Give to the poor or the needy: optimal carbon dividend distribution

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Carbon pricing regressivity and public acceptability

- Economists unanimously advocate a carbon dividend to efficiently reduce carbon emissions and make the accompanying cost increase socially acceptable.
- While an abundant literature estimates the optimal CO2 price path, no analysis of the optimal dividend distribution has been developed.
- Carbon price regressivity has lead this policy instrument to be largely debated and to face substantial public acceptability issue.
- Therefore, because of unsuitable distributional effects, the public acceptability of carbon pricing, and particularly of carbon taxation, forms a substantial challenge to implement climate policies.

Objective of the paper

- This article fills that gap, that derives the optimal redistribution for consumers heterogeneous along two dimensions: income and share of the carbon emitting good in their overall expenses.
- To our best knowledge, the existing academic literature does not derive the optimal carbon dividend distribution among heterogeneous consumers. A priori, two dimensions matter: (i) the income level - relative poverty, and (ii) the share of this income allocated to consumption of carbon-intensive / dirty goods - the need. One expects the optimal distribution trades-off these two dimension

Model time line

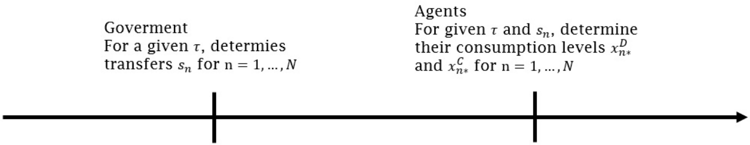

Figure 1: Model timeline

Consumers

Consumer's n utility function is:

$$U_n(x_n^D, x_n^C) = \alpha_n \ln(x_n^D) + (1-\alpha_n)\ln(x_n^C) \qquad \text{with } \alpha_n \in (0,1)$$

Consumer's n budget constraint

$$p^D(1+\tau)x_n^D + p^C x_n^D = m_n + s_n$$

We assume that consumer n is myopic: she takes s_n as given, i.e. she does not internalise the impact of her carbon intensive good consumption decision x_n^D on the tax levied by the government hence on the transfer s_n she receives.

Government's program - Budget constraint

Government's budget neutrality constraint [3] [4]:

$$\sum_{n=1}^{N} s_n \left(1 - \delta\alpha_n\right) = \delta m \tag{1}$$

The government budget neutrality equation (1) states that the adjusted additional income available to all agents is equal to the share of the pre-dividend income spent on the carbon-intensive / dirty good.
We order consumers by increasing adjusted income for a given δ:

$$m_1(1 - \delta\alpha_1) < ... < m_n(1 - \delta\alpha_n) < ... < m_N(1 - \delta\alpha_N) \tag{2}$$

[3] $\delta = \frac{\tau}{(1+\tau)}$, the share of the carbon tax in the carbon-intensive / dirty good's price

[4] $m = \sum_{n=1}^{N} \alpha_n m_n$ the share of pre-tax income spent as carbon-intensive / dirty good.

Government's program - Optimal transfers

Assuming $\tau > 0$, the government program is:

$$\begin{cases} \max_{\{s_n\}} W = \sum_{n=1}^{N} \alpha_n \ln\left(\alpha_n \frac{m_n+s_n}{p^D(1+\tau)}\right) + (1-\alpha_n)\ln\left((1-\alpha_n)\frac{m_n+s_n}{p^C}\right) \\ \text{s.t} \qquad \sum_{n=1}^{N} s_n\left(1-\delta\alpha_n\right) = \delta m \\ \qquad\quad -s_n \leq 0 \qquad \text{with} \qquad n = 1, ..., N \end{cases}$$

The first order conditions are:

$$\frac{\partial \mathcal{L}}{\partial s_n} = 0 \quad \Rightarrow \quad \frac{1}{m_n + s_n} - \lambda(1-\delta\alpha_n) + \mu_n = 0 \quad \text{for} \quad n = 1, ..., N \qquad (3)$$

2-consumer case - Optimal transfers

From equations (3), two cases are possible:

- Case n°1: $s_1 > 0$ and $s_2 > 0$ (i.e. $\mu_1 = \mu_2 = 0$)
- Case n°2: $s_1 > 0$ and $s_2 = 0$ (i.e. $\mu_1 = 0$ and $\mu_2 > 0$): only the poorer consumer receives a transfer

