

Preference Shifts and the Green Transition in General Equilibrium

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The context: Sufficiency

Four ways to reduce CO₂ emissions (Kaya identity):

- Reducing population size
- Slowing GDP per capita growth
- Lowering the energy intensity of GDP

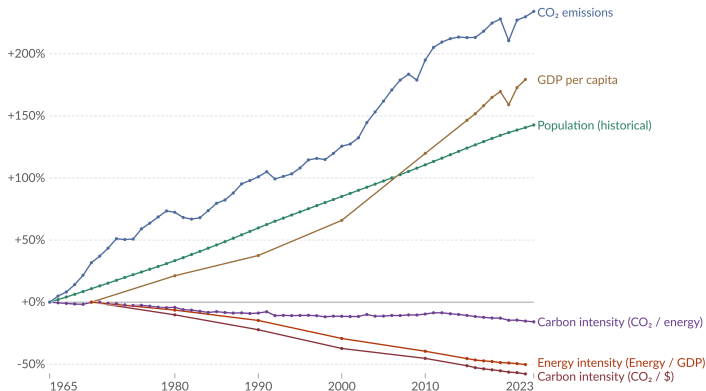
→ {
supply side: transitioning to a circular economy, improving recycling,
adopting energy-efficient technologies, innovating to produce
more energy-efficient goods, etc.
demand side: changing behaviors

- Decreasing the carbon intensity of energy

→ {
supply side: energy transition
demand side: changing behaviors

Kaya identity: drivers of CO₂ emissions, World

Percentage change in the four parameters of the Kaya Identity, which determine total CO₂ emissions. Emissions from fossil fuels and industry¹ are included. Land-use change emissions are not included.



Data source: Global Carbon Budget (2024) and other sources

OurWorldinData.org/co2-and-greenhouse-gas-emissions | CC BY

Note: GDP per capita is measured in 2011 international-\$² (PPP). This adjusts for inflation and cross-country price differences.

1. Fossil emissions: Fossil emissions measure the quantity of carbon dioxide (CO₂) emitted from the burning of fossil fuels, and directly from industrial processes such as cement and steel production. Fossil CO₂ includes emissions from coal, oil, gas, flaring, cement, steel, and other industrial processes. Fossil emissions do not include land use change, deforestation, soils, or vegetation.

2. International dollars: International dollars are a hypothetical currency that is used to make meaningful comparisons of monetary indicators of living standards. Figures expressed in international dollars are adjusted for inflation within countries over time, and for differences in the cost of living between countries. The goal of such adjustments is to provide a unit whose purchasing power is held fixed over time and across countries, such that one international dollar can buy the same quantity and quality of goods and services no matter where or when it is spent. Read more in our article: What are Purchasing Power Parity adjustments and why do we need them?

- So far, progress primarily driven by energy-saving technical progress and, for a lesser extend, the decarbonization of electricity generation
- However, progress insufficient and too slow

→ Growing emphasis on **reducing demand**

- Global demand? → **degrowth**
- Demand for GHG-intensive goods? → change in the **composition of demand**
- Even the 2nd option is challenging:
strong **path dependency**, **fossil fuel addiction**
- Moreover it may not be enough:
 - Debate about the sustainable level of consumption:
What is sustainable? What is “too much”? (Arrow et al., 2004)
 - Climate change is not our only problem – **planetary boundaries** (Röckstrom et al., 2009)

- Shifting demand can be achieved through price policies or it can be voluntary
- Price policies favored by economists, but by economists only
Acceptability issue
- We define “sufficiency” as the voluntary reduction of demand for carbon-intensive goods and technologies
- We attribute this voluntary reduction of demand to preference shifts
- We focus on modelling the consequences of voluntary behavioral changes at the micro level, and examining their macro consequences

Sufficiency according to IEA and IPCC

- IEA (2021): Defines sufficiency as behavioral changes that reduce energy demand or the energy intensity of activities

→ Focuses on shifting the composition of demand

- 3 main types of behavioral changes:

- ① Reducing excessive or wasteful energy use
- ② Shifting transport modes (e.g., cycling, walking, ridesharing, replacing regional air travel by high-speed rail where feasible)
- ③ Improving materials efficiency, (e.g., higher recycling rates, better buildings and vehicles design and construction)

