A transition to global carbon pricing:

Dual-track & multi-level

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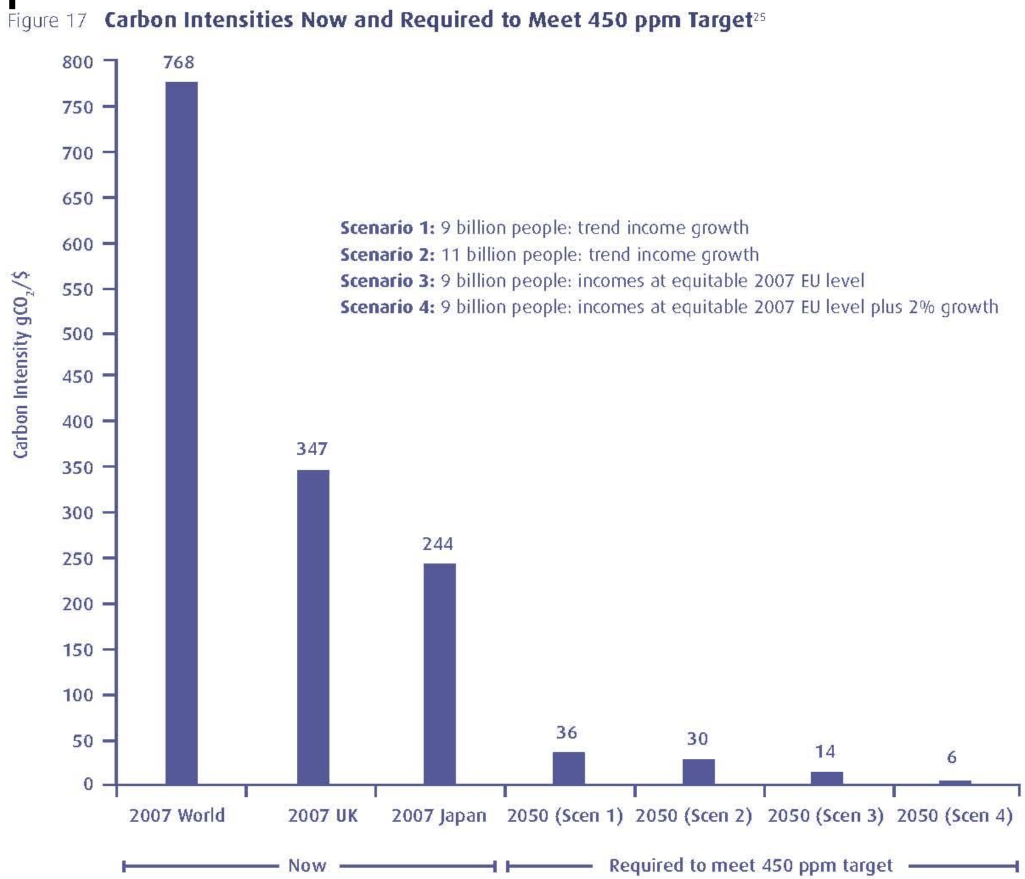
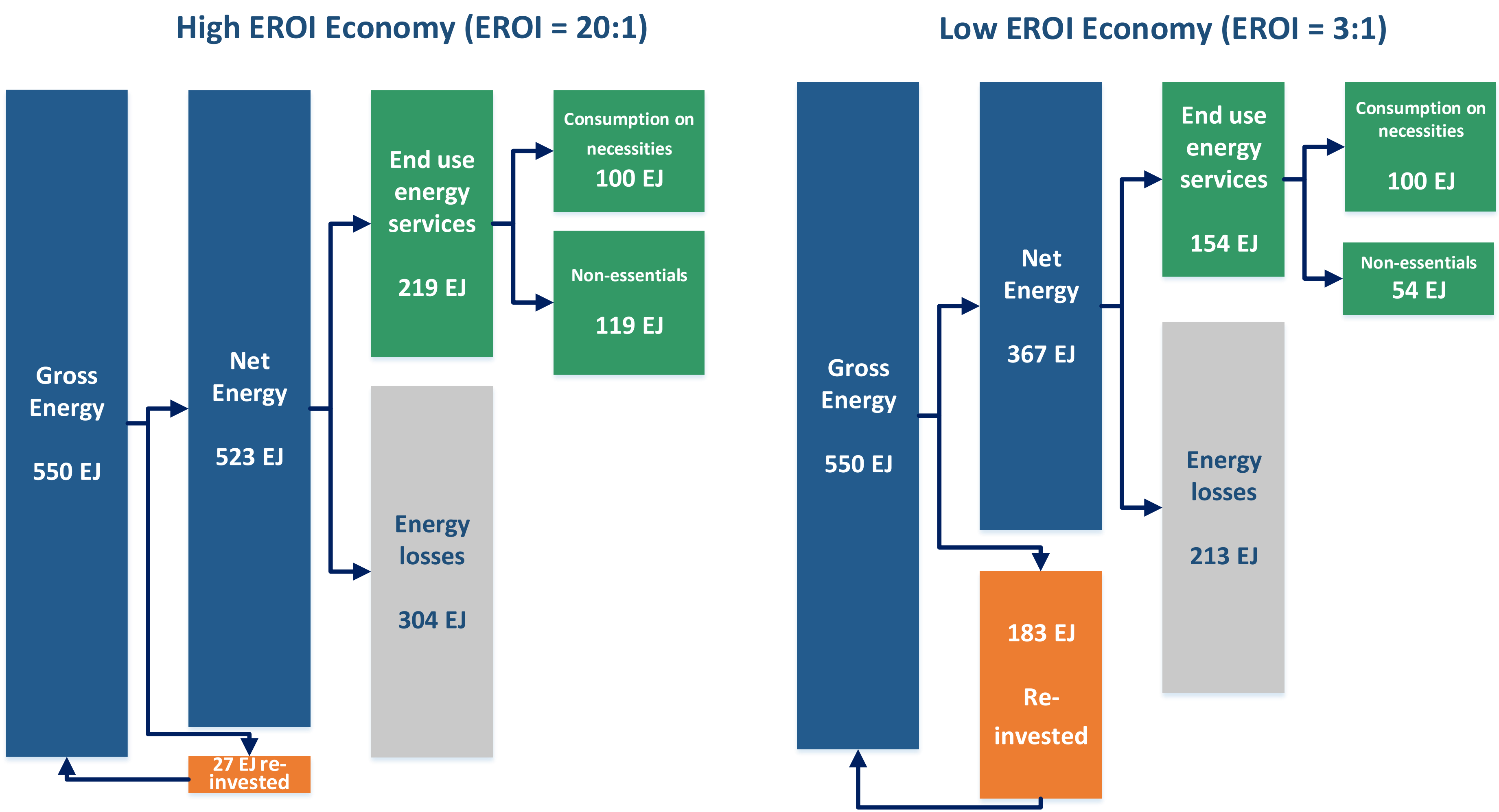
Decarbonisation challenge

Factor 20-100 reduction in carbon intensity of output needed.



Source: Jackson (2009).

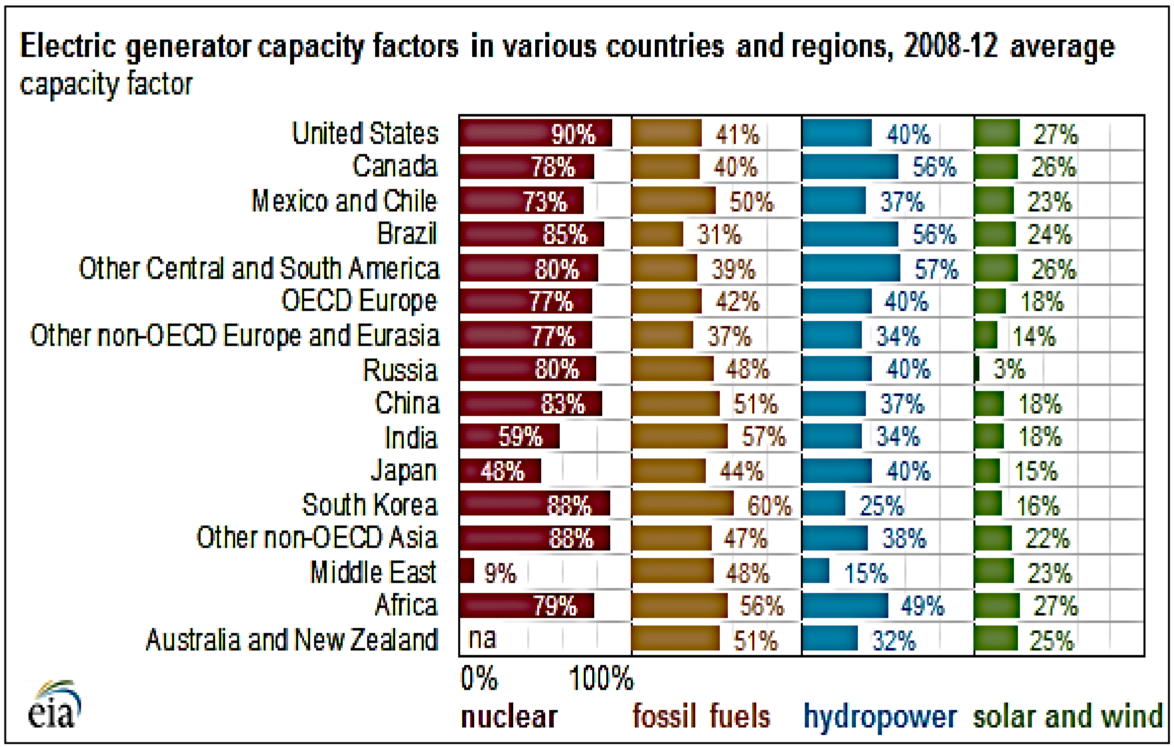
Low-carbon economy will run on low-EROI energy sources

