Climate Clubs:
Designing a Mechanism to Overcome Free-riding in International Climate Policy

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Presidential Address
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Outline

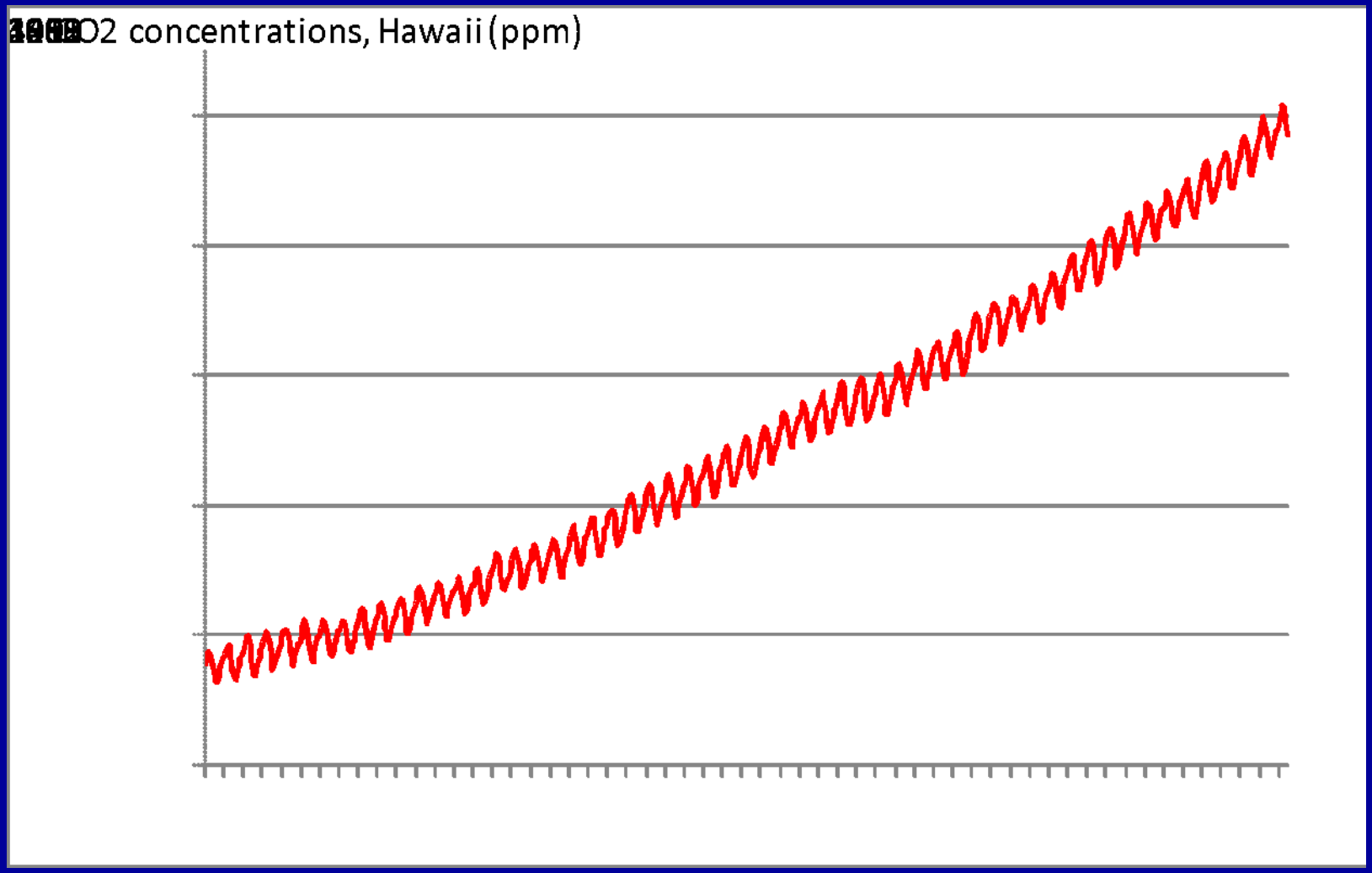
- Introduction to current state of climate economics
- The problem of free riding
- The concept of a Climate Club
- Modeling club formation and equilibrium
- Effectiveness of different Club regimes