→ Frontier between behavioral change, technological innovation, infrastructure development and social organization often blurred

- IPCC, 2022, AR6, WG III, Chapter 5: Defines sufficiency as measures and practices that avoid demand for energy, materials, land and water while delivering human well-being for all within planetary boundaries
- Evaluates the potential of reduction in demand for reducing global GHG emissions in the end-use sectors at 40–70% by 2050 compared to reference scenario (Creutzig et al., 2022)
- The reduction in demand considered is wider than behavioral changes:

Avoid – Shift – Improve

- Avoid = giving up some very carbon-emitting consumptions (e.g. abandoning long-haul flights and living car-free)
- Shift = adopting less carbon-intensive modes of consumption (e.g. cycling and plant-based diet)
- Improve = changing households equipments (adopting green innovations like heat pump or electric vehicle)

What we do

- Model voluntary behavioral changes as **taste shocks** experienced by a fraction of the population, and explore different types of taste shocks
- Separate direct substitution effects and general equilibrium effects; Identify the conditions under which a **rebound effect** occurs
- Attribute the results to specific parameters (elasticities) and characteristics of the economy
- Identify the conditions under which activity increases
- Compare the consequences of taste shocks with those of a carbon tax and of an improvement in the productivity of green activities

Research question

What are the environmental, macroeconomic and distributional effects of voluntary green preference shifts?

Literature

Taste shocks

- Redding & Weinstein, QJE 2020, Baqaee & Burstein, QJE 2023

How to account for taste shocks in welfare measures

- Besley & Persson, QJE 2023

Political economy model of green transition with changing preferences

- Oliu-Barton et al., 2024

Study sufficiency as taste shocks in a dynamic macro model.
Simulations.

- Escribe & Quirion, 2024

Study sufficiency as an increase for the preference for green goods in a static macro model with a detailed micro production network.
Analytical, but mostly simulations

Literature

Triggering behavioral change

- Raising consumer awareness through education, information campaigns, labels
- Nudges (List et al., 2022, Banerjee & Picard, 2023, etc.)
- Media, advertising, imitation of (online) influencers (Camilleri et al., 2019, Taufique et al., 2022)
- Peer effects: Van der Ploeg & Venables, 2025, 2026
- Renewal of generations
- Price policy itself: Goeschl & Perino, 2012, Mattauch et al., 2022
Intrinsic vs. extrinsic motivation

What we do

- We build a tractable static general equilibrium model of a brown–green economy with heterogeneous households
- Households differ in two exposure measures:
 - exposure to brown consumption
 - exposure to brown labor income
- We compare two shocks:
 - a green preference shock, interpreted as sufficiency
 - a carbon tax
- We disentangle direct partial equilibrium effects and general equilibrium effects on brown consumption
- We characterize the effects of the shocks on real income and welfare, and their distributional incidence

Model ingredients

- Two goods: brown b and green g (green good is the numéraire.). Two types of agents.
- CES consumption index:

$$C_i = \left[(1 - \alpha_i) C_{b,i}^{1 - \frac{1}{\sigma}} + \alpha_i C_{g,i}^{1 - \frac{1}{\sigma}} \right]^{\frac{1}{1 - \frac{1}{\sigma}}}$$

- CET labor supply index across brown and green firms:

$$L_i = \left[s_i L_{b,i}^{\frac{1+\nu}{\nu}} + L_{g,i}^{\frac{1+\nu}{\nu}} \right]^{\frac{\nu}{1+\nu}}$$

- Utility function:

$$U_i = \ln C_i - b L_i$$

- Linear production and perfect competition:

$$Q_k = A_k L_k \quad W_k = p_k A_k$$

- Carbon tax:

$$P_b = p_b + \tau$$

- Revenues redistributed lump-sum.