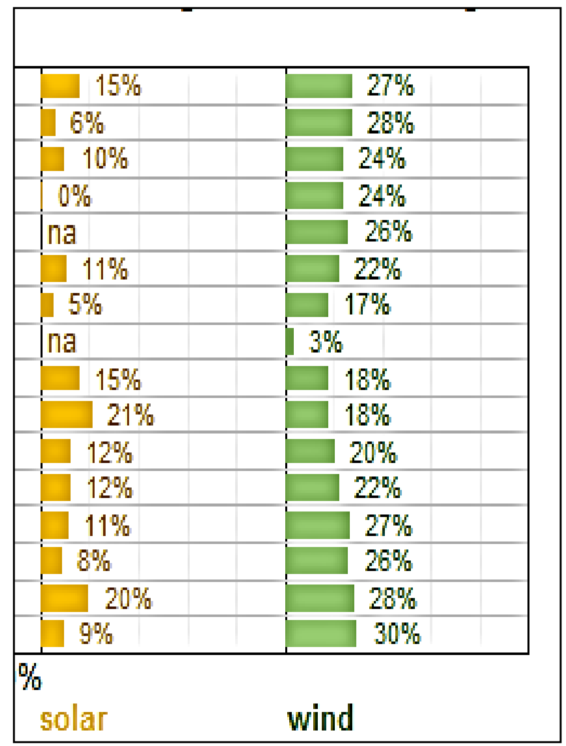


Source: King and van den Bergh (2018)

A renewable future involves many challenges

- Many (fossil fuel) energy and labor inputs needed indirectly
- Considerable energy storage if >1/3 of total electricity is renewable
- Night/day and seasonal cycles
- Recycling of equipment (if large-scale diffusion)
- Capacity unused => reduces EROI.





Source: U.S. Energy Information Administration, International Energy Statistics.

Pessimistic?

Economy has tremendous *flexibility to change*

- **We just have to activate the many possible changes**
  - Different input mix of production (KLEM)
  - Change sector structure/composition
  - Change demand composition and level
  - Alter technologies of energy generation and use/transformation (invention, innovation and diffusion)
  - Important changes in electricity production and transport

- **But**
  - Don't think it is only or mainly gonna be *technological innovation or energy supply*
  - Economic studies show that major part of GHG emissions reduction until 2050 has to occur through structural and behavioural change in demand/supply
  - *Voluntary individual action* and *unilateral national action* will not drive the changes required.

Policy design for transition: account for escape routes

- **System perspective on policies:** Control indirect and avoidable effects of well-intended strategies and policies, as these *undercut their effectiveness*

Four escape routes:

- **Carbon leakage** from countries with strong to those with weak policies
- **Green paradox** due to oil market prices compensating for adoption subsidies (for renewables) and carbon pricing
- **Energy/carbon rebound** of (voluntary) energy conservation & efficiency improvements under weak climate policies – economic mechanisms and psychological spillovers
- **Environmental problem shifting** of climate policies (biofuels to reduce CO_2 emissions => fertilizer/pesticide use↑, biodiversity↓)

Paris agreement and escape routes

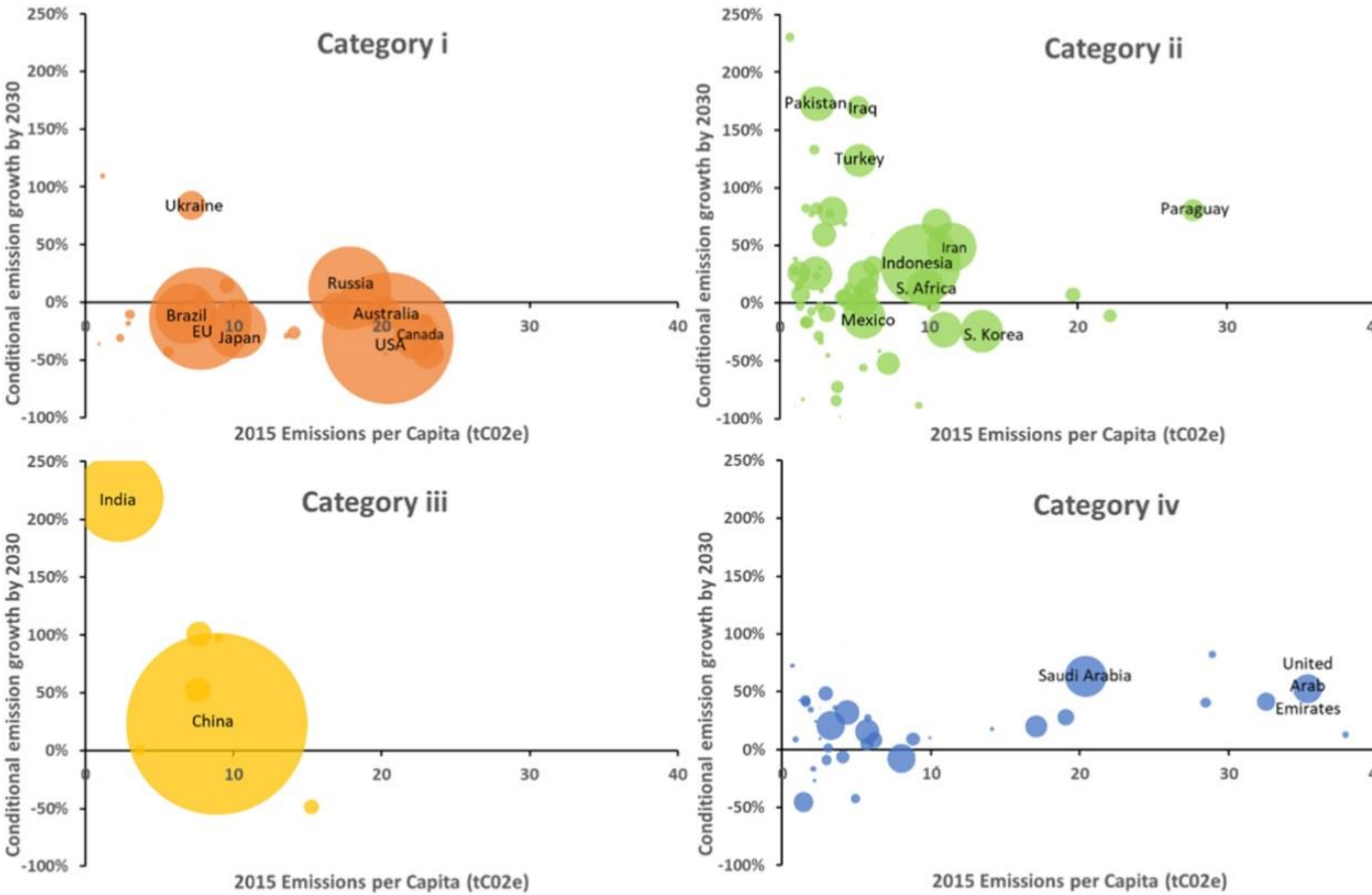
- Agreement provides no insurance against mentioned escape routes

- Not a real agreement: Voluntary country pledges or NDCs (Nationally Determined Contributions)

- Hoped to limit increase in global mean surface temperature to 2 or even 1.5°C but expected increase is 2.5-3°C (Rogelj et al., 2016 *Nature*; Schleussner et al., 2016 *Nature CC*).

