The Distributional Effects of Carbon Taxation in Italy

Francesco Caprioli   Giacomo Caracciolo

Public Finance Division - Bank of Italy

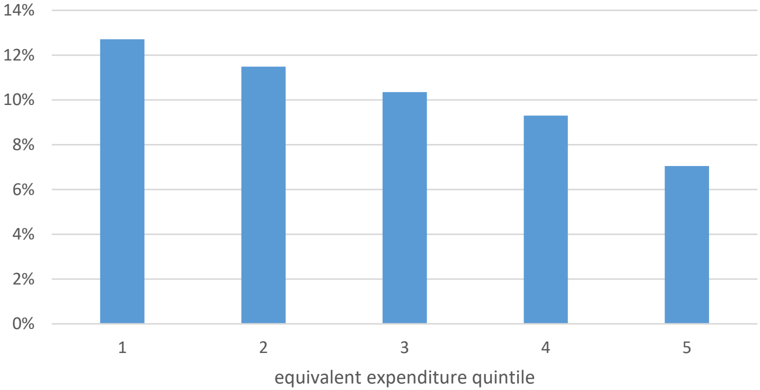
September 5th, 2024

Research question

How to redistribute the revenues from carbon taxation?

- Both academic literature and policy institutions identify in a carbon tax the preferred instrument to achieve the goals of CO_2 emissions reduction and of an energy-neutral economy;
- however there is not a general consensus on its distributional impact.
- How to redistribute carbon tax revenues?
- How does this apply to the Italian case?

Expenditure share for electricity, gas and other fuels by equivalent expenditure quintile in Italy (2021, Eurostat)



What we do

Sketch of the policy experiments

- General equilibrium model with both intra and inter-generational heterogeneity, a production network and the government;

- we model the carbon tax as an import tariff on energy consumption by households and sectors;

- the government uses its revenues to either:
  1. increase spending;
  2. redistribute via a uniform transfer;
  3. decrease distortionary income taxes (*double dividend hypothesis*).

- we compute the non-environmental welfare effects of each policy alternative for different agents (CEV).

Literature Review

two main strands

1. The evidence on the distributional impact of carbon taxation is mixed in the literature:

- **Poterba (1989)**: using lifetime income data vs. annual income data make excise taxes appear less regressive;
- **Sterner (2012)**: the distributive policy profile for tax exp. on fuel is increasing in Germany, Sweden, UK but decreasing in Italy;
- **Andersson & Atkinson (2020)**: the general trend of increasing income inequality may amplify the regressive effects of carbon taxation;
- **Faiella & Lavecchia (2021)**: estimate the price elasticity of demand of energy intensive goods in Italy.

Literature Review

two main strands

2. Optimal *revenues recycling*: reducing distortionary taxation vs. universal lump-sum transfer:

- **Metcalf (1999)**: reducing labor taxes can also be regressive;
- **Chioleu-Assouline & Fodha (2014)**: reduce labor taxes and increase their progressivity;
- **Fried, Novan & Peterman (2018)**: long-term vs. transitional welfare consequences make only lump-sum transfer politically attainable;

Households

70-gen OLG structure

$$V(a,z,ea,j) = \max_{C,l,a'} \quad u(C,l) + s(j)\beta EV\left(a',z',ea',j+1\right)$$

- Temporal utility $U(i)$ is increasing in consumption $C(i)$ and leisure

$$U\left(C(i),l(i)\right) = \frac{C(i)^{1-\frac{1}{\rho}}}{1-\frac{1}{\rho}} - \chi\frac{l(i)^{1+\nu}}{1+\nu}$$

$$C(i) = \prod_{j=1}^{n}\left(c_j(i) - \bar{c}_j\right)^{\omega_j}$$

- $C(i)$ is a consumption aggregator characterized by the Stone-Geary functional form. Parameters $\{\bar{c}_j\}_{j=1}^{n}$ give the subsistence level for each one of the goods consumed.