Model: two exposure measures

Consumption side

$$\omega_i = \frac{P_b C_{b,i}}{P_i C_i}$$

ω_i : exposure to brown goods as a consumer

High ω_i : vulnerable to brown consumer prices

Labor income side

$$\omega_{L,i} = \frac{W_b L_{b,i}}{W_i L_i}$$

$\omega_{L,i}$: exposure to brown production as a worker

High $\omega_{L,i}$: vulnerable to brown producer wages

Key object

$$\omega_i - \omega_{L,i}$$

The mismatch between brown consumption exposure and brown labor income exposure

Brown consumption: direct partial equilibrium effects

- Shocks:
 - Carbon tax shock: $d\tau > 0$ – No carbon tax at initial equilibrium
 - Green preference shock for agents of type 2: $\hat{\alpha}_2 > 0$
- A carbon tax reduces brown demand through the increase of the brown consumer price:

$$\hat{C}_b^{PE, tax} = -[\bar{\omega} + \sigma(1 - \bar{\omega})] t \quad \text{with } t = \frac{d\tau}{p_b} \quad \text{and } \bar{\omega} = \sum_i \gamma_i \omega_i$$

with γ_i the contribution of type i to aggregate brown demand

- A green preference shock reduces brown demand directly:

$$\hat{C}_b^{PE, pref} = -\gamma_2 \frac{\sigma(1 - \omega_2)}{1 - \alpha_2} \hat{\alpha}_2$$

Brown consumption: partial vs. general equilibrium

Partial equilibrium

$\hat{C}_{b,i}^{PE}$ = direct effect of the shocks at fixed producer price and income

$$= -[\omega_i + \sigma(1 - \omega_i)]t - \frac{\sigma(1 - \omega_i)}{1 - \alpha_i}\hat{\alpha}_i \quad \text{with } t = \frac{d\tau}{p_b}$$

$$\hat{C}_b^{PE} = -[\bar{\omega} + \sigma(1 - \bar{\omega})]t - \gamma_2 \frac{\sigma(1 - \omega_2)}{1 - \alpha_2}\hat{\alpha}_2 \quad \text{with } \bar{\omega} \equiv \sum_i \gamma_i \omega_i$$

and γ_i the contribution of type i to aggregate brown demand

General equilibrium

$$\begin{aligned}\hat{C}_{b,i}^{GE} &= \hat{C}_{b,i}^{PE} + \text{incidence of the adjustment of the brown producer price and of the lump-sum transfers} \\ &= \hat{C}_{b,i}^{PE} - [(\omega_i - \omega_{L,i}) + \sigma(1 - \omega_i)]\hat{p}_b\end{aligned}$$

Relative brown producer price

$$\hat{p}_b = -\frac{1}{r} [\bar{\omega} + \sigma(1 - \bar{\omega}) - \mu] t - \frac{1}{r} \gamma_2 \frac{\sigma(1 - \omega_2)}{1 - \alpha_2} \hat{\alpha}_2$$

$$r = \underbrace{\nu(1 - \bar{\omega}_L)}_{\text{labor reallocation}} + \underbrace{\sigma(1 - \bar{\omega})}_{\text{demand substitution}} + \underbrace{(\bar{\omega} - \eta)}_{\text{exposure covariance}}.$$

with $\bar{\omega}_L \equiv \sum_i \gamma_{L,i} \omega_{L,i}$ and $\eta \equiv \sum_i \gamma_{L,i} \omega_i$

- In the stable case $r > 0$
- $\bar{\omega} + \sigma(1 - \bar{\omega}) - \mu > 0$

Brown producer price

Demand-side green transitions lower the brown producer price:

$$\hat{p}_b < 0$$

Rebound

Definition

$$\mathcal{R} = 1 - \frac{\widehat{C}_b^{GE}}{\widehat{C}_b^{PE}}$$

- Rebound comes from the endogenous fall in the brown producer price: a lower brown producer price makes brown goods cheaper and partially offsets the direct demand reduction
- The carbon tax rebound is smaller than the preference shock rebound because the tax wedge remains
- Rebound may be negative (amplification)

Role of elasticities

- Higher σ : stronger substitution in consumption, stronger rebound
- Higher ν : easier labor reallocation away from brown production, weaker rebound

Distributional effects

$$\widehat{\left(\frac{I_i}{P_i}\right)} = \underbrace{-\omega_i t}_{\text{direct tax effect}} - \underbrace{\frac{\sigma}{1-\alpha_i} \frac{1-\alpha_i-\omega_i}{1-\sigma} \hat{\alpha}_i}_{\text{direct preference effect}} - \underbrace{(\omega_i - \omega_{L,i}) \hat{p}_b}_{\text{GE producer price incidence}}.$$