- Four categories of NDCs:
  1. Absolute emission reduction targets relative to (distinct) base year in the past
  2. Reduction relative to future emissions growth in BAU scenario
  3. Reduction of emission intensity of national income (carbon/GDP)
  4. Mere 'projects' without identifying implications for emissions

Four categories of Paris agreement pledges/NDCs



Source: King & van den Bergh (2019)

Paris' pledges imply two systemic effects

1. Generally weak policies (subsidies, encouraging voluntary action) out of fear to harm *international competitive position (exports)* => **rebound, with intensity increasing from categories 1 to 4**
2. Very distinct policies => *trade effects and industry relocation* => **carbon leakage from categories 1 to 2, 3 and 4**

Global mean surface temperature may then go well beyond 3.5°C

Fundamental problem: Paris Agreement does *not harmonize policy* and therefore national policies are in effect *unilateral.* This stimulates *free-riding* sentiments and fears of *competitiveness losses*. The result is overall ***weak national policies with exemptions for exports.***

Transition to global effective climate policy?

- → Harmonized or uniform approach among countries to avoid carbon leakage & (fear of) competitiveness (exports) losses

- → Specific approach to limit free-riding of countries in negotiations
  - – Country quota (NDCs) as in Paris Agreement do the opposite: they stimulate free riding.

- → Transition process from feasible start to ambitious end
  - – Considering multiple levels: UNFCCC negotiations, coalitions of countries, and sub-country regions/states (notably in USA).

Which policy instrument: Four main approaches

Instrument	*Performance criteria*			
	Effectiveness emissions reduction	*Distributional equity*	*Economic cost per unit of emission avoided*	*Global upscaling*
Carbon pricing	High *- full control, purchase + use, incentive for adoption + innovation*	High *- if revenues partly recycled to poor households*	Low / minimal	Feasible
Technical standards	Medium *- incompliance, rebound (intenser use), very many technologies, lobby by countries/sectors*	Medium *- no revenues raised to compensate poor households*	Medium to high *- does not select cheap options*	Difficult as there are many standards and distinct national interests
Adoption subsidy	Medium *Rebound*	Low *- poor housholds do not buy solar PV or electric cars*	High *- not select cheap options, people don't resist subsidies*	Difficult as it weighs heavily on national budgets
Information provision & natges	Low *voluntary action, re-spending rebound*	High	Low	Limited by cultural habits and norms

Essential part of solution: *carbon pricing*

Classical arguments economists:

1. Change relative prices of high/low carbon goods & services
2. Can deal with *heterogeneous polluters:* equalizes marginal abatement costs among polluters => *cost-effective (=cheapest)*

   - contributes to *political acceptability*

3. Pricing means "decentralisation" of regulation

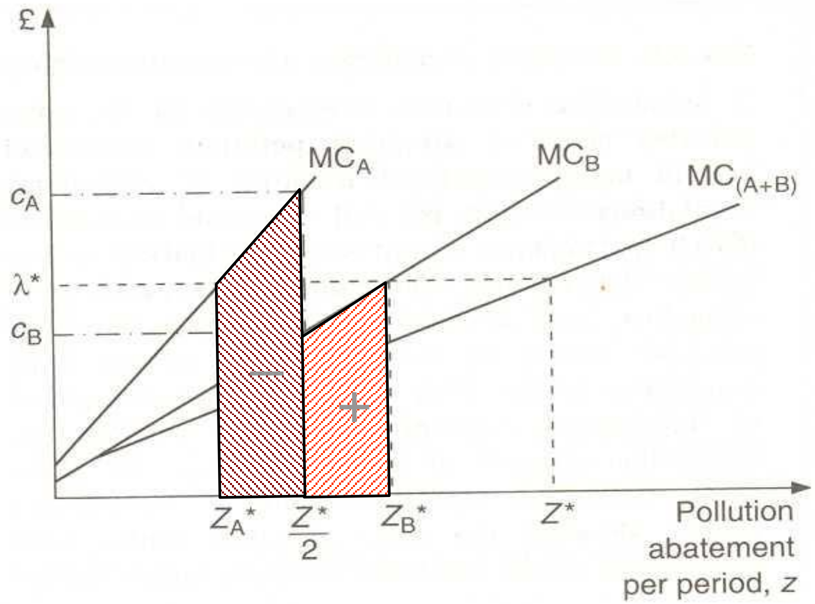
   => *low information needs.*

4. Permanent incentive for both *technology adoption & innovation*

   - In fact, environmental innovation trajectories misguided if prices wrong.

Carbon pricing cost-effective and decentralizing

Emissions reduction achieved against minimum cost,
or maximum emissions reduction for a given cost.



MC_A = Marginal cost of abatement of firm A
MC_B = Marginal cost of abatement of firm B
MC_{A+B} = Combined marginal cost of abatement for industry, A + B

$$Z_A^* + Z_B^* = Z^*$$

$$2\left(\frac{Z^*}{2}\right) = Z^*$$

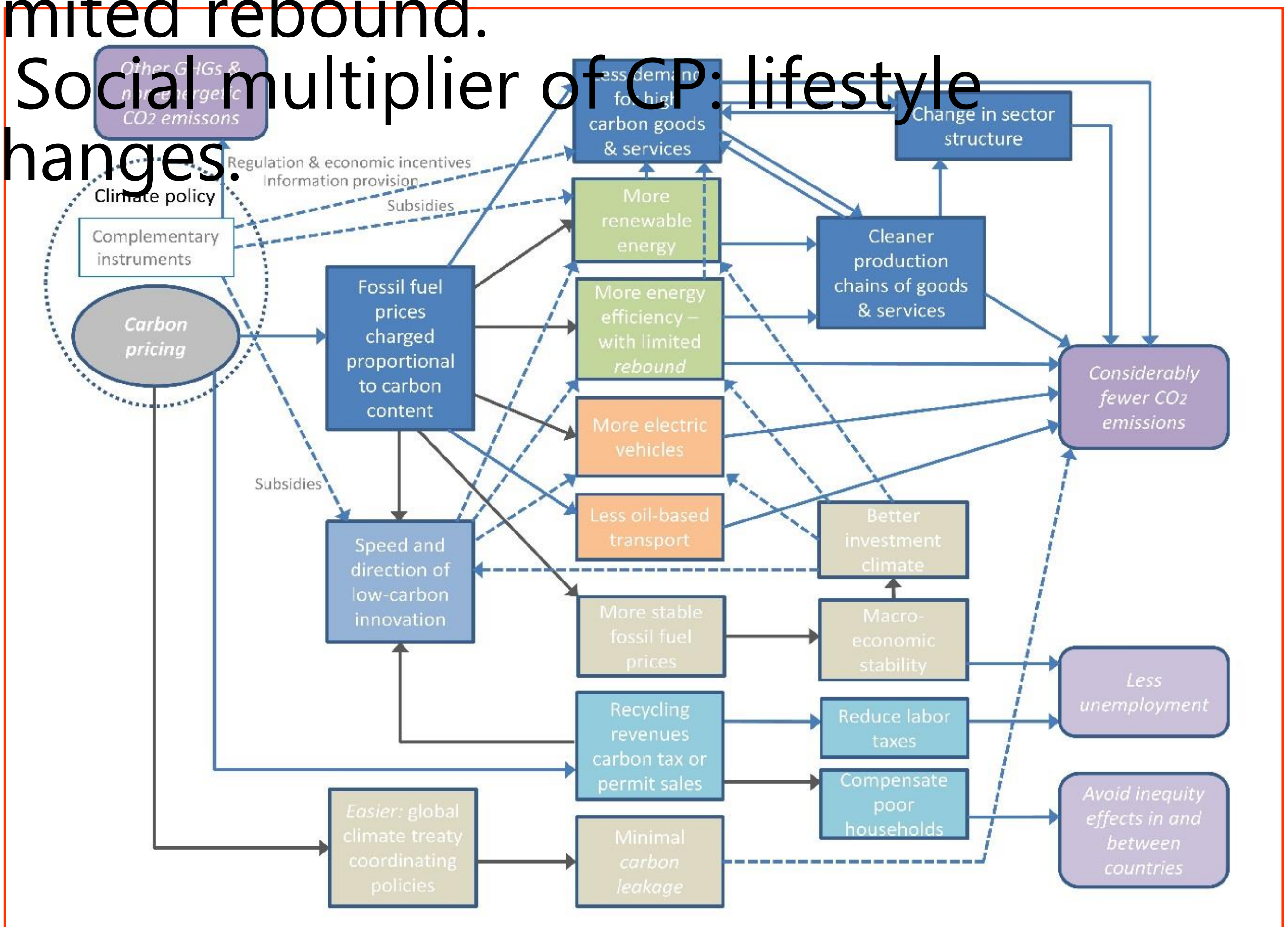
Source: Perman et al. (2003)

Additional arguments for carbon pricing

1. **Complete control**: all goods/services have price correction *proportional to emissions over life-cycle*, and affects *purchase + use* decisions => ***maximum control of rebound***
2. Most emissions by **market decisions**. Price correction logical
3. No **separate LCA**, integrate in **financial accounting firms**
4. Pricing generates **revenues** for correcting undesirable distribution effects – *helps garner public/political support*
5. Pricing seen as politically difficult, but **international policy coordination** easiest with pricing – ***limits carbon leakage***
6. Guarantees **minimal oil price –** ***limits green paradox***
7. Shifts revenues from **OPEC** to **oil importing countries**
8. Pricing optimizes + spreads efforts => smooth & least painful transition

CP means complete and consistent control

- Of all emitters: big and (many) small; firms and households.
- Effective emissions reduction and limited rebound.
- Social multiplier of CP: lifestyle changes.