Four key issues for climate change

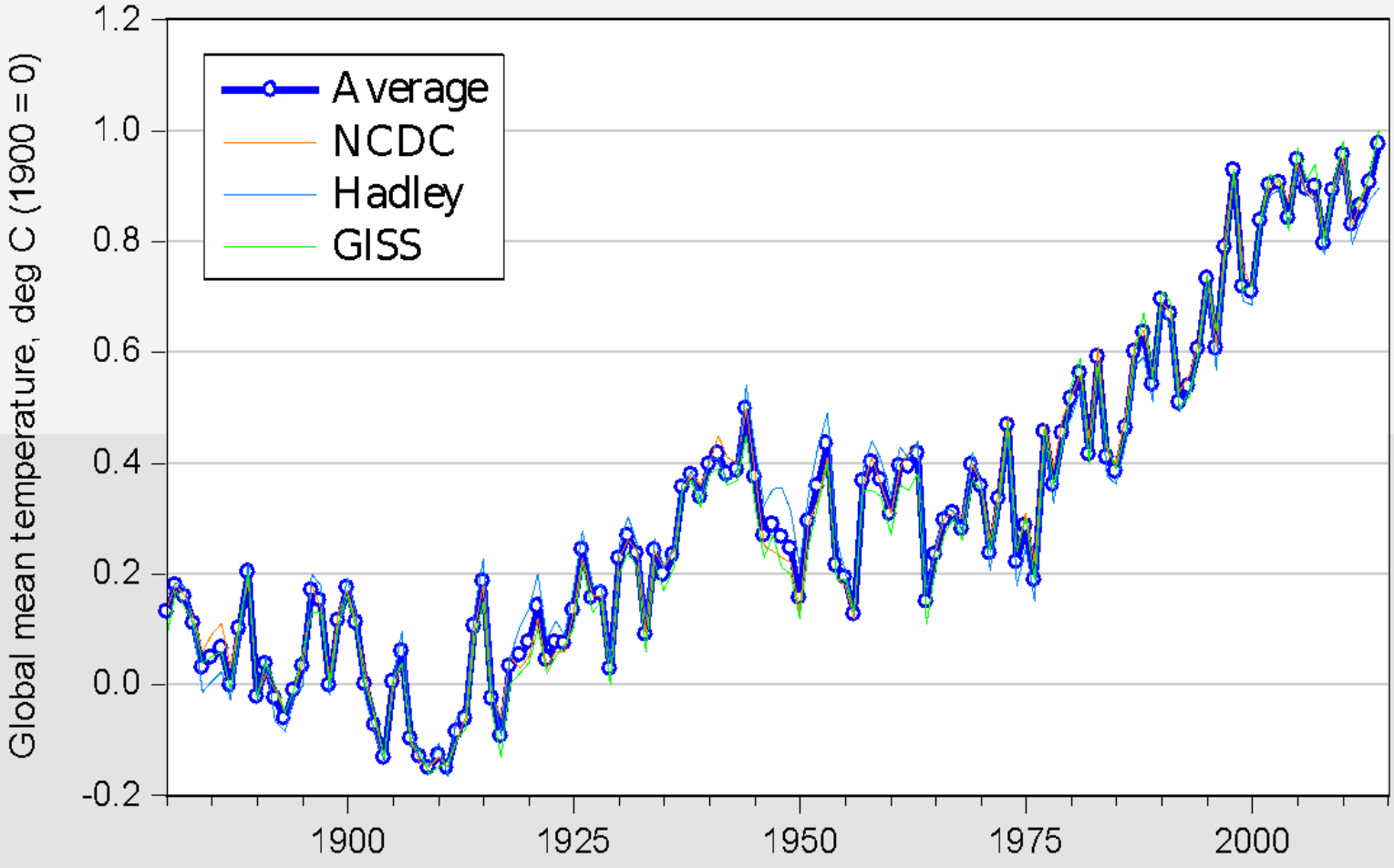
1. Climate science: Likely path of earth system over this century and beyond	Mature science and projections
2. Estimate costs and benefits of emissions reductions	Mature estimates of costs; very rudimentary determination of damages
3. Instruments for implementing policy	Well understood for national carbon taxes and national cap-and-trade systems
4. System to prevent international freeriding	Zero progress

