Curbing Carbon Emissions: Is a Carbon Tax the Most Efficient Levy?

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OUTLINE

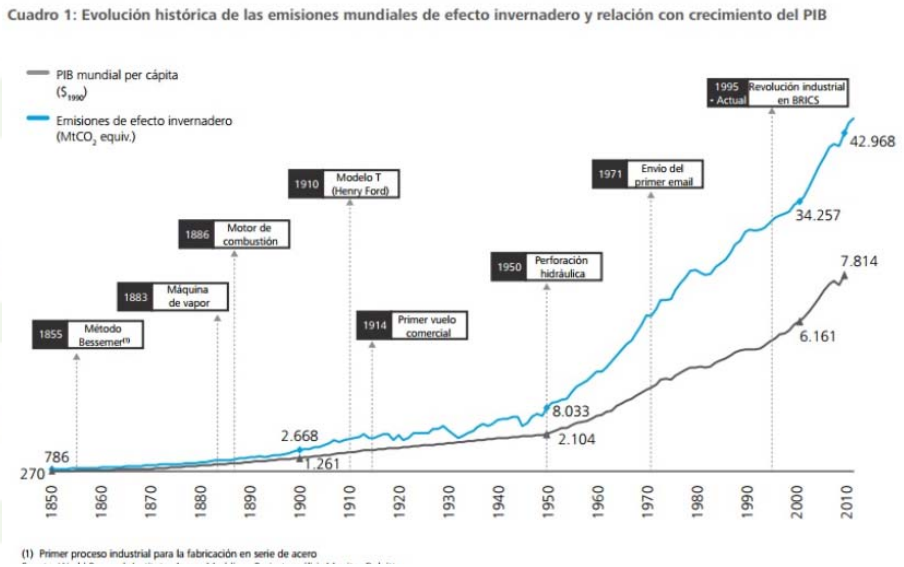
1. Introduction
2. Goals
3. The Model
4. Empirical Results and Discussion
5. Conclusions

1. The context of this paper is the **new agreement of Climate Change reached in December 2015**, known as the Paris Agreement. This agreement shows wide international consensus on the need to limit global warming to no more than 2 degrees.

1. Proof of this consensus is that **195 countries adopted a binding deal** on global climate change.

1. It is important to emphasize that the **required reduction in emissions to limit global warming to no more than 2 degrees is quite significant**. To illustrate this, the two-degree scenario defined by the International Energy Agency (2016) considers a reduction of “CO2 emissions of almost 60 percent by 2050 as compared to 2013.

Motivation… do I need a motivation?



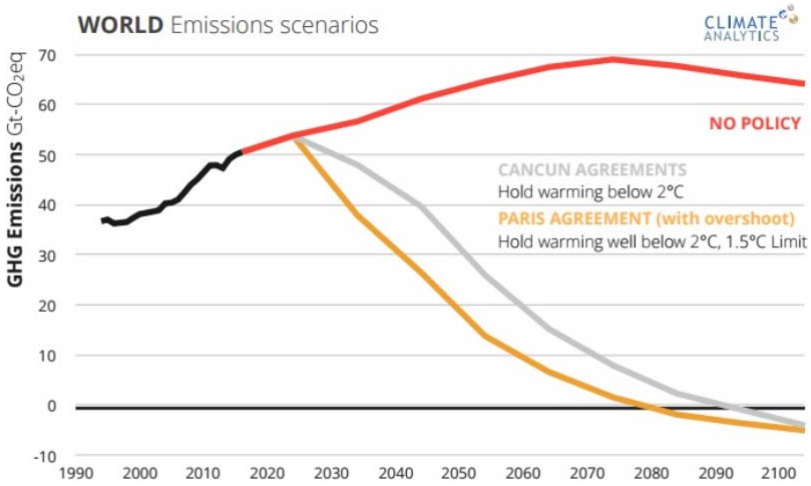


Figure 2: Global policy-relevant emissions scenario cases. GHG emissions, including LULUCF.
Source: IIASA/(Rogelj et al., 2015)

Motivation: Why another paper on carbon tax?

theguardian

Monday, 30 october 2017

"Global atmospheric CO2 levels hit record high

UN warns that drastic action is needed meet climate targests set in the Paris agreement"

Motivation: Why another paper on carbon tax?