Note: Carbon tax ≠ energy or fuel tax

Charge of price per unit of carbon: tax will then be proportional to carbon emissions factor.

Energy source	*EROI*	*Carbon emission factor*[37] *($kgCO_2/TJ$)*	*EROC ($EJ/GtCO_2$)*
Coal	46:1	94.6	10.3
Oil	19:1	73.3	12.9
Oil shale	7:1	107.0	8.0
Tar sands	4:1	107.0	7.0
Natural gas	19:1	56.1	16.9

EROI = ‘Energy return on energy investment’
EROC= ‘Energy return on carbon’ of combusting fossil fuels

Source: King & van den Bergh (2015)

Resistance to carbon pricing in social sciences

- ➔ Many sociologists, political scientists and geographers do not show enthusiasm for, or even resist, carbon pricing – focus on *equity* & *spontaneous* bottom-up solutions; they do not always show much concern for *effectiveness of emissions reduction.*

- ➔ Hopeful alternative offered by such social scientists is voluntarism (bottom-up) but *without "sufficiency proof"*
  - Reviews of information provision: achieves less than < 10% emissions reduction
  - Also overlooks rebound and negative psychological spillovers (Sorrell, 2018)

- ➔ If social scientists speak with many voices, politicians and voters will be confused.

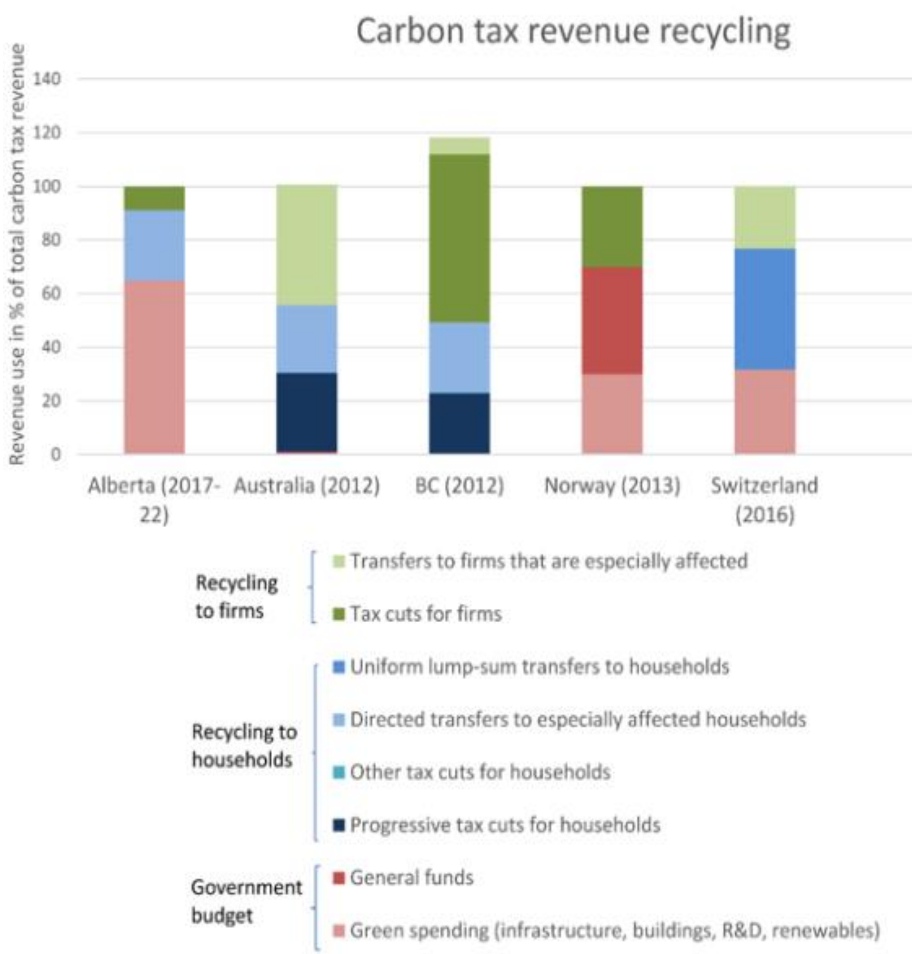
Carbon pricing and inequity: *misunderstood*

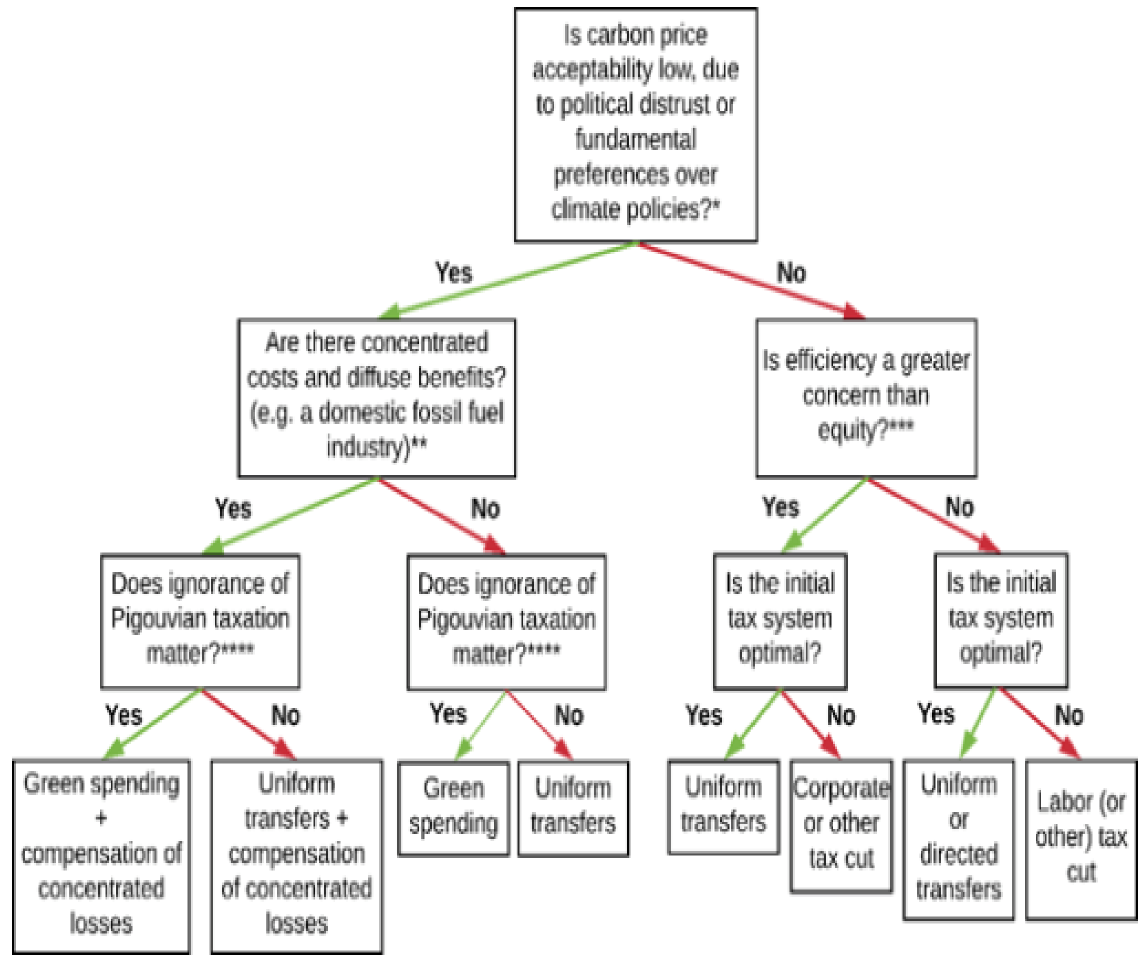
- CP only instrument that generates revenues for **redistribution**, compensating poor households for more expensive basic goods

- Other policy instruments also cause inequitable effects (e.g., adoption subsidies for electric vehicles or rooftop PV) but **do not generate compensating revenues** (e.g, standards) or even **consume financial resources** (e.g., adoption subsidies)

- Revenue recycling for equity goals can be applied to both **national and international scales**

Use of carbon pricing revenues





Source: Klenert et al. (2018)

