

# The Economic and Environmental Effects of an Environmental Fiscal Reform in a Dynamic CGE Framework



**Jaume Freire-González**

Department of Economics, Harvard University  
ENT Environment and Management, Barcelona

**Mun Ho**

Harvard China Project on Energy, Economy and Environment, Harvard University

## THE DOUBLE DIVIDEND HYPOTHESIS

- **Double dividend hypothesis (DD)** = environmental and economic benefits from using environmental taxes if revenues are used to reduce other pre-existing taxes.
- DD is an economy-wide issue so there is an empirical challenge. **How to test it?**
- Most used empirical tools for macroeconomic analysis: macroeconometrics, input-output methods and **applied computable general equilibrium methods (CGE)**.
- CGE are the most comprehensive way to take into account the most relevant aspects of an economic system. The great development of computing and IT technologies during the last half century have fostered their general use and an increasing its complexity.
- On the other side, these methods sometimes rely on controversial assumptions on the general functioning of economies.

## THE SOCIAL ACCOUNTING MATRIX (SAM)

- A **SAM** is a square matrix that provides information on the different flows of payments among the various elements of the economic system described: *commodities, industries, capital, labor, land, households, enterprises, government, taxes and tariffs, investments, savings, and the exterior sector*.
- Sources:
  - **General Intervention Board of the State Administration (IGAE)**: government accounts, including social security and tax accounts.
  - **INE**: supply and use tables, foreign sector accounts.
  - **Exiobase**: supply and use tables and environmental information on pollutants.
  - **Bank of Spain**: Enterprise accounts.
  - **IEA**: Hydrocarbons consumption.
- Compared to previous SAMs, ours is more detailed:
  - Detail on **101 industries and 101 commodities**.
    - Electricity generation technologies disaggregation (coal, gas, nuclear, hydro, wind, petroleum, biomass, solar, and other). A total of 11 industries inside this category.
    - Waste treatment technologies disaggregation (incineration, biogasification, composting, and landfill). A total of 19 industries inside this category.
  - Detail on **taxes**: tax on capital, tax on labor, property tax, tax on dividends, social security contributions, value added tax (VAT), sales taxes, other taxes on products, tariffs and VAT imports, subsidies, and special taxes on alcohol, tobacco, hydrocarbons, electricity, and retail hydrocarbons.

## THE DYNAMIC

## ENERGY-ENVIRONMENT-ECONOMY MODEL (I)

### Other technical features:

- **Growth is driven by savings**; thus, conceptually, it is a Solow growth based model. Economic growth also depends on population growth, capital accumulation, and technical change or growth in total factor productivity.
- **Savings come from three sources**: households, enterprises, and the foreign sector. Households save a share of their income, enterprises retain part of their earnings, and foreign sector invests through foreign investment. These savings finance the government deficit and are used for investment in domestic capital.
- The **factors of production** are capital, labor, land, energy, and other intermediates.
- Production functions are specified as **Cobb-Douglas** technology functions with constant returns to scale, as output expands in proportion to inputs.
- Imports and domestic output follow **Armington's (1969) assumption, to be combined through constant elasticity of substitution (CES) functions**, producing a composite commodity supply.
- Technical coefficients can change over time in two different ways: (1) there is technical progress, meaning that there is more output with the same inputs; and (2) there is biased technical change, i.e., changes in input demands unrelated to prices.
- The **capital input** for each industry is rented from a total capital stock that changes over time; it increases with new investments and decreases with depreciation.
- **Labor is assumed to be mobile** across sectors, and the labor supply depends on the level of unemployment.

# The Economic and Environmental Effects of an Environmental Fiscal Reform in a Dynamic CGE Framework



**Jaume Freire-González**  
Department of Economics, Harvard University  
ENT Environment and Management, Barcelona

**Mun Ho**  
Harvard China Project on Energy, Economy and Environment, Harvard University

## THE DYNAMIC ENERGY-ENVIRONMENT-ECONOMY MODEL (II)

Moreover, the model contains an energy and an environmental module.

- **Energy:** we track the use of energy through the system (coal, oil, natural gas and electricity) in physical units.



- **Environment:** the environmental module tracks the emissions of **31 pollutants**, by using environmentally extended input-output coefficients (from Exiobase):

$CO_2$  (carbon dioxide),  $CH_4$  (methane),  $N_2O$  (nitrous oxide),  $PM_{10}$  (particulate < 10 microns),  $SO_2$  (sulphur dioxide),  $NO_x$  (nitrogen oxide),  $PM_{2.5}$  (particulate < 2.5 microns),  $NH_3$  (ammonia),  $CO$  (Carbon monoxide), Benzo(a)pyrene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Indeno(1,2,3-cd)pyrene, PAH (polycyclic aromatic hydrocarbons), PCBs (polychlorinated biphenyl), PCDD\_F (dioxins), HCB (hexachlorobenzene), NMVOC (Non-methane volatile organic compounds), TSP (trimethylsilylpropanoic acid), As (arsenic), Cd (cadmium), Cr (chromium), Cu (copper), Hg (mercury), Ni (nickel), Pb (lead), Se (selenium), Zn (zinc),  $SF_6$  (sulfur hexafluoride), HFC (hydrofluorocarbons) and PFC (perfluorocarbon).