Most recent data

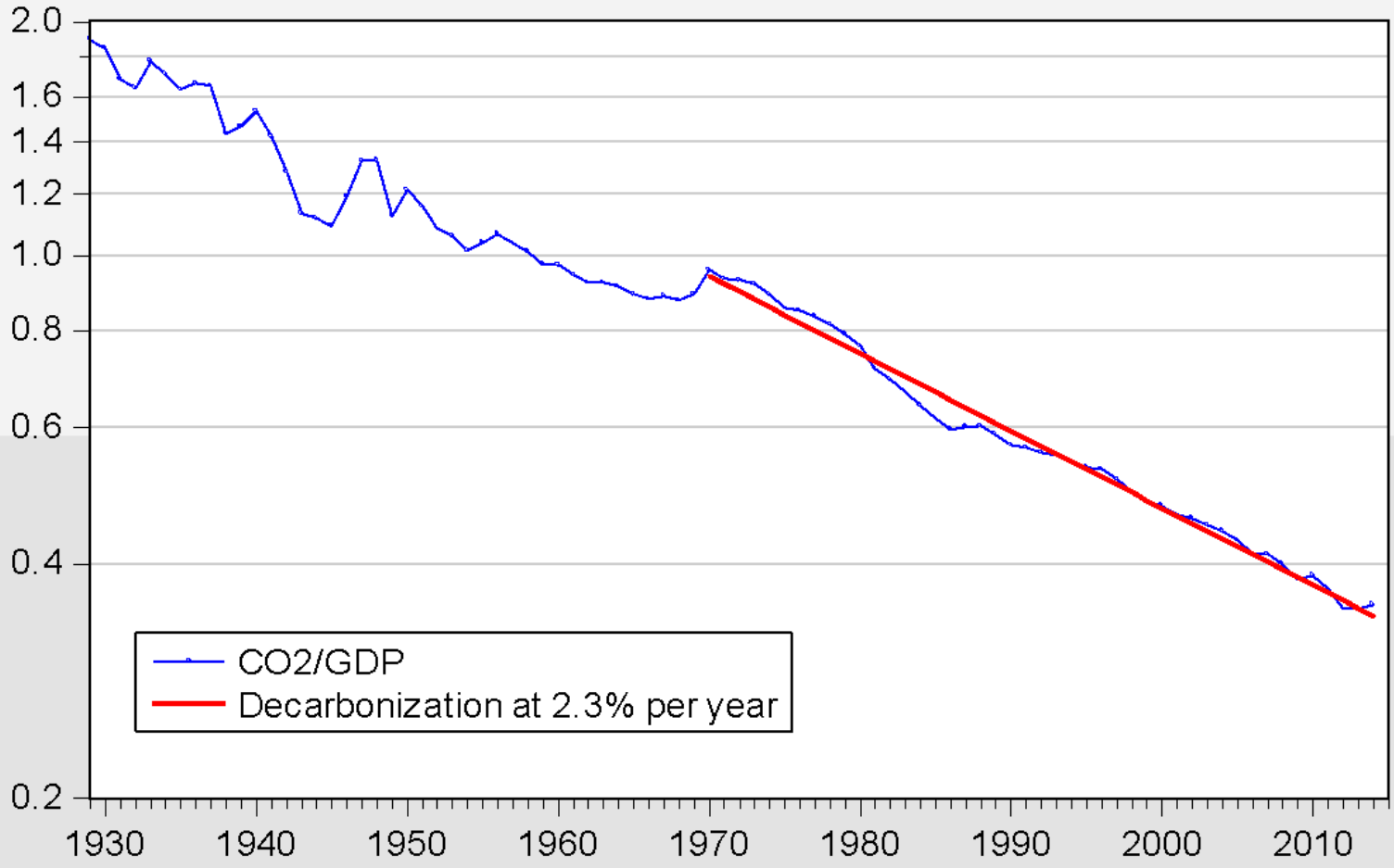
CO2 concentrations through August 2014



Global temperatures (prelim 2014 data)