Public opinion on CP revenue use

- Although people express concern for uneven distribution of policy burden, they prefer earmarking revenues for environmental/climate projects (renewable energy)
  - Perhaps because most people don't distinct between regulation and financing (revenue raising) effects
  - "Climate projects" also confusing: government don't invest in renewable energy; more accurate to speak about "subsidies for innovation or adoption".
- Mixed use of revenues more complicated, less evidence
- Potential additonal uses: tax revision to reduce distortionary labour or capital taxes; compensating (temporarily) exports sectors (rather than exempting them from carbon pricing).
- Clever labelling important to create support ("read my lips: no new taxes"): *dividend, fee, carbon market, reducing labour taxes, tax revision*

Norm & lifestyle changes through social multiplier of CP

- T. Konc, I. Savin & J. van den Bergh

Consumption choice

- Agents maximize:

$$U_{i,t}(\alpha_{i,t}, H_{i,t}, L_{i,t}) = \left(\alpha_{i,t} H_{i,t}^{\frac{\sigma-1}{\sigma}} + (1-\alpha_{i,t}) L_{i,t}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$$

$$\text{s.t.} \quad L_{i,t} P_L + H_{i,t} P_H(\tau) \leq w_i$$

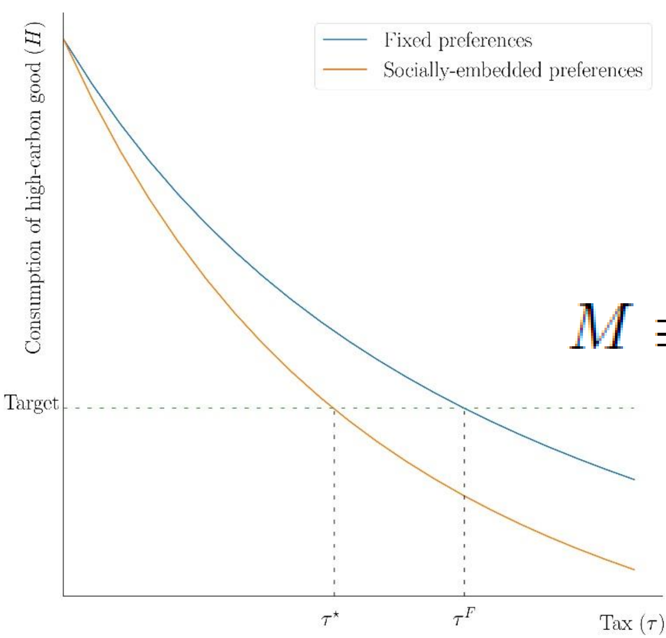
Elasticity of substitution

Preference for H

Income

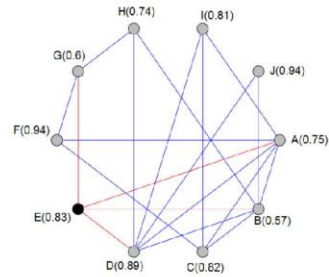
- We normalize $P_L = 1$ and assume that carbon tax τ only affects H:

$$P_H(\tau) = p_H(1+\tau)$$



$$M \equiv \frac{\tau^F}{\tau^\star} \geq 1.$$

Socially-embedded agents



$$\alpha_{i,t}(\pi_i, S_{i,t}) \equiv (1-\gamma) \times \pi_i + \gamma \times S_{i,t}$$

Strength of social influence $\in [0, 1]$

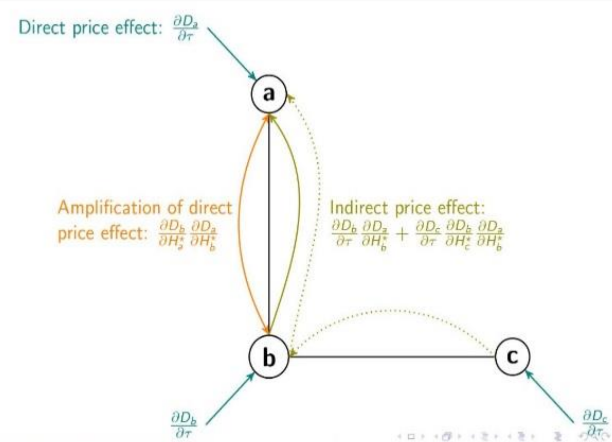
Intrinsic preference for H $\in [0, 1]$

Social influence:

$$S_{i,t} \equiv \frac{\sum_{j \in N_i} H_{j,t-1}}{\sum_{j \in N_i} H_{j,t-1} + L_{j,t-1}}$$

Set of peers

Two-step effect of carbon tax visualized



Simulation settings

- Distribution of intrinsic preferences, $\pi \sim B(1,1)$.
- Social network $\mathcal{N}$, $10,000$ agents, mean degree $= 4$, small-world topology.
- Strength of the social influence, $\gamma = 0.30$.
- Gini coefficient of income distribution: 0.4.

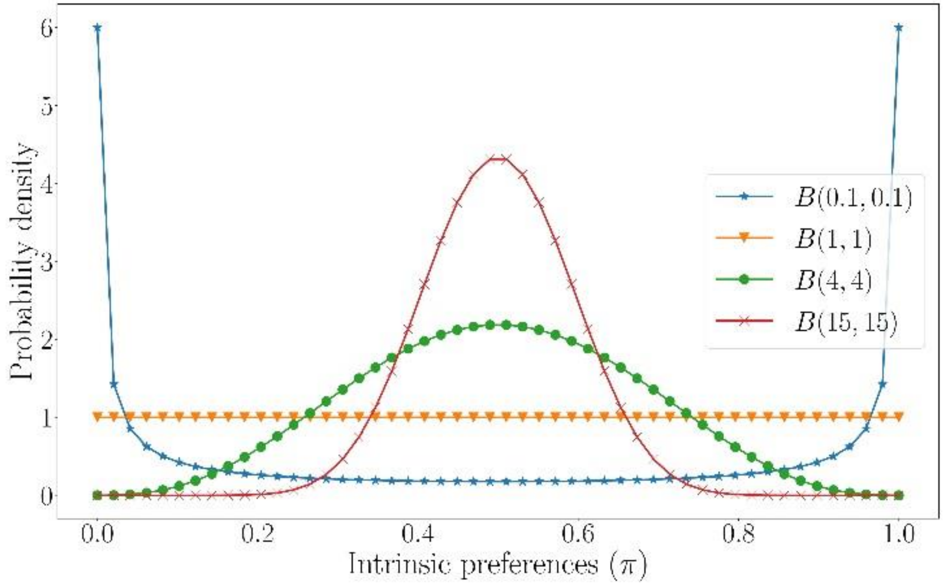
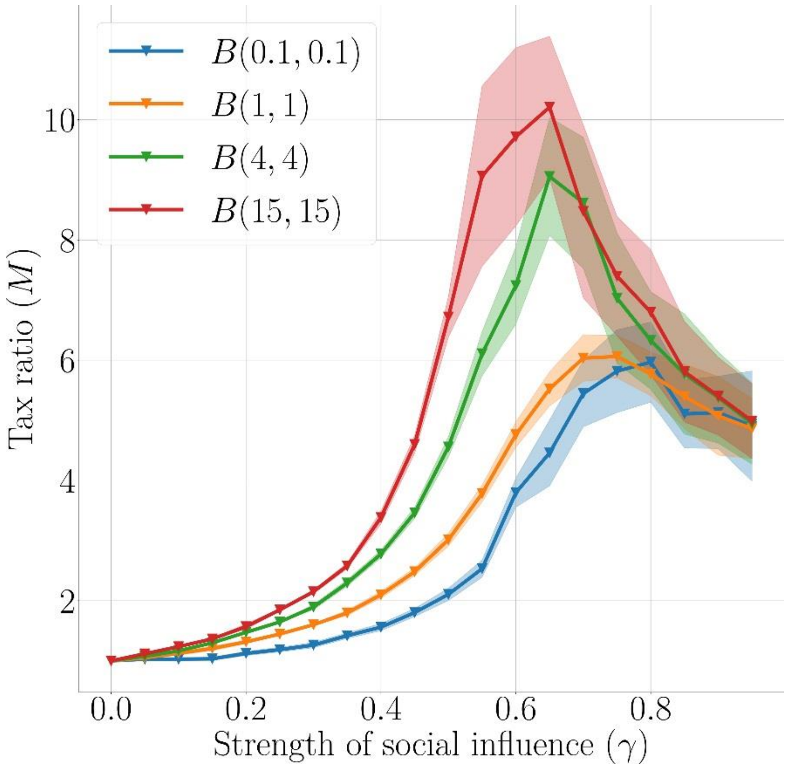