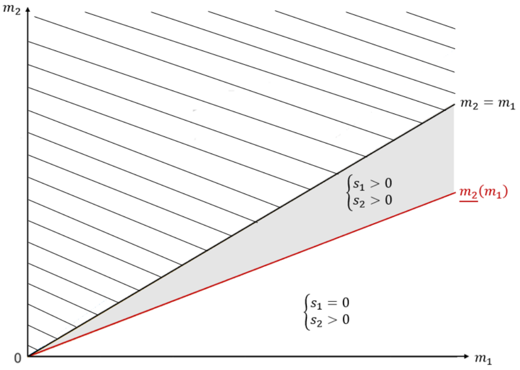

Figure 2: Transfers in the (m_1, m_2) plane

2-consumer case - Optimal transfers

Result

With the ordering of consumers we have selected, if the richer consumers receive a positive transfer, then so do the poorer ones.
Furthermore, richer consumers receive a positive transfer as long as the pre-tax income disparity remains below a given threshold.

2-consumer case - Social welfare impact

The social welfare function is taken as the sum of the consumers' utilities:

$$W = \sum_{n=1}^{2} \left[\alpha_n \ln\left(\alpha_n \frac{m_n + s_n}{p^D (1+\tau)} \right) + (1-\alpha_n) \ln\left((1-\alpha_n) \frac{m_n + s_n}{p^C} \right) \right] \tag{4}$$

2-consumer case - Social welfare impact

Both consumers receive positive transfer
Algebra yields:

$$\begin{aligned}\frac{\partial W}{\partial \tau} &= \sum_{n=1}^{2} \frac{\alpha_n}{1+\tau}\left[\frac{1}{(1-\delta\alpha_n)(1+\tau)} - 1\right] \\ &= -\frac{\tau}{1+\tau}\sum_{n=1}^{2}\frac{\alpha_n(1-\alpha_n)}{1+\tau(1-\alpha_n)} < 0\end{aligned} \quad (5)$$

If the government provides positive transfers for both consumers, the positive income effect produced by redistribution is not sufficient to compensate for the negative quantity effect from taxation.

2-consumer case - Social welfare impact

Only the poorer consumers receive a positive transfer

$$\left.\frac{\partial W}{\partial \tau}\right|_{\tau=0} = \frac{m}{m_1} - (\alpha_1 + \alpha_2) = \frac{\alpha_2(m_2 - m_1)}{m_1} \tag{6}$$

Then, a small carbon tax optimally redistributed increases welfare if and only if the pre-tax and dividend income is higher for richer consumers than for poorer ones. The intuition is that the negative impact of the reduction in consumption of the carbon-intensive / dirty good is more than offset by the positive income impact on the poorer consumers.

N-consumer case - Optimal transfers

As with the 2-consumers case, not all consumer classes receive a transfer. We denote $k \leq N$ the number of customers receiving a carbon dividend. Unless otherwise specified, we assume $\tau > 0$, hence $k \geq 1$.
The FOCs and budget-neutrality constraint are:

$$\begin{cases} \frac{1}{m_n} - \lambda(1-\delta\alpha_n) + \mu_n = 0 \quad \text{for} \quad n > k \\ \frac{1}{m_n + s_n} - \lambda(1-\delta\alpha_n) = 0 \quad \text{for} \quad n \leq k \\ \sum_{i \geq k}^{N} s_n(1-\delta\alpha_n) = \delta m \end{cases} \tag{7}$$

The k poorer consumers receive a carbon dividend $s_n > 0$, which equalize their marginal utility of income. This is not possible for the $(N-k+1)$ richer consumers, hence they receive no carbon dividend: $s_n = 0$ for $n > k$.

N-consumer case - Optimal transfers

Lemma

The optimal dividends are such that:

$$
\begin{aligned}
m_n + s_n &= \frac{\delta m + \sum_{i \leq k} m_i (1 - \delta \alpha_i)}{k(1 - \delta \alpha_n)} \quad \textit{for} \quad n \leq k \\
&= m_n \quad \textit{for} \quad n > k
\end{aligned} \tag{8}
$$

N-consumer case - Optimal transfers

Proposition

The government distributes carbon dividends

$$s_n = \frac{\delta m + \sum_{i \leq k} \left(m_i(1-\delta\alpha_i) - m_n(1-\delta\alpha_n) \right)}{k(1-\delta\alpha_n)} \tag{9}$$

for all $n \leq k$, where k is the highest consumer class verifying:

$$\sum_{i \leq k} \left(m_k(1-\delta\alpha_k) - m_i(1-\delta\alpha_i) \right) < \delta m. \tag{10}$$

For all $n > k$, no carbon dividends are distributed.
The number of consumer classes receiving a carbon dividend increases with the carbon price.