Households

Constraints

$$\sum_{n=1}^{5} p_n c_n + \left(1+\tau^{ct}\right) p_6 c_6 + a' = R(j)a + \left(1 - 1_{j>J^r}\right) y + 1_{j>J^r}\, pen + T \tag{1}$$

$$y = (1-\tau^w) wh(j)l \left[1 - \tau^y((1-\tau^w)wh(j)l)\right] \tag{2}$$

$$pen = \xi ea \left[1 - \tau^y(\xi ea)\right] \tag{3}$$

$$ea' = \begin{cases} ea & \text{if } j > J^r \\ \frac{jea + wh(j)l}{j+1} & \text{if } j \le J^r \end{cases} \tag{4}$$

$$R(j) = \frac{1 + r(1-\tau^k)}{s(j)} \tag{5}$$

$$log\left(h\left(j\right)\right) = z + d(j) \tag{6}$$

$$z = \rho_z z_{-1} + \epsilon \quad \epsilon \sim \mathcal{N}(0, \sigma_\epsilon^2) \tag{7}$$

$$z_1 \sim \mathcal{N}(0, \sigma_{z_1}^2) \tag{8}$$

$$a' \ge 0 \tag{9}$$

Firms

There is a representative firm in each sector, with production function:

$$Y(n)=A\left\{\left[\alpha_n\left(K(n)^{\epsilon_n}L(n)^{(1-\epsilon_n)}\right)^{\frac{\iota_n-1}{\iota_n}}+(1-\alpha_n)E(n)^{\frac{\iota_n-1}{\iota_n}}\right]^{\frac{\iota_n}{\iota_n-1}}\right\}^{\psi_n} * \left\{\prod_{i\neq n}^{5}\left(Y^d(i,n)\right)^{\theta_{i,n}}\right\}^{(1-\psi_n)}$$

- All firms employ a combination of labor, capital, energy and intermediate inputs to produce their output.
- All goods and factors markets are perfectly competitive and prices are fully flexible, so that goods (factors) are priced their marginal cost (product) and firms make zero profits.

The main mechanisms

How does the tax affect inequality

1. A **demand** channel: being energy a necessity, poor households suffer more an increase in its price as they devote a larger fraction of their income to consume it;

2. a first **supply** channel: different sectors are asymmetrically dependent on energy as an input (heterogeneous effect on output prices);

3. a second **supply** channel: the substitutability between energy and the other factors of production varies across sectors (heterogeneous effect on sectoral wages).

4. a **network** channel: as all products are both used for consumption and for production, changes in prices feedback on prices and wages.

Government

Policy options

- The government runs a balanced budget in each period;
- it levies taxes on energy consumption, on labor (and pension) income and on capital income, respectively with the tax rates τ^{ct}, τ^{y} and τ^{k};
- it consumes an exogenous amount G of total production;
- it increases τ^{ct} from 0 to 10% (compatible with carbon tax of 75 dollars per CO_2 tonne);
- it faces four alternatives to recycle the energy tax revenues:
  1. increase government spending G;
  2. rebate them via uniform transfers $T(i)$;
  3. cut distortionary labor income taxes τ^{y};
  4. cut distortionary capital income tax τ^{k}.

Calibration (1/3)

Parameters estimated directly from the data	Symbol	Source
Capital share in the K-L composite	$\{\epsilon_n\}_{n=1}^{5}$	Istat I/O tables
K-L share in the K-L-E composite	$\{\alpha_n\}_{n=1}^{5}$	Istat I/O tables
Complement of the intermediate input share	$\{\psi_n\}_{n=1}^{5}$	Istat I/O tables
Sector i share in the intermediate input of sector n	$\{\theta_{i,n}\}_{i\neq n}^{5}$	Istat I/O tables
Sector n expenditure share in government consumption	$\{\omega_n^g\}_{n=1}^{5}$	Eurostat
Age-dependent survival probabilities	$\{s_j\}_{j=1}^{70}$	Istat
Age-dependent productivity profile	$\{d_j\}_{j=1}^{37}$	Social Security (INPS)
Employer and employee social security contribution rates	$\{\tau^f, \tau^w\}$	Social Security (INPS)
Capital income tax rate	τ^k	

Calibration (2/3)

Parameters calibrated matching some data moments	Symbol	Value
Rate of time preference	β	0.98
Weight of labor disutility	χ	120
Private consumption shares	$\{\omega_n\}_{n=1}^{6}$	
Subsistence consumption levels	$\{\bar{c}_n\}_{n=1}^{6}$	
Gouveia-Strauss labor income tax parameters	{t1, t2, t3}	0.40, 6.89, 1.58
Depreciation rate	δ	0.06
Energy price	p_6	0.24
Variance of initial earnings	$\sigma_{z_1}^2$	0.36
Variance of transitory earnings process component	σ_{ϵ}^2	0.032

Calibration (3/3)