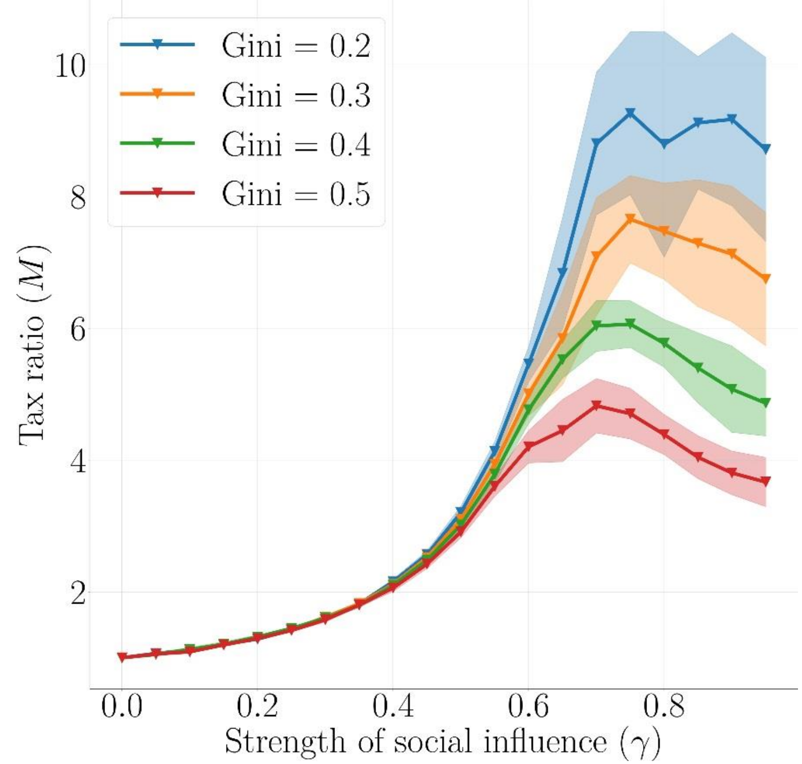
Table 2: Network characteristics for 10 000 nodes and 20 000 undirected links

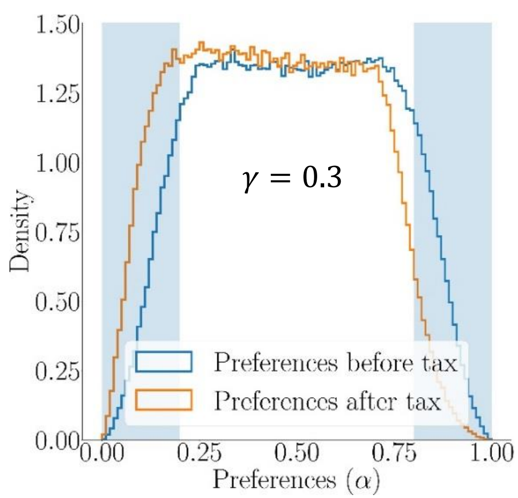
	Average clustering	Average path length	Degree asymmetry
Regular lattice	50.00 %	1250.00	0.00
Small world	35.62 %	12.50	0.12
Random	0.04 %	6.76	0.50
Scale free	0.15 %	4.27	36.30

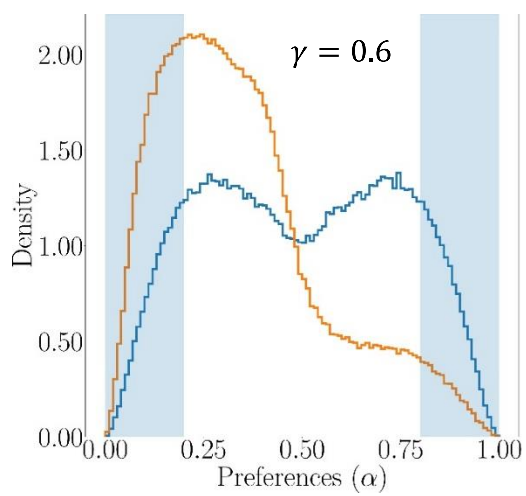
Note: Degree asymmetry of a network is measured by the skewness of its degree distribution.

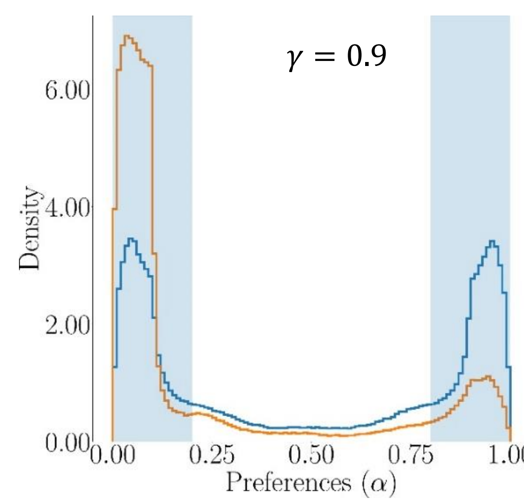
Simulation results: distributions of initial preferences & income



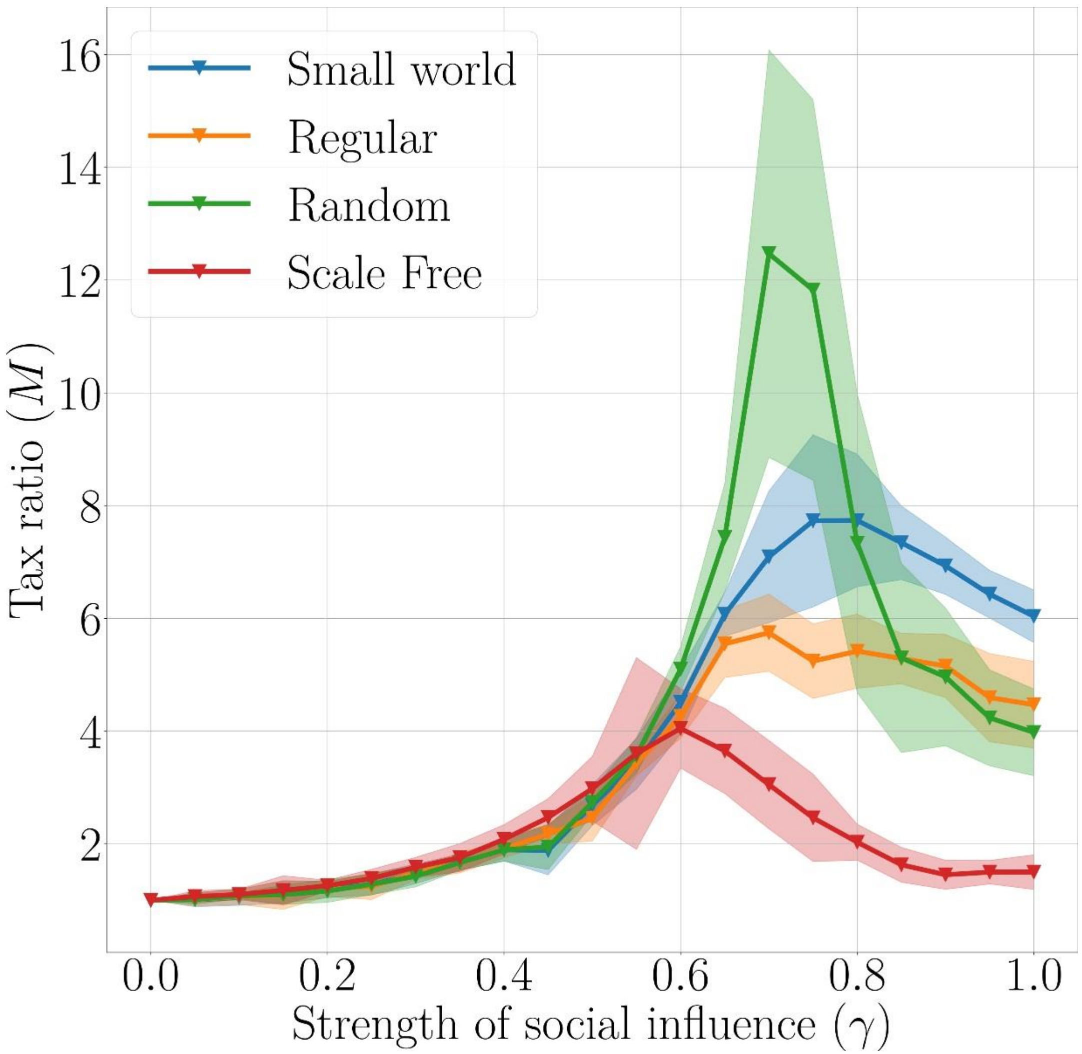








More results: distinct networks, relating to different goods/services



Improve effectiveness of carbon taxation through "network policies": comparative information, social marketing, awards for good behaviour – will affect γ or even the network type, and limit polarization.