## EFFECTS OF AN ENVIRONMENTAL FISCAL REFORM (EFR) (I)

We **simulate an EFR** by adding/increasing a tax and reducing/eliminating subsidies on **39 different industry outputs**. New tax of 20% of total output; subsidies are correspondingly reduced by 20% of their total output:

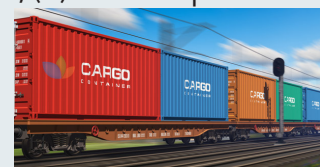
- **Energy** industry reforms are expected to increase the price of energy, thus reducing overall demand and consequently the emission of several pollutants. Particularly, they are expected to have a specific impact on GHG emissions. We have 16 industries in this category.



- **Water supply** industry fiscal reform is expected to increase the price of water and thereby reduce its consumption. This reduction is not reflected in air pollutants modeled, but is consistent with an EFR. **1 industry**.



- **Transport industries** fiscal reform is expected to increase the price of levied transport, and reduce its consumption. **3 industries:** (i) "Sale of motor vehicles", and thus the externalities associated with their production; (ii) "Retail trade services of motor fuel"; (iii) "Air transport services".



- **Waste treatment** industry reform aims to increase the costs and market prices of waste treatment, and thereby to reduce waste generation. Consequently, pollutants associated with waste treatment would drop. There are **19 industries** in this category.



# The Economic and Environmental Effects of an Environmental Fiscal Reform in a Dynamic CGE Framework

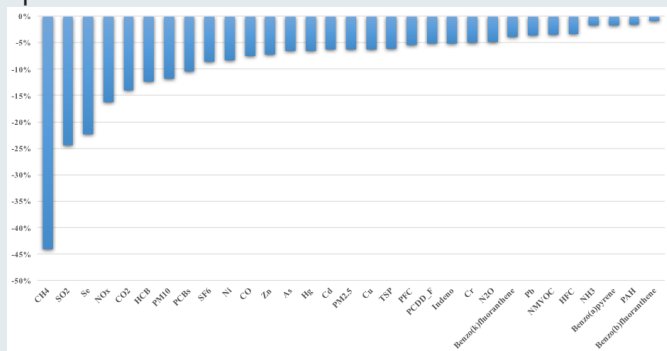


**Jaume Freire-González**  
Department of Economics, Harvard University  
ENT Environment and Management, Barcelona

**Mun Ho**  
Harvard China Project on Energy, Economy and Environment, Harvard University

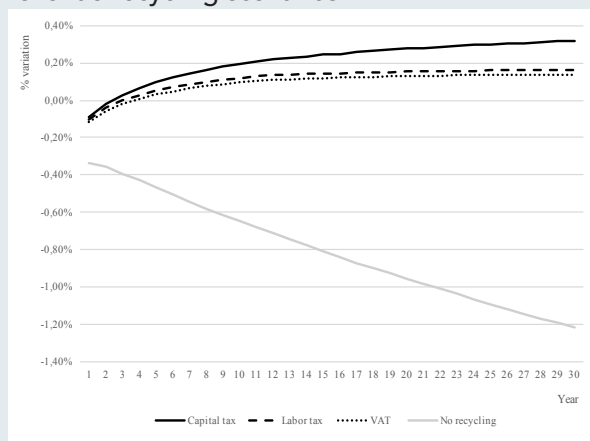
## EFFECTS OF AN ENVIRONMENTAL FISCAL REFORM (EFR) (II)

1) Average pollutant emissions variation of an ERF in Spain:



Freire-González, J., & Ho, M. S. (2018). Environmental Fiscal Reform and the Double Dividend: Evidence from a Dynamic General Equilibrium Model. *Sustainability*, 10(2), 501.

2) GDP variation of an ERF in Spain under different revenue recycling scenarios:



## CONCLUSIONS

- Environmental taxes are effective in reducing pollutant emissions.
- Using revenues from environmental taxes to reduce other pre-existing taxes reduces the costs of adopting an environmental tax.
- Under certain circumstances, a double dividend shows up.
- Non-monetary benefits of reducing environmental loads are not considered (so benefits are higher).
- Income redistribution aspects need to be taken into account for tax design and implementation.
- This study shows again that the believe that measures to reduce environmental loads are bad for the economy is a myth.