- Direct tax effect is negative and proportional to exposure to brown consumption.
- Direct preference effect only affects type 2 households. Sign is ambiguous.

$$\frac{1-\alpha_2-\omega_2}{1-\sigma} < 0 \iff \alpha_2 > \frac{1}{1+p_b} \iff C_{g,2} > C_{b,2}$$

If type 2 is already very green, becoming greener makes P_2 decrease

- General equilibrium redistributive channel:

Key sufficient statistic

$$\omega_i - \omega_{L,i}$$

- Net brown consumers gain from a fall in the brown producer price, net brown workers lose
- Sufficiency is voluntary for the agents who change preferences, but it changes prices faced by everyone

Welfare effects of the carbon tax shock

$$dU_i^{tax} = -(\omega_i - \omega_{L,i})\widehat{p}_b^{tax} + (w_i - \gamma_i)\frac{\omega_i}{\gamma_i}t$$

- Two redistributive channels:
 - ① producer price incidence channel, governed by $\omega_i - \omega_{L,i}$
 - ② tax-and-transfer channel, governed by $w_i - \gamma_i$, which measures the difference between type i 's population share and contribution to brown consumption
- A household gains if the sum of the two channels is positive

Welfare effects of the preference shock

- When preferences change, welfare comparisons require a reference preference ordering
- Welfare change can be evaluated with initial or final preferences
- With smooth preferences and marginal shocks, the two measures coincide at first order
- For both types:

$$dU_i^{pref} \simeq -(\omega_i - \omega_{L,i})\hat{p}_b^{pref}$$

- The direct preference-revaluation term does not enter fixed-preference welfare of the type whose preferences change

Real income is not welfare

Real income

$$\widehat{\left(\frac{l_i}{P_i}\right)} = -(\omega_i - \omega_{L,i})\hat{p}_b - \omega_i t - \frac{\sigma}{1 - \alpha_i} \frac{1 - \alpha_i - \omega_i}{1 - \sigma} \hat{\alpha}_i$$

Fixed-preference welfare

$$dU_i = -(\omega_i - \omega_{L,i})\hat{p}_b + (w_i - \gamma_i) \frac{\omega_i}{\gamma_i} t$$

- Preference revaluation affects measured real income
- Labor disutility effects matter for welfare under taxation
- Real income may increase even when fixed-preference welfare falls, and vice versa

Homogeneous population

If the population is homogeneous and of type 2, real income increases after a green preference shock iff

$$\underbrace{s_2 \frac{\alpha_2}{1 - \alpha_2}}_{\text{preferences}} > \underbrace{\left(\frac{A_b}{A_g} \right)^{\frac{1+\nu}{\nu}}}_{\text{technology}}$$

Interpretation

The greater the productivity gap between brown and green technologies, the more green preferences must be for real income to rise.

Extensions

Supply shocks

- Green productivity shock and preference for green labor
- Unlike demand shocks, supply-side greening raises the brown producer price
- Incidence is reversed: net brown workers benefit from higher brown producer prices

Positive carbon tax at the initial equilibrium

- Demand and supply respond to different prices
- The relevant sufficient statistics becomes $\omega_{L,i} - (1 - \omega_\tau)\omega_i$ with ω_τ the share of the tax in the consumer price
- New effect: a tax-base effect

Many-agent economy

- Theory extends naturally to n types
- Distribution of sectoral exposure becomes central

Quantitative illustration: France

Type i	1	2	3	4	5
Population weight w_i (%)	20	20	20	20	20
Income weight λ_i (%)	9.0	14.3	18.0	22.2	36.6
Brown consumption share ω_i (%)	20.0	18.0	16.0	14.0	12.0
Brown labor-income share $\omega_{L,i}$ (%)	10.0	20.0	22.5	18.0	8.1

Calibration

	Preference shock	Matched tax shock
Partial eq. aggregate brown consumption	-2.7	-2.7
General eq. aggregate brown consumption	-1.3	-1.6
Rebound	50.6	41.0
Brown producer price	-2.0	-1.6
Aggregate green consumption	0.2	-0.3
Aggregate real income	0.8	-0.5