1.The Paris Agreement with aggressive environmental targets. Over the next few years governments will attempt to identify a set of cost-effective policy tools to curb emissions and, probably, mitigate the consequences of climate change. However, the final impact of these instruments is difficult to assess.

2.Policymakers need a clear vision about the pros and cons of each policy instrument. The final impact of a specific tax on emissions will depend on the structure of the economy, the preferences of households, technological conditions for the production of goods and services, international energy prices and the flexibility available to switch among different fuels.

3.Most of the papers in the literature focus on the macroeconomic impact of carbon taxes. However, no study compares a carbon tax with other taxes independently on each of the fossil fuels (oil, natural gas and coal).

Research question, research strategy and academic relevance

Research question:

- **This study aims to evaluate the optimal taxes on oil, natural gas and coal to curb carbon emissions. It compares them to a carbon tax in a general equilibrium context.**

This study makes no focus on the optimal level of emissions, but rather on the optimal tax mix required to curb emissions within a given environmental target.

Research strategy:

- Dynamic General Equilibrium model (DGE)
- DGE for a small open economy (Spain)
- Focuses on the long-run

Relevance of this research:

- To the best of our knowledge, this is the first analysis that compares **carbon tax to other taxes on fossil fuels**.

The Model

1. We adapted the neoclassical growth model proposed by Blázquez et al. (2017) to include government. The model by Blázquez et al. (2017) is a dynamic general equilibrium model. This model has been estimated using Bayesian techniques.

2. Please let me make a clear point: **CO2 emissions DO NOT impact on household welfare or economic activity.** In this model, the level of carbon emissions is irrelevant to the household or the firm, which **only pays attention to economic variables like private consumption, investment or profits.**

3. We assume that **the government sets a carbon emission target according to exogenous environmental criteria.**

The Model

It represents the Spanish economy through a **dynamic general equilibrium model within the characteristic small open economy**.

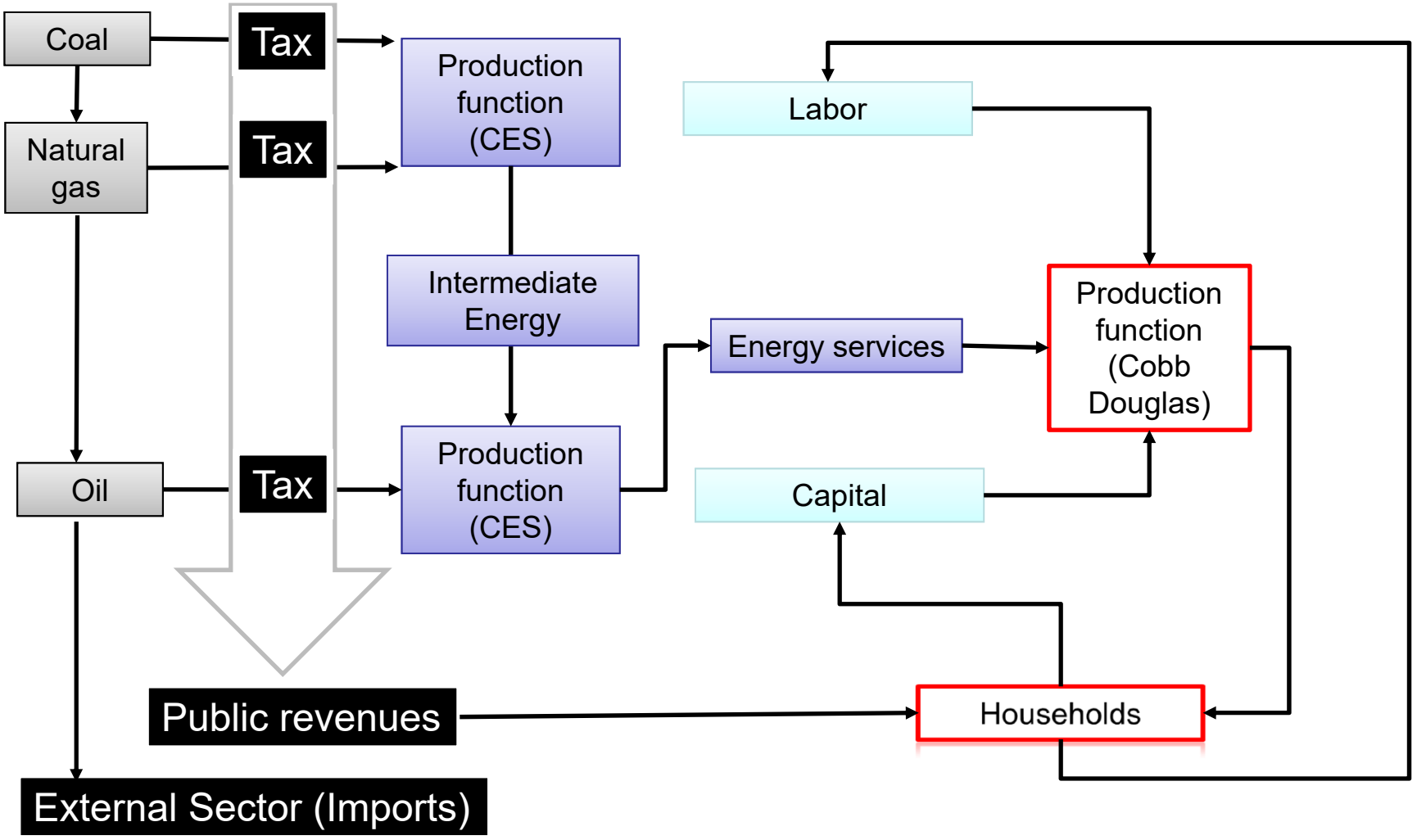
1. There is a representative household.

