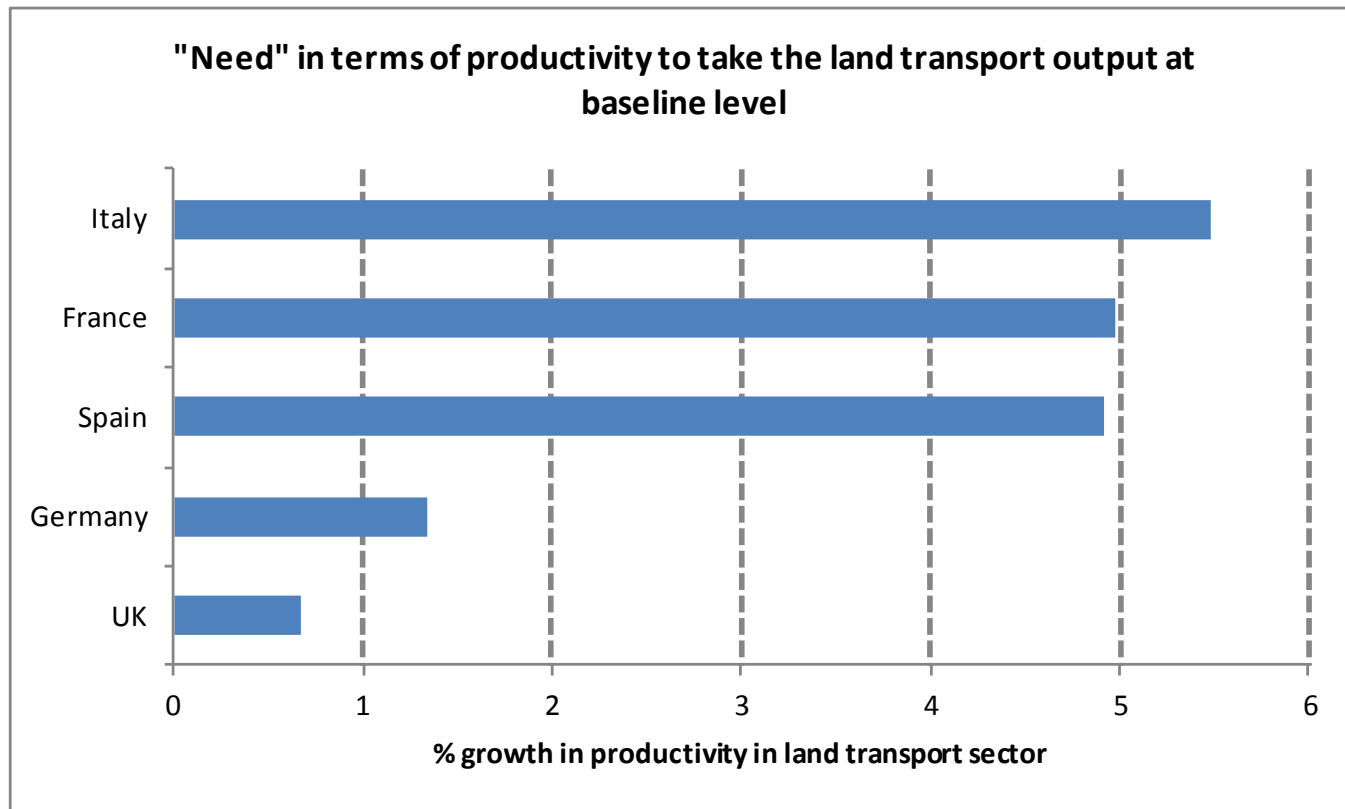


- **Preserving the output of the land transport sector**
- or
- **Maintaining the trade balance**

We “ask” to the model to “give back” the “level” of productivity growth we should achieve, to take at the baseline level the value of output in the land transport sector or the trade balance.

# A set of policy options: fixing the Output of the land transport sector (1)

In this case we can see that the political intervention is “almost feasible” for all countries, going from a “required” productivity growth by 0.7% in UK to 5.5% in Italy



# A set of policy options: fixing the Output of the land transport sector (2)

Impact on GDP growth (%), difference between baseline and policy (2020)

	CO2 policy	CO2 + Policy_output
Italy	-0.64	<b>-1.08</b>
France	-0.01	<b>-0.29</b>
Germany	-0.11	<b>-0.19</b>
Spain	-0.33	<b>-0.73</b>
UK	-0.20	<b>-0.24</b>

For all countries, when the objective of the policy is to “fix” the land transport sectoral output, it implies a decrease in GDP and higher carbon tax.