Preference shock $\hat{\alpha}_5 = 0.01$ vs. tax shock $t = 0.0326$

Quintile	Real income		Welfare		Brown cons.		Green cons.	
	Pref.	Tax	Pref.	Tax	Pref.	Tax	Pref.	Tax
1	0.2	-0.5	0.2	0.6	1.5	-1.5	-0.1	-0.2
2	-0.0	-0.6	-0.0	0.1	1.3	-1.7	-0.3	-0.4
3	-0.1	-0.6	-0.1	-0.1	1.2	-1.7	-0.4	-0.4
4	-0.1	-0.5	-0.1	-0.1	1.3	-1.6	-0.3	-0.3
5	2.3	-0.3	0.1	-0.1	-7.6	-1.5	1.1	-0.2

Individual responses

Next steps

- The model is static and local $\Rightarrow$ a dynamic version would allow to study the green transition more fully
- In particular, the timing of the shocks is important
- Preferences are treated as exogenous shocks
 $\Rightarrow$ an extension with endogenous social norms or policy-induced preference formation would make it possible to study sufficiency policies more directly

Thank you for your attention

Model (1)

Type i households: consumption

$w_i \in (0, 1)$ households of type i , $i = 1, 2$

Utility function:

$$U_i = \ln C_i - bL_i$$

Budget constraint:

$$P_i C_i \leq I_i$$

with the nominal income

$$I_i = W_i L_i + T_i$$

FOC:

$$bC_i = \frac{W_i}{P_i}$$

CES consumption basket:

$$C_i = \left((1 - \alpha_i) C_{b,i}^{1-\frac{1}{\sigma}} + \alpha_i C_{g,i}^{1-\frac{1}{\sigma}} \right)^{\frac{1}{1-\frac{1}{\sigma}}}$$

Demand for brown and green goods:

$$C_{b,i} = \left((1 - \alpha_i) \frac{P_i}{P_b} \right)^{\sigma} C_i, \quad C_{g,i} = \left(\alpha_i \frac{P_i}{P_g} \right)^{\sigma} C_i$$

with the price index:

$$P_i = \left((1 - \alpha_i)^{\sigma} P_b^{1-\sigma} + \alpha_i^{\sigma} P_g^{1-\sigma} \right)^{\frac{1}{1-\sigma}}$$

α_i : preference for green goods

σ : elasticity of substitution

Model (2)

Type i households: labor supply

Labor supply index:

$$L_i = \left(s_i L_{b,i}^{\frac{1+\nu}{\nu}} + L_{g,i}^{\frac{1+\nu}{\nu}} \right)^{\frac{\nu}{1+\nu}}$$

with $L_{b,i}$ and $L_{g,i}$ the hours worked in brown and green firms

FOCs:

$$L_{b,i} = s_i^{-\nu} \left(\frac{W_b}{W_i} \right)^{\nu} L_i, \quad L_{g,i} = \left(\frac{W_g}{W_i} \right)^{\nu} L_i$$

with the nominal wage index:

$$W_i = \left(s_i^{-\nu} W_b^{1+\nu} + W_g^{1+\nu} \right)^{\frac{1}{1+\nu}}$$

s_i : disutility from working in a brown firm

ν : elasticity of transformation

Model (3)

Firms, government and equilibria

Perfect competition

Representative firm in sector k with linear production function:

$$Q_k = A_k L_k, \quad k = \{b, g\}$$

FOC of profit maximization:

$$\frac{Q_k}{L_k} = \frac{W_k}{p_k}$$

Labor demand:

$$L_k^d = \frac{Q_k}{A_k}$$

No profits

► Back

Consumer prices:

$$P_b = p_b + \tau, \quad P_g = p_g \text{ taken as numéraire}$$

Government collects the carbon tax and redistributes the revenues to households: $\tau C_b = \sum_i T_i$

Equilibrium of the labor markets:

$$\sum_i w_i L_{k,i} = L_k^d$$

Equilibrium of the good markets:

$$C_k = \sum_i w_i C_{k,i} = Q_k$$