US decarbonization

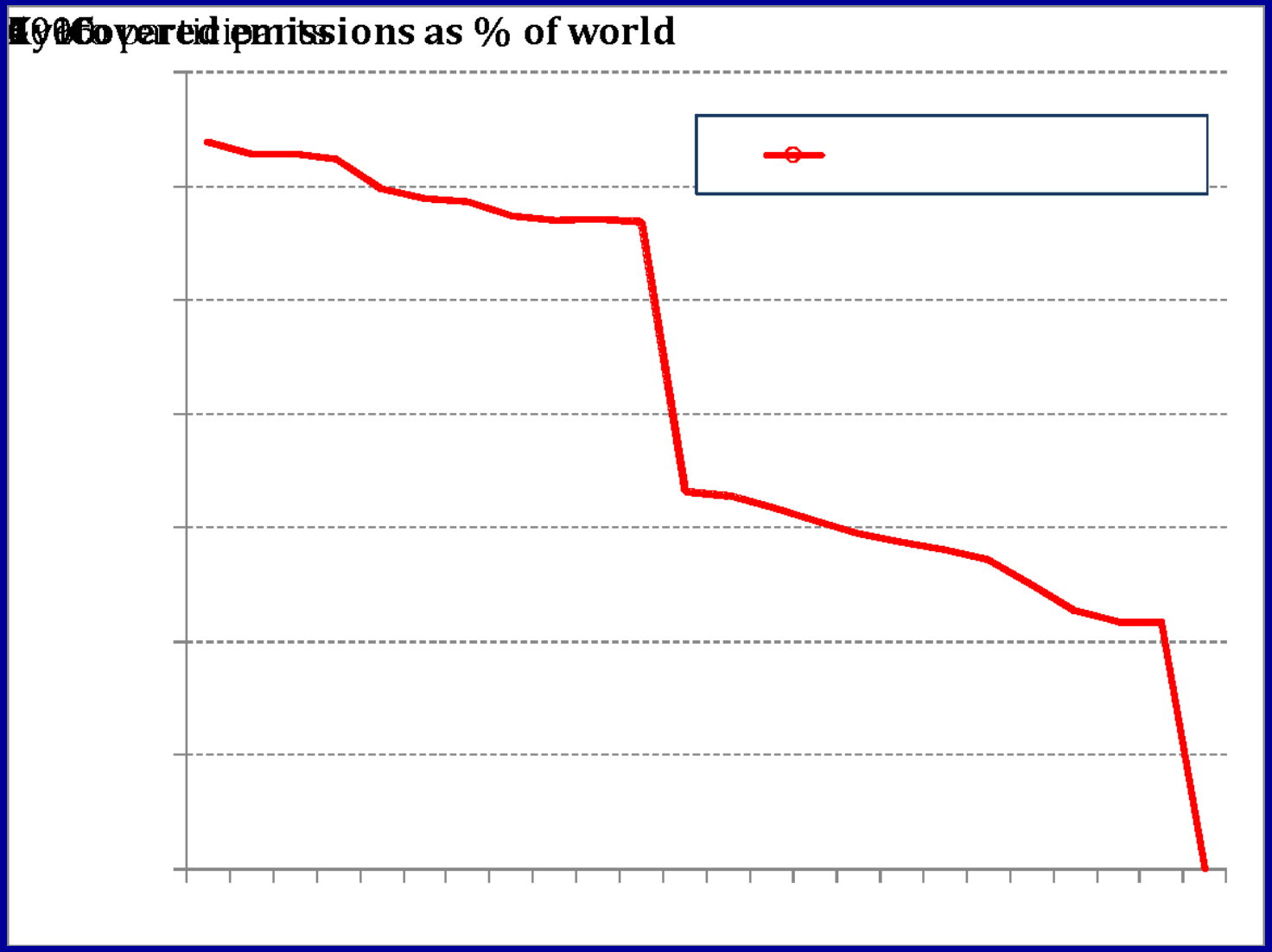


EPA estimates, real GDP, 5 months for 2014