2. Three representative and competitive firms.

3. External sectors actively interact by trading a final good, foreign bonds and three primary energy inputs (oil, natural gas and coal).

4. A government that taxes fossil fuels and makes a lump-sum transfer of the revenues from these taxes to the representative household.

A visual representation of the model



PREFERENCES

$$U = E_0 \left\{ \sum_{t=0}^{\infty} \rho^t \frac{1}{1-\sigma} \left[\left[C_t - \psi N^{\nu} \right]^{1-\sigma} - 1 \right] \right\}$$

$$\psi > 0, \quad \nu > 1, \ \sigma > 0$$

INVESTMENT

$$I_t = K_{t+1} - (1-\delta) K_t + \frac{\Phi}{2} \left(\frac{K_{t+1} - K_t}{K_t} \right)^2$$

BONDS OR ASSETS

$$TB_t = -D_{t+1} + \left[1 + R_t^* + \Lambda(D_t)\right] D_t - P_{o,t} E_{o,t} - P_{g,t} E_{g,t} - P_{c,t} E_{c,t}$$

$$r_t = R_t^* + \Lambda(D_t)$$

$$\Lambda(D) = sign(D_{t-1})\varphi\left[e^{|D_{t-1} - D_{ss}|} - 1\right]$$

HOUSEHOLDS' BUDGET CONSTRAINT

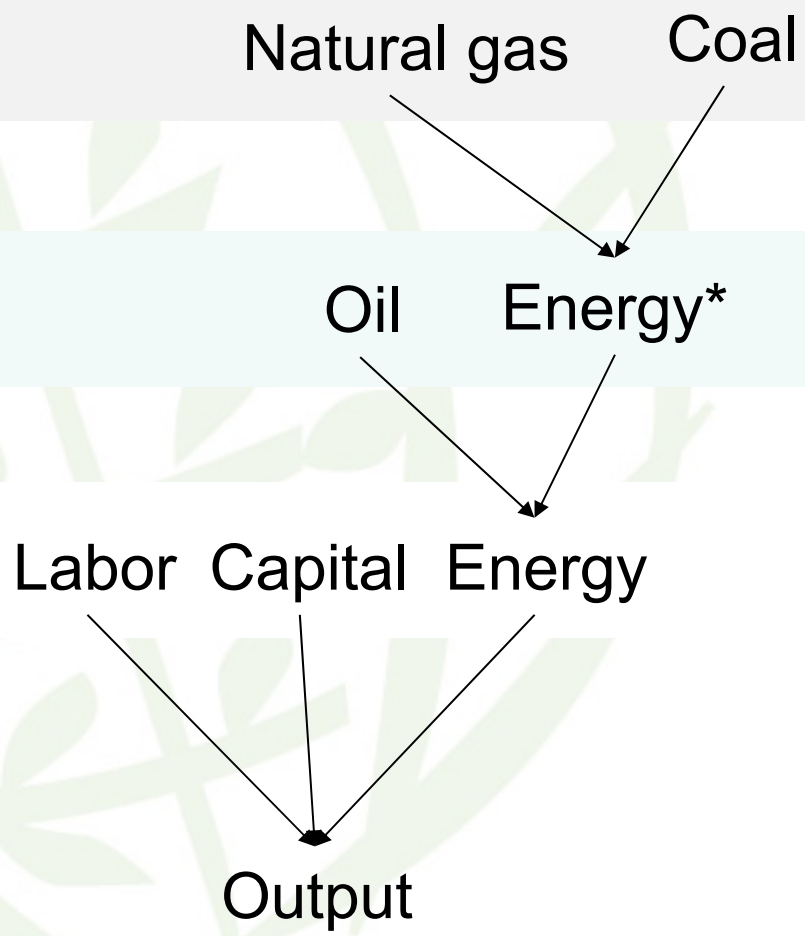
$$w_t N_t + r_t K_t + (R_t^* + \Lambda(D_t)) D_t + T_t = C_t + I_t + D_{t+1} - D_t$$

Firms

$$E_t^* = \left(bE_{g_t}^{\delta_E} + (1-b)E_{c_t}^{\delta_E} \right)^{1/\delta_E}$$

$$E_t = \left(aE_{o_t}^{\gamma_E} + (1-a)E_t^{*\,\gamma_E} \right)^{1/\gamma_E}$$

$$Y_t = Z_{T_t} F(K_t, N_t, E_t) = \theta_t N_t^{\alpha} K_t^{\beta} E_t^{1-\alpha-\beta}$$