Thus social multiplier

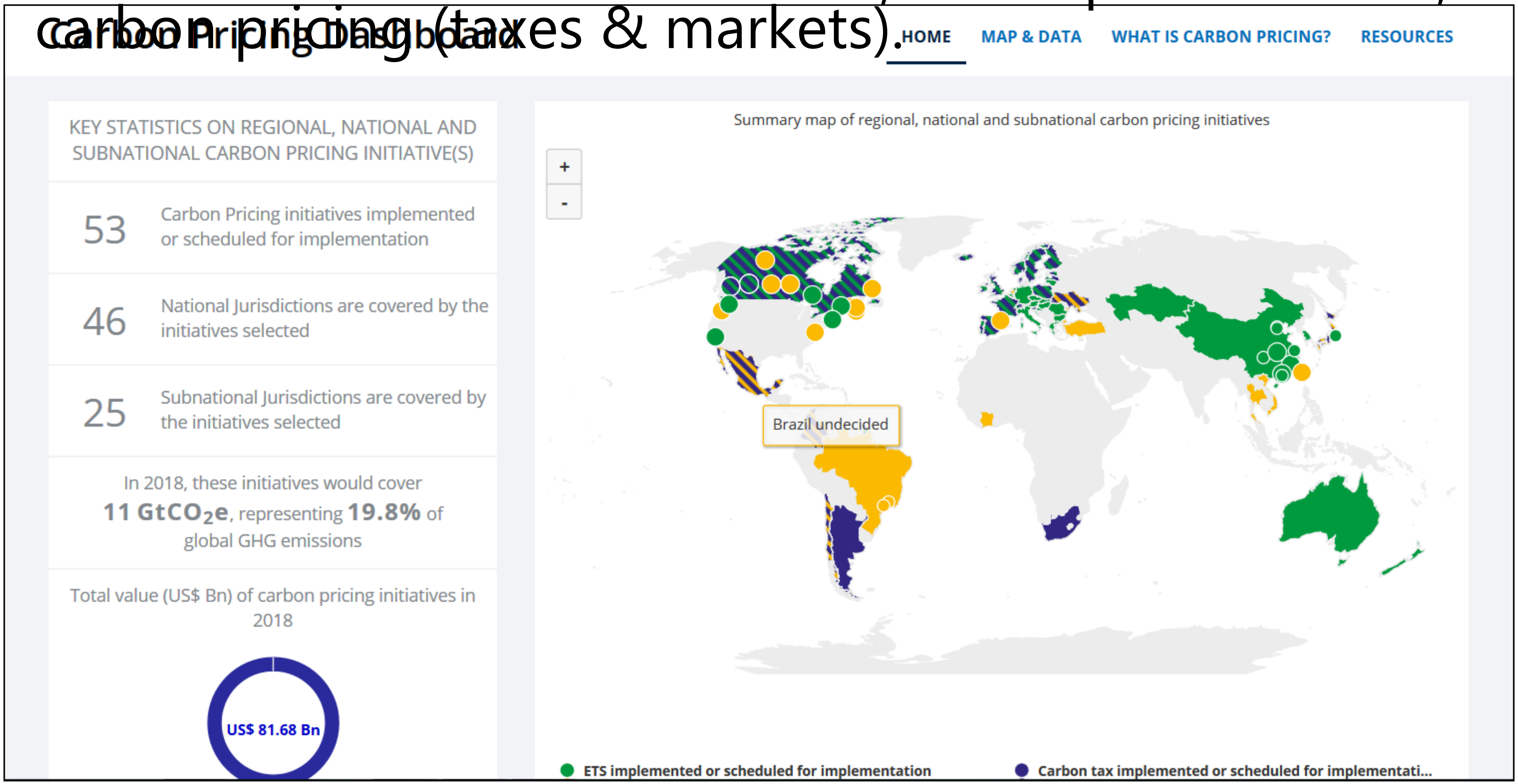
Broader policy package *(with CP at the core)*

- **Relating to social networks and behavior:**
  - ***Information provision:*** About climate change, need for internat. policy coordination, role of carbon pricing, consumer alternatives, etc.
  - ***Nudges:*** physical and behavioral context/feedback to employ bounded rationality and social sensitivity of consumers
- **If only carbon pricing** => early lock-in of non-optimal solutions, closes innovation trajectories of expensive options with much potential

  => ***innovation subsidies*** to keep such options open
- ***Policy for other emission sources:*** e.g., deforestation, land fills
- ***Technical standards:*** limits on car power, speed and acceleration – but won't reduce use, rather opposite (rebound through intenser use).

Good starting point for upscaling

- But low carbon price levels and limited coverage of emissions (exports exempted).
- Unilateral carbon taxes/markets will never escape these shortcoming.
- Positive: shows broad interest in, and experience with, carbon pricing (taxes & markets).



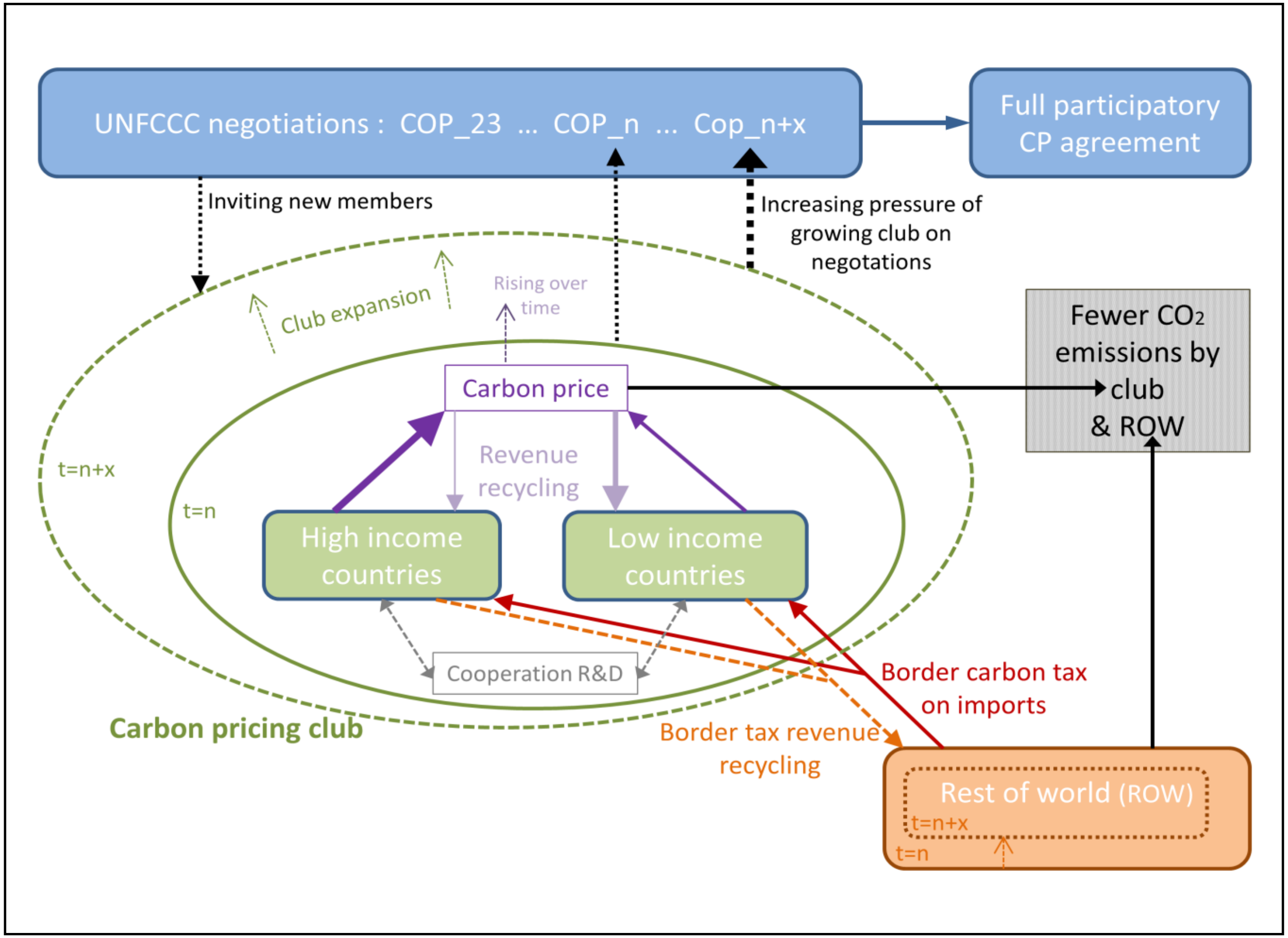
Source: World Bank (2018)

Best chance for post-Paris CP negotiations on policy harmonization through a carbon price

- → Untried: climate agreement on global carbon price/tax or on quota/standards: **1- vs n-dimensional problem**
- → **Free rider behavior discouraged**: carbon price applies equally to all countries; start with CP=0 & raise gradually.
- → **Redistribution** of revenues (already part of Paris Agr.) to assure support from poor nations.
- → But some countries will resist, notably fossil-fuel exporters (Saudi Arabia, Russia, etc.), hence **insufficient approach**.