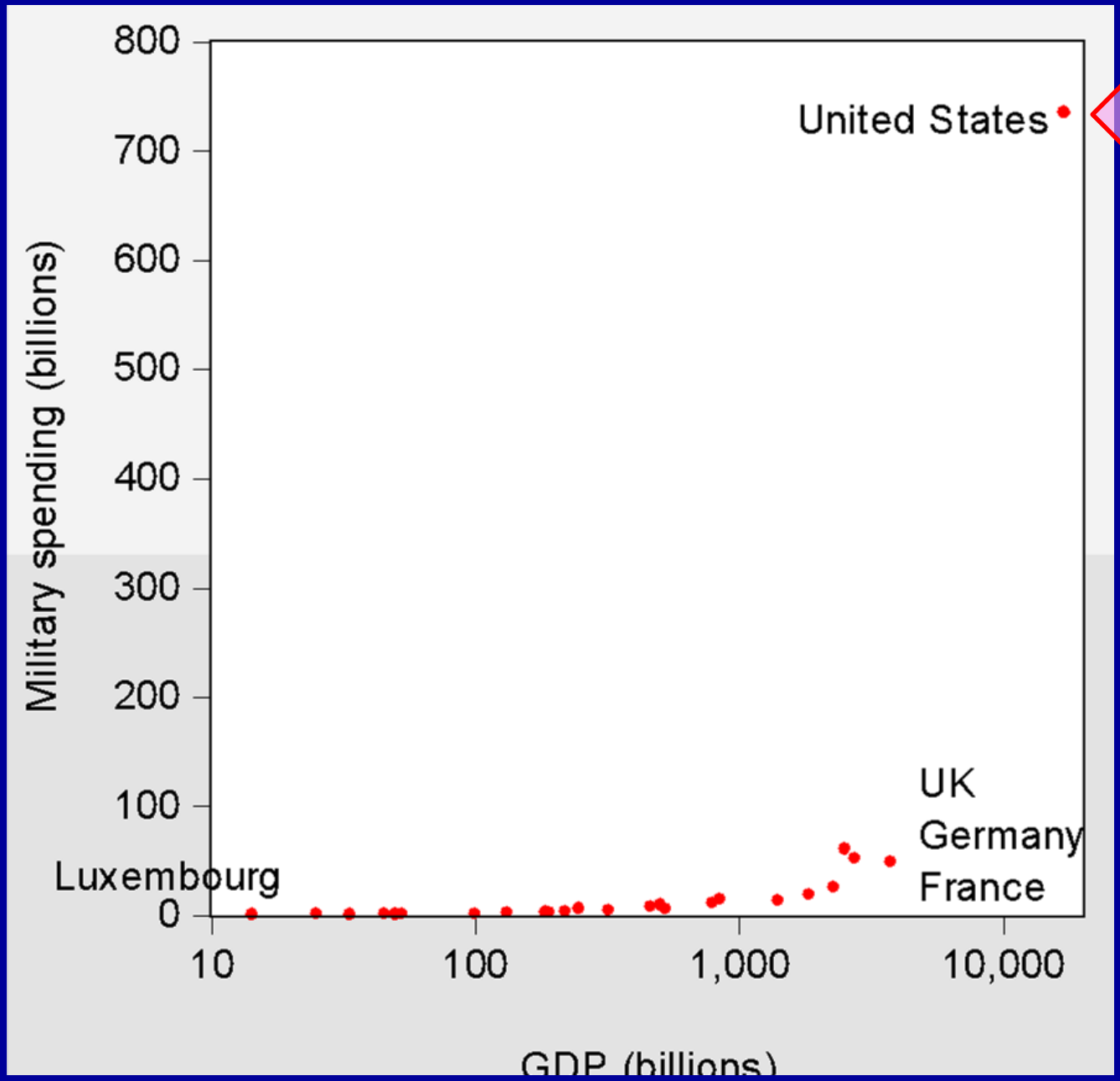
Free-riding equilibrium for public goods