THE GOVERNMENT

$$G_t = -T_t = P_{o_t}\tau_o E_{o_t} + P_{g_t}\tau_g E_{g_t} + P_{c_t}\tau_c E_{c_t}$$

THE GOVERNMENT PROBLEM

There are the steady state allocations in competitive equilibrium

$$\{C_{ss}, N_{ss}, D_{ss}, K_{ss}, E_{ss}, E^*_{ss}, E_{o,ss}, E_{g,ss}, E_{c,ss}, P_{E^*}, P_E, T_{ss}\}$$

which are a function of a tax mix $\{\tau_o, \tau_g, \tau_c\}$. We solve the following second- best problem:

$$\underset{\{\tau_c, \tau_o, \tau_g\}}{Max} \sum_{t=0}^{\infty} \rho^t \frac{\left[C_{ss}(\tau_c, \tau_o, \tau_g) - \Psi\left(N_{ss}(\tau_c, \tau_o, \tau_g)\right)^v\right]^{1-\sigma} - 1}{1-\sigma}$$

$$\text{subject to} \quad Em = \xi_o E_{o,ss}(\tau_c, \tau_o, \tau_g) + \xi_c E_{c,ss}(\tau_c, \tau_o, \tau_g) + \xi_g E_{g,ss}(\tau_c, \tau_o, \tau_g)$$

This is, the government choses the tax mix that maximizes welfare in descentralize steady state, given a maximum level of carbon emissions.

What is an optimal tax mix?.

1. First, we define the optimal tax-mix as the **combination of tax rates on fossil fuels that minimizes the negative impact on household welfare while achieving, at the same time, a specific target of CO2 emissions**.

2. As standardly done, we define welfare losses in terms of the increase in private consumption required to maintain social welfare constant.