On trade balance, the policy is almost neutral in Germany and UK, has a positive effect in France and a slight positive effect in Spain and Italy

Impact on carbon tax (\$) in the policy scenarios (2020)

	CO2 policy	CO2 + Policy_output
Italy	118	<b>126</b>
France	84	<b>87</b>
Germany	53	<b>54</b>
Spain	121	<b>128</b>
UK	75	<b>76</b>

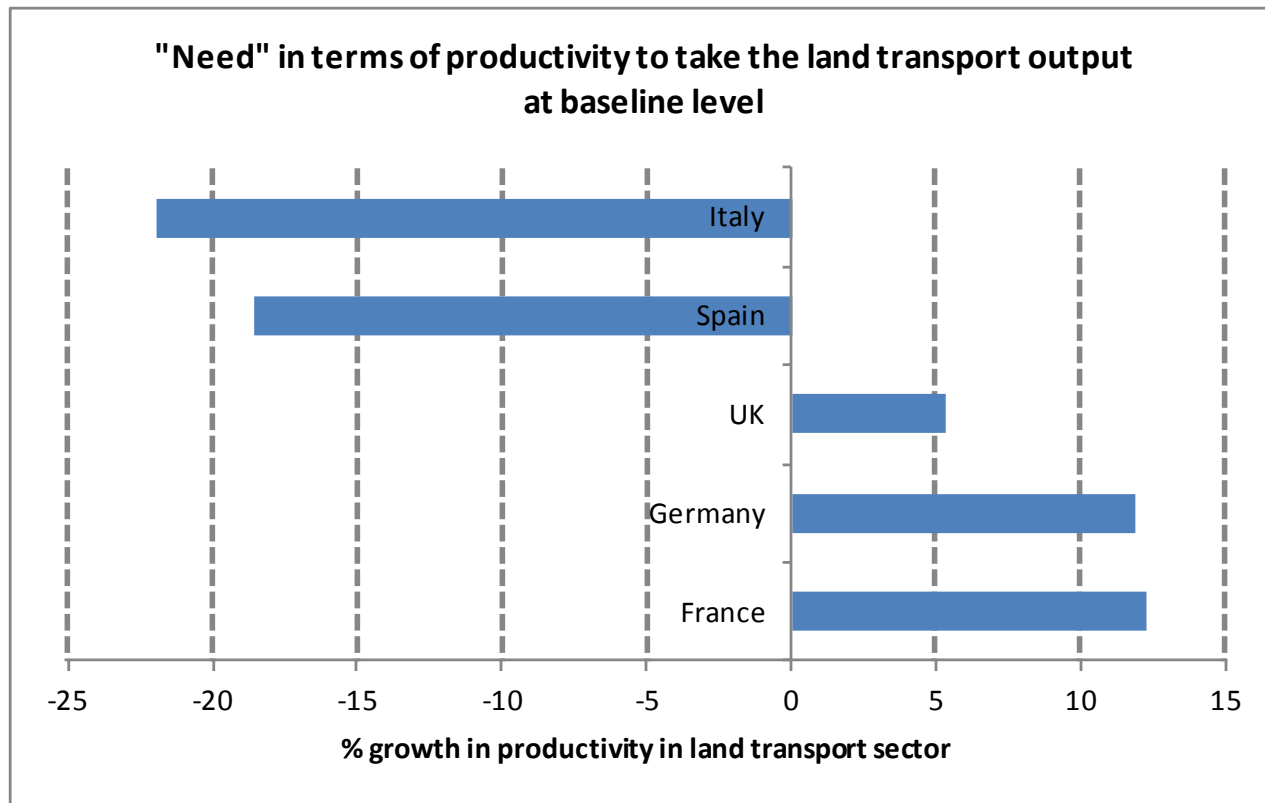
Impact on trade balance (US million): baseline and policies (2020)

	Baseline	CO2 policy	CO2 + Policy_1
Italy	-99,456	-78,723	<b>-71,288</b>
France	5,644	<b>-3,261</b>	<b>-804</b>
Germany	417,930	415,263	415,654
Spain	-321,615	-314,541	<b>-311,924</b>
UK	114,454	113,227	113,364



# A set of policy options: fixing the trade balance (1)

In this case we can see that the political intervention is “more” feasible for UK (growth rate by 5,4%) while the investment in productivity for Germany and France is higher. On the opposite side, Spain and Italy, given the different way in which land transport would impact the economy, could “disinvest” in the land transport efficiency if the objective is keeping unchanged the trade balance



# A set of policy options: fixing the trade balance (1)

Land transport output (%): difference between baseline and policy (2020)

	CO2 policy	CO2 + Policy_trade
Italy	-3.34	-9.79
France	-2.50	3.16
Germany	-0.88	0.05
Spain	-3.45	-9.19
UK	-0.64	3.70

For all countries, focusing on policy for trade balance, produce a significant impact on the output of land transport

Carbon tax remains more or less similar, while for Italy and Spain this policy option improves the GDP growth rate

Impact on carbon tax (\$) in the policy scenarios (2020)

	CO2 policy	CO2 + Policy_trade
Italy	118	103
France	84	<b>91</b>
Germany	53	52
Spain	121	116
UK	75	75

Impact on GDP growth (%), difference between baseline and policy (2020)

	CO2 policy	CO2 + Policy_trade
Italy	-0.64	<b>0.24</b>
France	-0.01	-0.71
Germany	-0.11	-0.23
Spain	-0.33	<b>0.28</b>
UK	-0.20	-0.56

# Some conclusions and further steps

- An integrated model is “necessary” tool for “next” policies;
- Emissions reduction impact heavily transport sectors but impact and policy interventions could have different “results”;

## Next steps

- Under methodological point of view we plan to introduce an **uniform variable** for the productivity for all transport sectors (air, water and land), in order to make more comparable the two policies analyzed, trade balance versus sectoral output (for transport sectors), and then to be coherent with the metric used for the “theoretical sound index” (like TRI, ndr)
- Adding the no-Co2 emissions to the data;
- Introducing biofuels (and nuclear) nest;