- ***Free-riding*** occurs when someone receives the benefits of a public good without contributing to the costs.
- This syndrome is seen widely for public goods or "tragedy of the commons" (whales, global warming, contagions)
- Because of structure of international law, strong tendency for free-riding in global public goods.
  - Public goods theory from Paul Samuelson
  - History and treaty theory from Scott Barrett
  - Kyoto Protocol for climate change (later)
  - Modeling simulations (later)

Free-riding in the Kyoto Protocol:
Share of global emissions covered by binding restraints



Free riding in NATO



Source: Data from NATO

Free-Riding in International Climate Agreements

- Basic theoretical results:
  - Without international agreements, have non-cooperative (NC) equilibrium. In simple example, carbon prices are efficient levels time Hirfindahl index of country size (≈ 10% of efficient).
  - With international cooperation and bottom-up treaties without sanctions, have *small coalition paradox*: Stability can sustain only a small number of countries (2 or 3).
- Climate Club: Top-down treaty with penalties for non-participants: Can lead to high participation with efficient abatement.

International Treaties as "Clubs"

Clubs are agreements where:

1. Have economies of scale or public goods
2. Members pay dues
3. Can exclude non-members (avoid free riders)
4. Stability issues (next slide)

Examples of effective club: Why did Greece stay in EU?

Kyoto Protocol defective club:

membership cost > membership value

Should Greece stay in the EU?

The Times (London)

International Treaties as Games

- Climate policy without penalties is repeated n-person prisoners' dilemma (PD) game.
  - Presumption is that high discount rate (or low frequency of decisions) will lead to PD rather than cooperative equilibrium.
- By adding penalties for non-participants, payoffs change so that stage game has (relatively) efficient Nash equilibrium.
  - Presumption is then that the repeated game has the stage-game efficient Nash equilibrium.
  - In Scott Barrett's language, treaties are "self-enforcing" at efficient level.
- Key issue is "coalition stability" of high-participation treaty.

Penalties are necessary for effective climate treaties

- Need penalties on non-participants to induce participation in deep abatement treaties
- History and law suggest the most practical penalty is trade sanctions
- What kind of sanctions?
  - *Standard approach:* Countervailing duties on carbon content of imports (US and EU legislation)
  - *Climate Club tariffs:* Simple ad valorem tariff on all imports of non-participants into climate-club regions.

Modeling Climate Clubs with the TRICE model

- Designed a new model to study properties of Climate Club with realistic country parameters.
  - TRICE model (Trade in a Regional Integrated Model of Climate and the Economy)
- Model assumptions:
  - A standard one-period regional model.
  - Key variables are the social cost of carbon (SCC), national carbon prices, tariff rates, and national income.
  - Countries can form Carbon Club to set carbon prices jointly at international carbon price target.
  - Clubs can impose penalty tariffs on imports of non-participants.

Objectives of modeling

1. Examine different Club structures or regimes (carbon prices and penalty tariffs).
2. Determine whether regimes contain stable coalitions (Nash coalition stability).
3. Determine effectiveness of regimes (whether actual carbon price approaches target price).

Algorithmics

- Thought to be a NP-hard problem to find optimal coalition.
- Designed “evolutionary” algorithm to find coalition which usually find the stable coalition in < 500 mutations.
- Decision criterion is “coalition Nash.” No sub-coalition can improve its welfare by leaving and/or joining.