3. **The second element that I would like to clarify is that this study assumes the economy is in a steady state or long run equilibrium.**

Research question:

This study aims to assess the optimal taxes on oil, natural gas and coal required to curb carbon emissions, and it compares them to a carbon tax within a general equilibrium context.

Empirical results and discussion

- As usual in this type of model, **we obtain the optimal tax-mix numerically**. However, we find that the optimal tax-mix satisfies the following two conditions:

Marginal productivity of oil

Domestic price of oil

Emissions from oil

$$\frac{\partial Y_t / \partial E_o}{\partial Y_t / \partial E_c} = \frac{P_o(1+\tau_o)}{P_c(1+\tau_c)} = \frac{\xi_o}{\xi_c}$$

$$\frac{\partial Y_t / \partial E_g}{\partial Y_t / \partial E_c} = \frac{P_g(1+\tau_g)}{P_c(1+\tau_c)} = \frac{\xi_g}{\xi_c}$$

- **Economic interpretation of these conditions**: the ratio of marginal productivity between two fuels equals the ratio of domestic prices and, in addition, the ratio of marginal productivity also equals the ratio of marginal levels of emissions

Empirical results and discussion

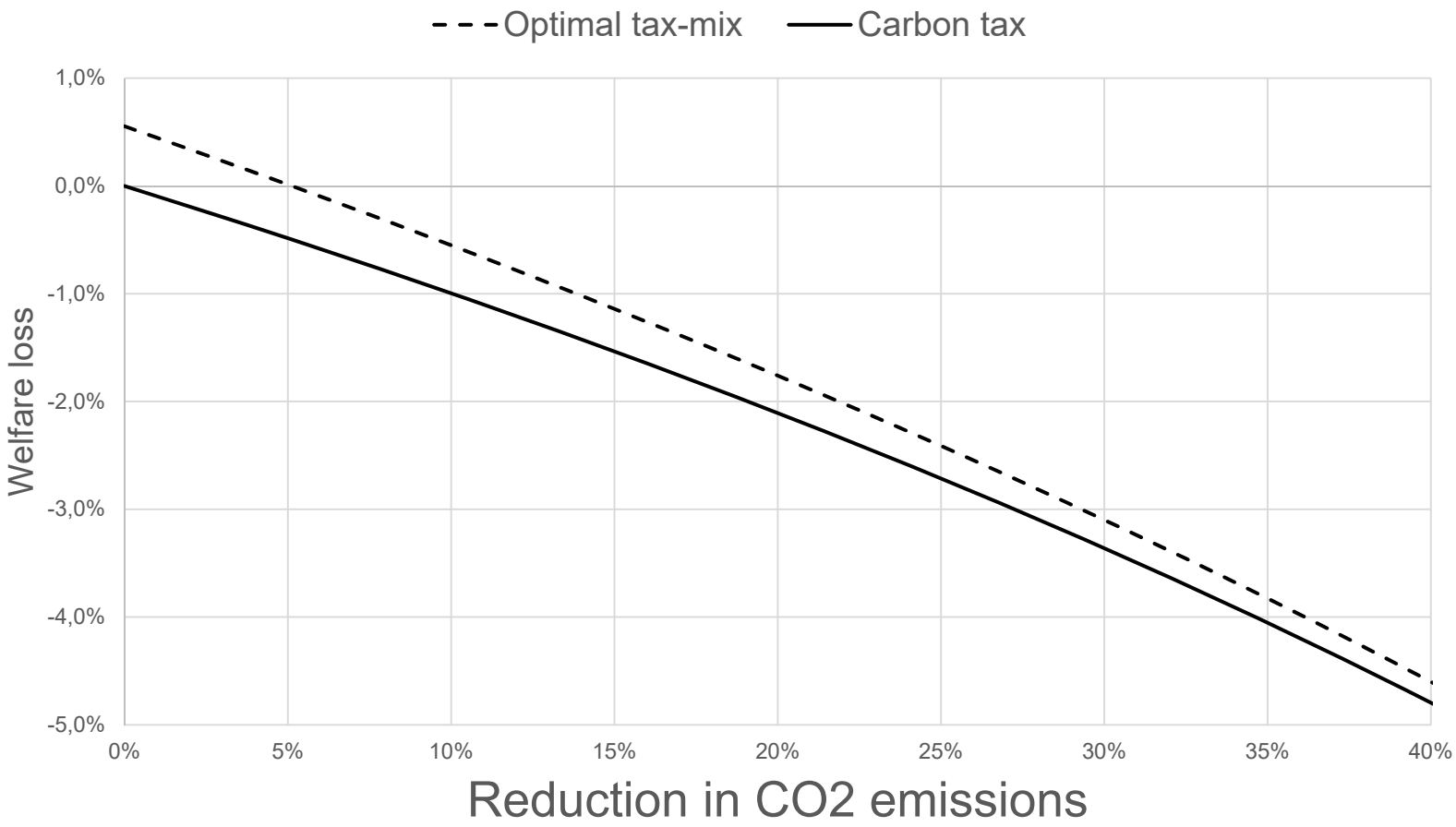
$$\frac{\partial Y_t / \partial E_o}{\partial Y_t / \partial E_c} = \frac{P_o(1+\tau_o)}{P_c(1+\tau_c)} = \frac{\xi_o}{\xi_c}$$