N-consumer case - Social welfare impact

The social welfare function is:

$$W = \sum_n \left[\alpha_n \ln \left(\alpha_n \frac{m_n + s_n}{p^D (1+\tau)} \right) + (1-\alpha_n) \ln \left((1-\alpha_n) \frac{m_n + s_n}{p^C} \right) \right]$$

N-consumer case - Social welfare impact

Proposition

If all consumers receive a carbon dividend, then social welfare is reduced. Consider a infinitely small but positive carbon tax. If only one consumer receives a positive dividend at the optimal redistribution, the social welfare is increased locally if and only if $\sum_{n>1} \alpha_n (m_n - m_1) > 0$.

Application to France dataset

Using the N-consumer case developed in section 4, we provide an application using INSEE French data. As discussed previously, few data are required to provide insightful intuition about the impact of optimal carbon dividend on French economy: goods demands, revenues and social welfare variation.

Application to France dataset

	m_n	α_n	$m_n(1-\delta\alpha_n)$
1^{st} *decile*	1282	6%	1251,2
2^{nd} *decile*	1423	6.1%	1388,3
3^{rd} *decile*	1552	5.9%	1515,4
4^{th} *decile*	1697	5.6%	1659,0
5^{th} *decile*	1871	5.4%	167,3
6^{th} *decile*	2088	5%	2046,2
7^{th} *decile*	2383	5%	2335,3
8^{th} *decile*	2848	4.4%	2797,9
9^{th} *decile*	3776	4.3%	3711,1
10^{th} *decile*	4932	4%	4853,1

Table 1: Data presentation. Income m_n, share of the carbon-intensive / dirty good in expenditures α_n and adjusted income $m(1-\delta\alpha)$ per decile for a carbon tax level $\tau = 0.4$.
Source: INSEE - Distribution des salaires mensuels nets en équivalent temps plein (EQTP) en 2018 ; INSEE - Les dépenses des ménages en 2017 Enquête Budget de famille

Application to France dataset

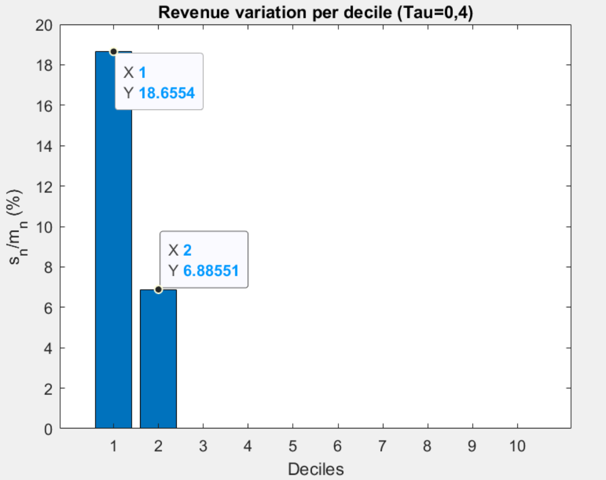

Figure 3: Revenue variation with and without carbon dividend per decile. Source: INSEE data and authors' computation.

Application to France dataset

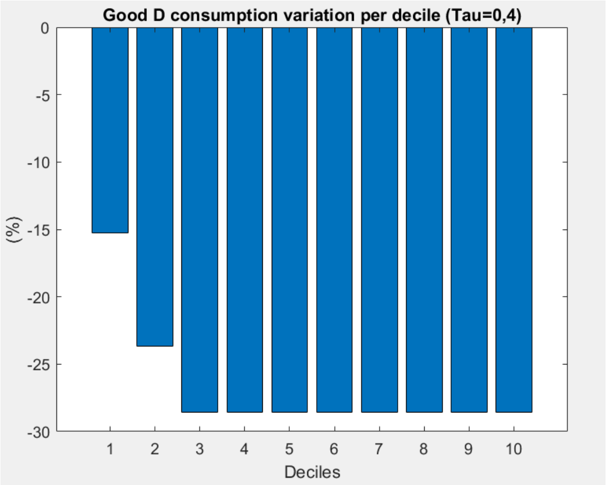

Figure 4: Good D's consumption variation with and without carbon dividend per decile.
Source: INSEE data and authors' computation.