Parameters	Symbol	Value	
Taken from the literature			Source
Elasticity of intertemporal sub.	ρ	0.5	Standard in literature
AR(1) component of earnings	ρ_z	0.98	Standard in literature
Invers of Frisch elasticity of sub.	ν	-2	Standard in literature
Energy elasticity of sub.	$\{\iota_n\}_{n=1}^{5}$		Baccianti (2013)
Target data moments			
Capital- and investment-output ratios		{3.3, 0.2}	
Average time spent working		$\frac{1}{3}$	
Energy consumption share of households		0.32	MASE(2023)
Variance of log earnings at age 26 and 62		{0.28, 0.58}	Social Security (INPS)
Cons. exp. shares by income quintile			Istat HBS
Income average tax rate by income quintile			Istat & Curci et al. (2017)

The model sectors

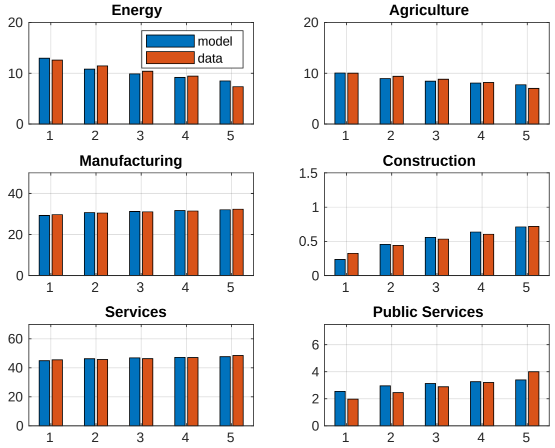
NACE Rev. 2 sectors		Sector	Model sector name
A	Agriculture, Forestry and Fishing	1	Agriculture
B	Mining and Quarrying		
C	Manufacturing	2	Manufacturing
C19	Manufacturing - Coke,Petroleum Prod	6	Energy
D	Electricity, Gas, Steam and Air Con	6	Energy
E	Water Supply; Sewerage, Waste	1	Agriculture
F	Construction	3	Construction
G	Wholesale and Retail Trade	4	Services
H	Transportation and Storage		
I	Accommodation and Food Service		
J	Information and Communication		
K	Financial and Insurance		
L	Real Estate		
M	Professional, Scientific and Technical		
N	Administrative and Support		
O	Public Administration	5	Public services
P	Education		
Q	Human Health and Social Work		
R	Arts, Entertainment	4	Services
S	Other Service Activities		
T	Act. of Households as Employers		

Calibration of the production parameters by sector

Sectors	ϵ	α	σ	ψ
Agriculture, mining and water	0.7	0.97	0.6	0.7
Manufacturing	0.4	0.98	0.2	0.7
Construction	0.5	1	0.1	0.6
Services	0.7	0.99	0.4	0.9
Public services	0.3	0.98	0.4	0.7

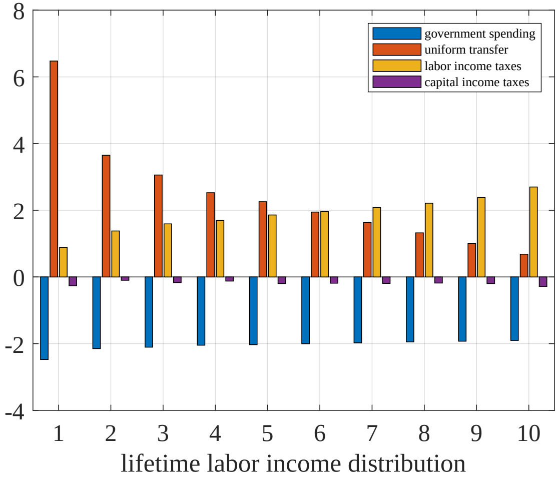
Calibration of consumption expenditure shares by income quintile

Model fit



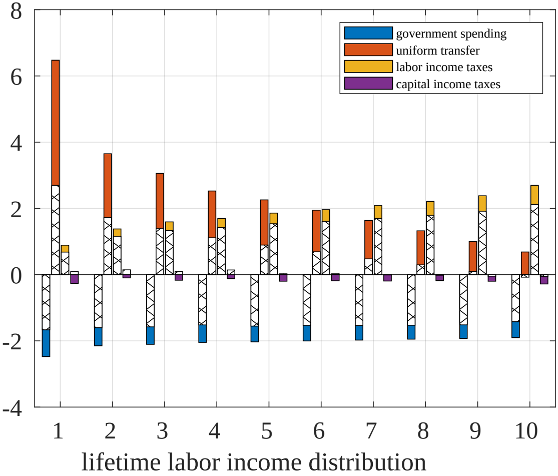
Consumption equivalent variation % (*CEV*)

for the 10 deciles of the average labor income distribution, in the long-run equilibrium