$$\frac{\partial Y_t / \partial E_g}{\partial Y_t / \partial E_c} = \frac{P_g(1+\tau_g)}{P_c(1+\tau_c)} = \frac{\xi_g}{\xi_c}$$

A policymaker, in order to achieve the optimal tax-mix, must pay simultaneous attention to carbon emissions, international fossil fuel prices and the level of productivity.

Empirical results and discussion

WELFARE LOSS AND CARBON EMISSIONS



Empirical results and discussion

Optimal tax-mix (percentage)	→					
Target of CO_2 reduction compared to baseline scenario	***10%***	***20%***	***30%***	***40%***	***50%***	***60%***
Tax rate on oil	-22.3	-14.5	-4.8	7.9	25.0	49.7
Tax rate on natural gas	-1.3	8.6	21.0	37.0	58.8	90.1
Tax rate on coal	139.3	163.2	193.2	232.0	284.7	360.7
Carbon tax (constant euros 2010)	6.9	15.4	26.4	40.9	60.7	89.7

Corollary: We find that, for any environmental target, **the carbon tax leads to a higher level of tax revenue.**

This could create a dilemma for policymakers given that revenue from taxation could also represent a policy objective.

- **An insight for policymakers would be the sole implementation of carbon taxes to achieve large reductions in CO_2 emissions. Carbon taxes are an inadequate policy tool for mild environmental targets.**

The ambitious environmental objectives of the Paris Agreement imply that, in order to curb carbon emissions, all cost-effective policy options should be considered. These options include carbon taxes, probably the most popular fiscal tool for curbing emissions, and various other taxes on fossil fuels.

This study uses Spanish data to determine the optimal tax on oil, natural gas and coal from a welfare perspective, and it compares them with a carbon tax in a general equilibrium context.

Conclusions:

1. Policymakers may consider taxing coal heavily as one of their options for reducing CO2 emissions. Less punitive taxation of oil and natural gas could also form part of an optimal strategy.

2.For maximum effectiveness, any planned tax on oil should always be lower than a tax on natural gas, and it should be even lower than a tax on coal. This counterintuitive result appears because, out of the three types of fuel, oil has the highest marginal economic productivity even though natural gas is the cleanest fossil fuel in terms of CO2 emissions.

3.Carbon tax has both advantages and disadvantages for policymakers.

THANK YOU

Why isn't a carbon tax an optimal strategy?

• The international price of fossil fuels provides information to economic agents in two different ways:

- It gives information on the 'economic value' of one unit of caloric energy.
- It also provides information on the 'economic value' of one unit of carbon emissions.

• The optimal-tax-mix modifies domestic prices via taxes to assure no divergence between the 'economic value' of one calorific unit (productivity) and the 'economic value' of one unit of CO2 emission.

• Nevertheless, the carbon tax totally focuses on emissions and does not take into consideration the international price of fossil fuels.