Transition path to uniform global carbon price

Two interactive tracks: coalition (club) and UNFCCC-COPs



Multiple phases in a transition to global CP

Phase	Track 1: coalition	Track 2: UNFCCC negotiations	Interaction between tracks
1	Climate coalition initiated by ambitious countries with low uniform carbon price and border tariff	Raising awareness in UNFCCC-COPs for relevance of coordinating national policies and potential role of carbon price	Coalition speaks with one voice at UNFCCC-COP meetings
2	Expansion of coalition; moral and economic pressure on countries outside the coalition	Frequent discussions and initial negotiations about carbon price among majority of UNFCCC countries	Coalition strongly lobbies for focus on carbon price during COP meetings
3	Higher carbon price and border tariff; further expansion	Negotiation of heterogeneous carbon prices adapted to income levels in UNFCCC countries with joint carbon price floor	Lessons learned in coalition about design and coordination of carbon price transferred to UNFCCC negotiations
4	Large coalition which includes major emitting countries	Converging carbon price in majority of UNFCCC countries; complemented by financial transfers from rich to poor countries	Large coalition creates critical mass in UNFCCC process
5	Remaining countries (notably fossil-fuel suppliers) come on board under large political and economic (trade) pressures; results in all countries having consistent, economy-wide and strong climate policy. After harmonization, gradual rise in carbon price; frequently revised in response to extent of global emissions reduction achieved and advances in climate sciences on required reduction.		Carbon pricing coalition and UNFCCC climate agreement integrate

Suitable large emitters to start coalition (>55% emissions)

Analysis based on data from opinion surveys, NDCs & participation in relevant coalitions

Nation	Effectiveness		Likelihood of involvement	
	% of total global CO_2 emissions	% of total global GDP	Net likelihood score	Net likelihood ranking
Australia	1.1	1.8	0.758	1
Brazil	1.6	2.4	0.746	2
Canada	1.6	2.1	0.721	3
South Korea	1.7	1.9	0.711	4
Mexico	1.4	1.6	0.661	5
Japan	3.6	5.9	0.585	6
EU	9.6	21.9	0.571	7
India	6.6	2.9	0.517	8
South Africa	1.4	0.4	0.515	9
Indonesia	1.4	1.2	0.438	10
US	15.5	24.5	0.383	11
China	30.4	15.0	0.366	12
Iran	1.9	0.5	0.326	13
Russia	5.0	1.9	0.284	14
Saudi Arabia	1.8	0.9	0.227	15

Source: Martin and van den Bergh (2019)

States in resistant country (USA)

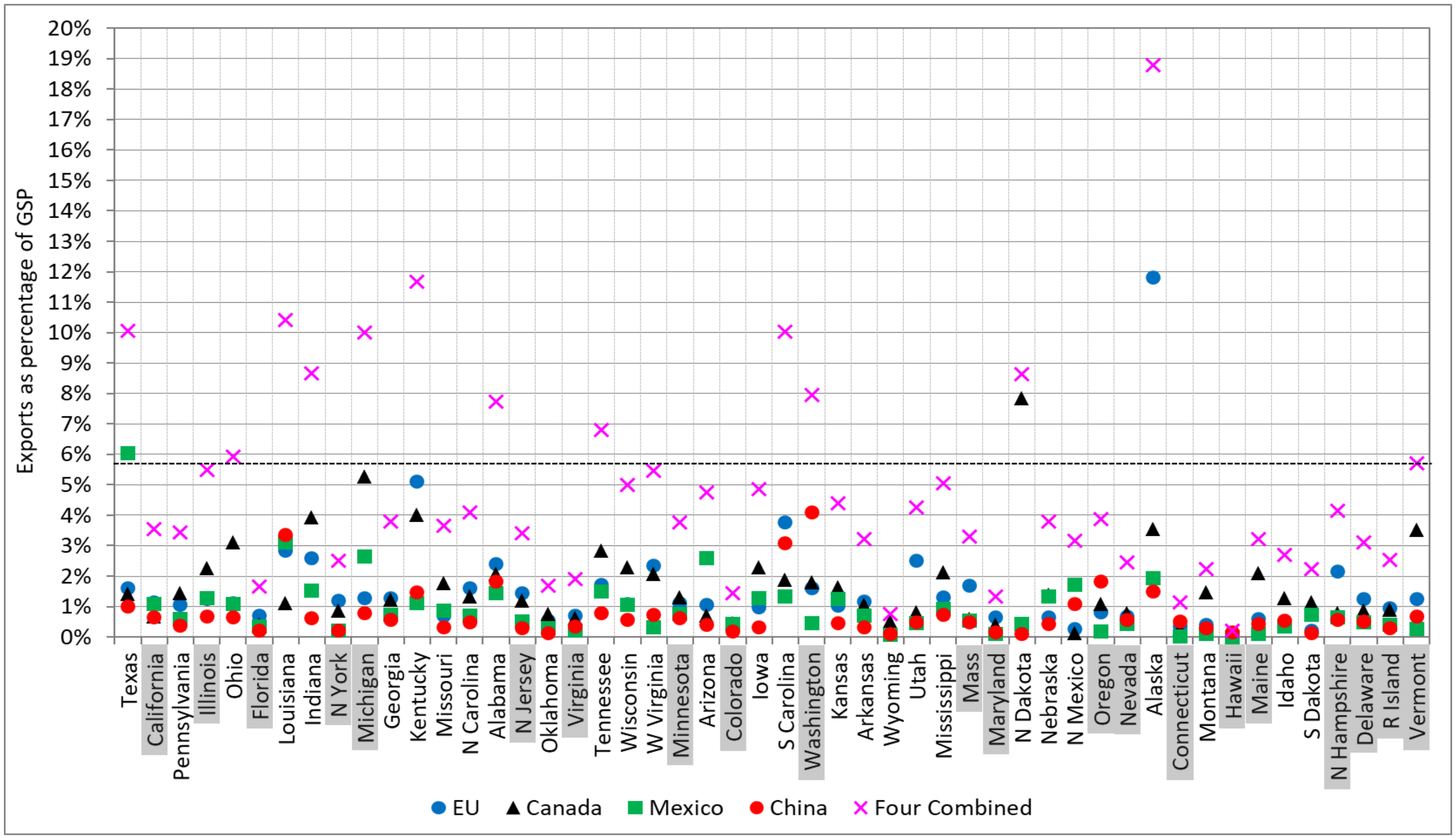
Analysis based on data from opinion surveys, NDCs & participation in relevant coalitions

State	% of total US CO_2 emissions	% of total US GDP	Likelihood-of-involvement: Score	Ranking	Rating
Mass	1.2	2.7	0.961	1	Very Likely
N York	3.1	8.1	0.953	2	
Connecticut	0.6	1.4	0.924	3	
California	6.6	14.0	0.919	4	
Maryland	1.1	2.1	0.882	5	
R Island	0.2	0.3	0.876	6	
Vermont	0.1	0.2	0.862	7	
Washington	1.4	2.5	0.859	8	
Oregon	0.7	1.2	0.858	9	
Delaware	0.2	0.4	0.850	10	
Hawaii	0.3	0.5	0.847	11	
N Jersey	2.1	3.2	0.838	12	
N Hampshire	0.3	0.4	0.803	13	Moderately Likely
Virginia	1.9	2.7	0.786	14	
Maine	0.3	0.3	0.742	15	
Minnesota	1.8	1.8	0.735	16	
Illinois	4.3	4.3	0.725	17	
Nevada	0.7	0.8	0.721	18	
Colorado	1.7	1.8	0.711	19	
Michigan	3.0	2.6	0.704	20	
Florida	4.2	5.0	0.699	21	

Source: Martin and van den Bergh (2019)

State-country trade as push force for additional members

About 70% of US emissions may be amenable to climate-club involvement via a combination of both pathways (36% + 34%)



US state exports sold to four key countries and combined sum of all four as percentage of gross state product (GSP). Threshold line representing the 75th percentile of combined scores is also shown. States previously identified as "very likely" and "moderately likely" climate club members are highlighted in grey.

Source: Martin and van den Bergh (2019)

Conclusions: 7 main insights

1. **Carbon pricing (CP)** more subtle than many commentators realize: well-performing on 4 core criteria, unmatched by other instruments
2. **Energy/carbon rebound** limited, unlike with information provision and especially technological standards **=> effectiveness CP high**
3. CP is **nationally & globally equitable** if design includes revenue recycling to poor households and countries
4. CP arguably only instrument to achieve **global harmonization & upscaling** => essential for climate policy to become **sufficiently strong**
5. CP becomes through social network interactions & related policies more effective; will ultimately change **consumption norms & lifestyles**
6. **Social scientists** should embrace & explicitly support CP; **economists** must explain better CP & design a feasible global transition path
7. Huge challenge to arrive at serious global climate policy; proposal to try a **dual-track transition**: *Multilevel club + UNFCCC CP-negotiations*.

Relevant publications

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