Application to France dataset

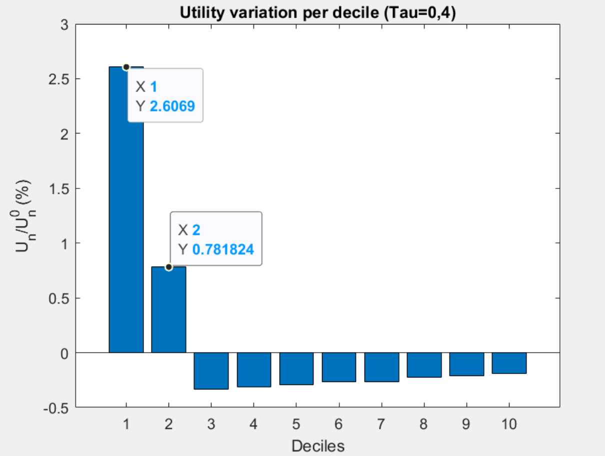

Figure 5: Utility variation with and without carbon dividend per decile, $\tau = 4$, $p^C = 3$, $p^D = 4$. Source: INSEE data and authors' computation.

Application to France dataset

	Demand for good D	Demand for good C	Social welfare
No carbon price	100	100	100
Carbon price with optimal redistribution	72,68	101,40	100,10
Carbon price ***without*** redistribution	71,43	100	99,76
Carbon price with identical lump-sum transfers	72,50	101,41	99,98

Table 2: Total consumption and social welfare. The results in value are normalised to 100 for the *No carbon price* case. Each other case present the variation from the *No carbon price* case. The normalised results are presented for the prices $p^C = 4$ and $p^D = 3$. Source: INSEE data and authors' computation. (See appendix **??** for identical lump-sum transfers computations)

Application to France dataset

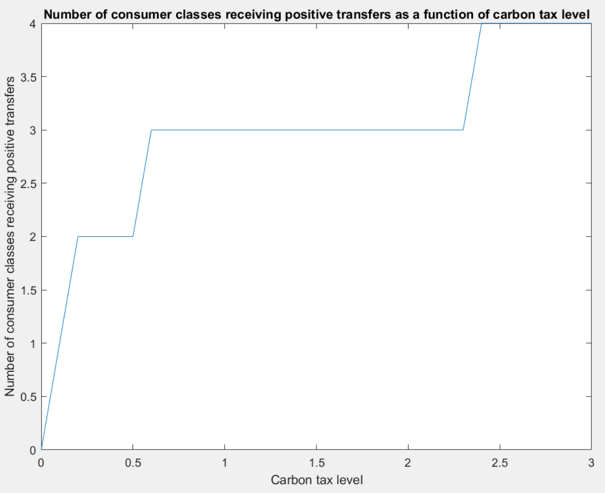

Figure 6: Number of consumer classes receiving positive transfer as a function of the carbon tax level. Source: INSEE data and authors' computation.

Application to France dataset

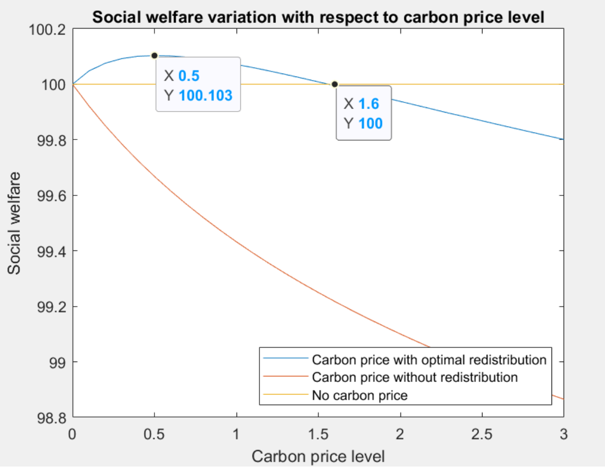

Figure 7: Social welfare variation with respect to carbon price level for three possible model assumptions: carbon price with optimal redistribution, carbon price without redistribution, and no carbon price. Source: INSEE data and authors' computation.

Conclusion

- For the Cobb-Douglas utility function, **optimal carbon dividend distribution is driven by income not by need**.
- **If residual incomes among different consumer classes are close enough, optimal carbon dividend distribution equalises their marginal utility**. Otherwise, carbon dividends are primarily distributed to consumers with lowest adjusted income.
- **At least for low values of the carbon tax, if a mild condition on income is met, carbon pricing and optimal dividend distribution increases welfare**: the positive income effect received by the few more than compensates for the negative price effect imposed on all.