CEV (%) due to the consumption response vs. overall *CEV*

across policy scenarios



An alternative decomposition of the *CEV*

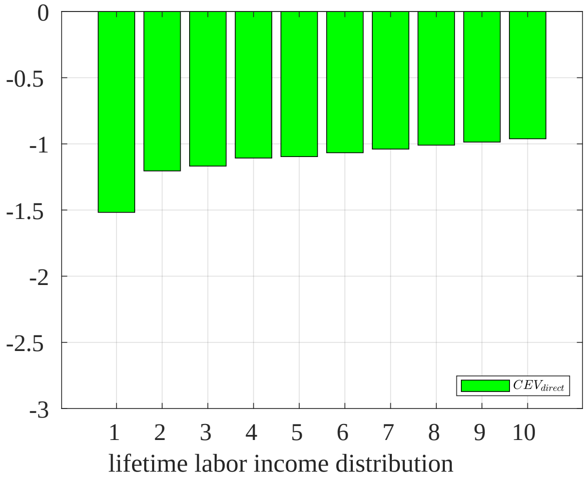
direct vs. indirect effects

$$CEV \approx CEV_{direct} + CEV_{fiscal-policy} + CEV_{GE}$$

1. CEV_{direct} is the welfare effect due only to the change in the energy tax τ^c from 0 to 10%;
2. $CEV_{fiscal-policy}$ is the welfare effect due only to the different revenue-recycling schemes (the change in G, T, t_4 or τ^k);
3. CEV_{GE} is the welfare effect due to general equilibrium effects (the change in prices, wages and the real interest rate $\{p_n\}_{n=2}^{6}$, w and r).

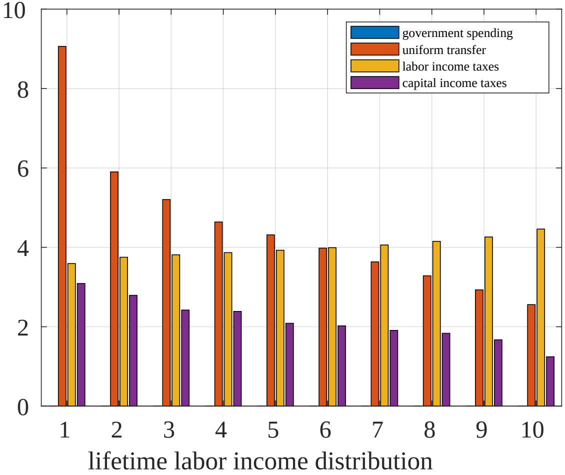
CEV_{direct} (%)

the component only due to the energy price increase



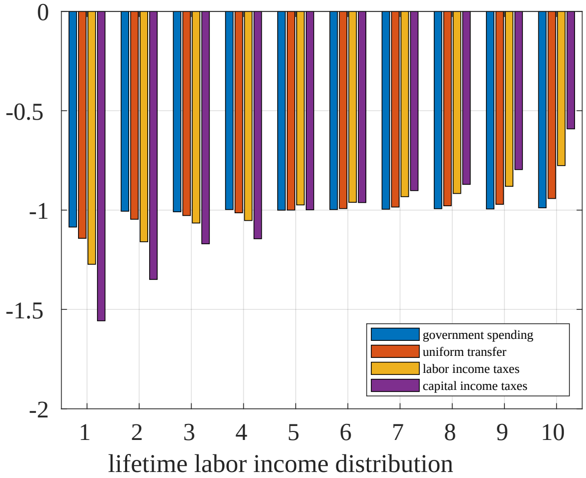
$CEV_{fiscal-policy}$ (%)

the component only due to revenue-recycling



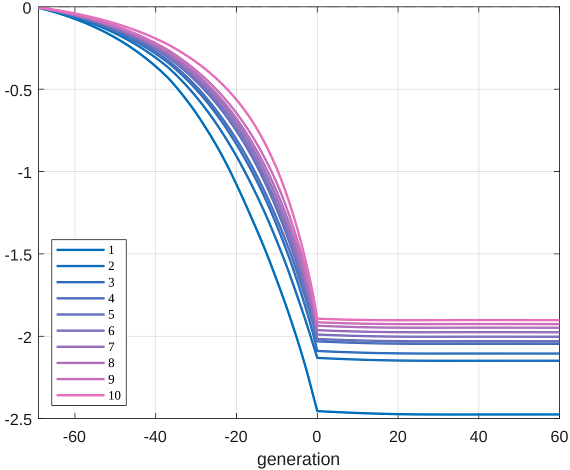
CEV_{GE} (%)

the component only due to changes in goods prices, wages and in the interest rate



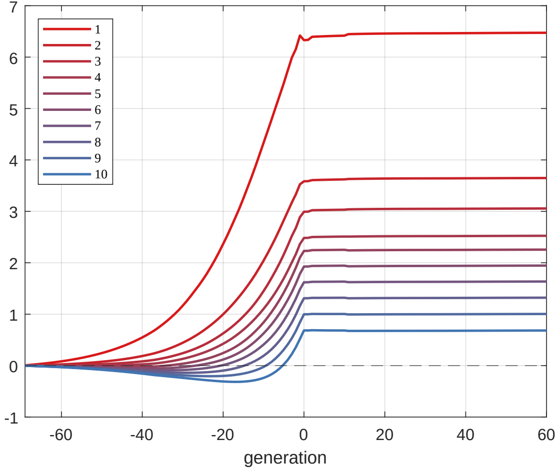
CEV (%) by decile during the transition

under the government spending scenario



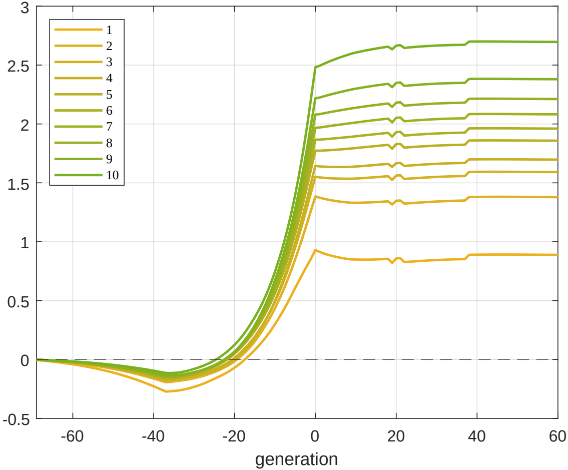
CEV (%) by decile during the transition

under the uniform transfer scenario



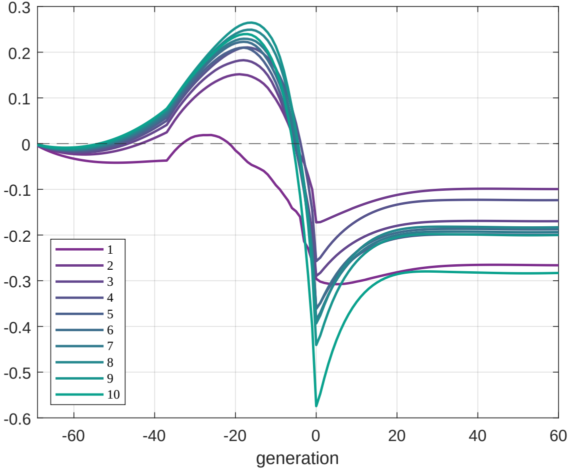
CEV (%) by decile during the transition

under the labor income taxes scenario



CEV (%) by decile during the transition

under the capital income taxes scenario



What we want to do next

Imperfect labor mobility and sectoral wages

- the previous results involve a substantial reallocation of workers across sectors in response to the policy;
- results hinge on perfect labor mobility, a unique labor market and one equilibrium wage;
- in reality, workers do not move so much across sectors during their working life;
- study the transition under the assumption that workers decide the sector of employment before entering the labor market and are locked in them for their lifetime.

Conclusions

Summary of results

- The distributional effects of introducing the carbon tax are relatively small, but crucially depend on the revenue-recycling scheme implemented and on GE forces;
- both a uniform transfer and a parallel downward shift in the personal income tax schedule generate a welfare gain for all households in the long-run;
- but they have different distributional implications, as well as a different impact on production;
- many of the generations alive when the energy tax is introduced suffer a welfare loss, even under the "best" policy scenarios.