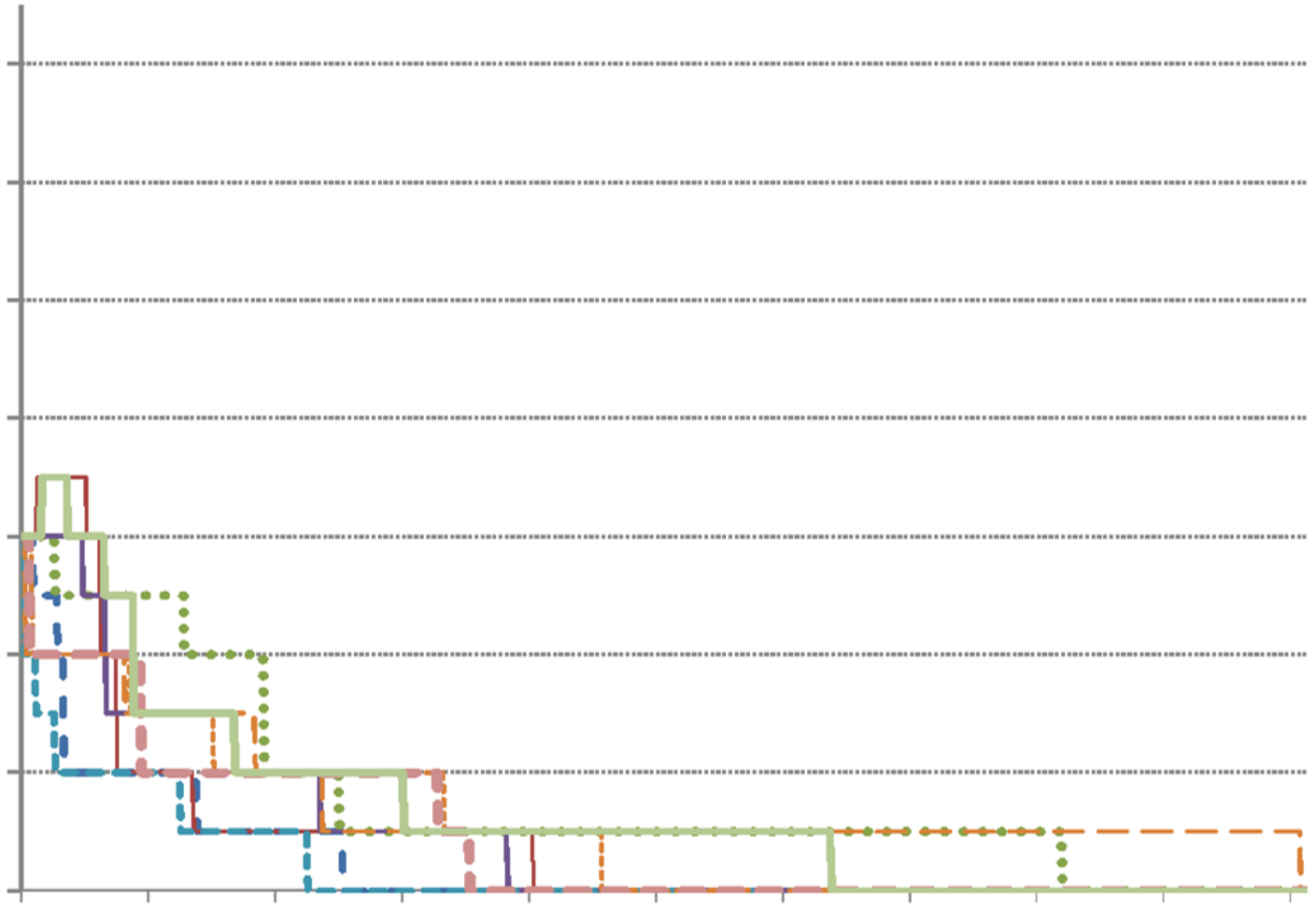
Data for model for 2011

- Damage functions: Simplified from Nordhaus survey of estimates (*JAERE*, 2014)
- Abatement functions: From different models for aggregate and McKinsey estimates for regions.
- GDP, emissions, population from World Bank
- Trade data from UNCTAD.
- Parameters for trade model from Ralph Ossa (*AEA*, forthcoming, 2014).
- 15 regions (US, EU, China, India, Japan, Brazil, Russia, Canada, and other aggregates).

Experiments with the TRICE model

1. Kyoto Protocol
2. Climate Clubs
   - Tariff rates from 0% to 10%.
   - Carbon tax target is from $25 to $100 per ton CO2 (rough range of proposals).

With no penalty, Kyoto regime disintegrates to NC



- Assumes carbon tax = $25 and tariff rate = 0%

Now look at results for positive tariffs: What are results for different Climate Clubs?

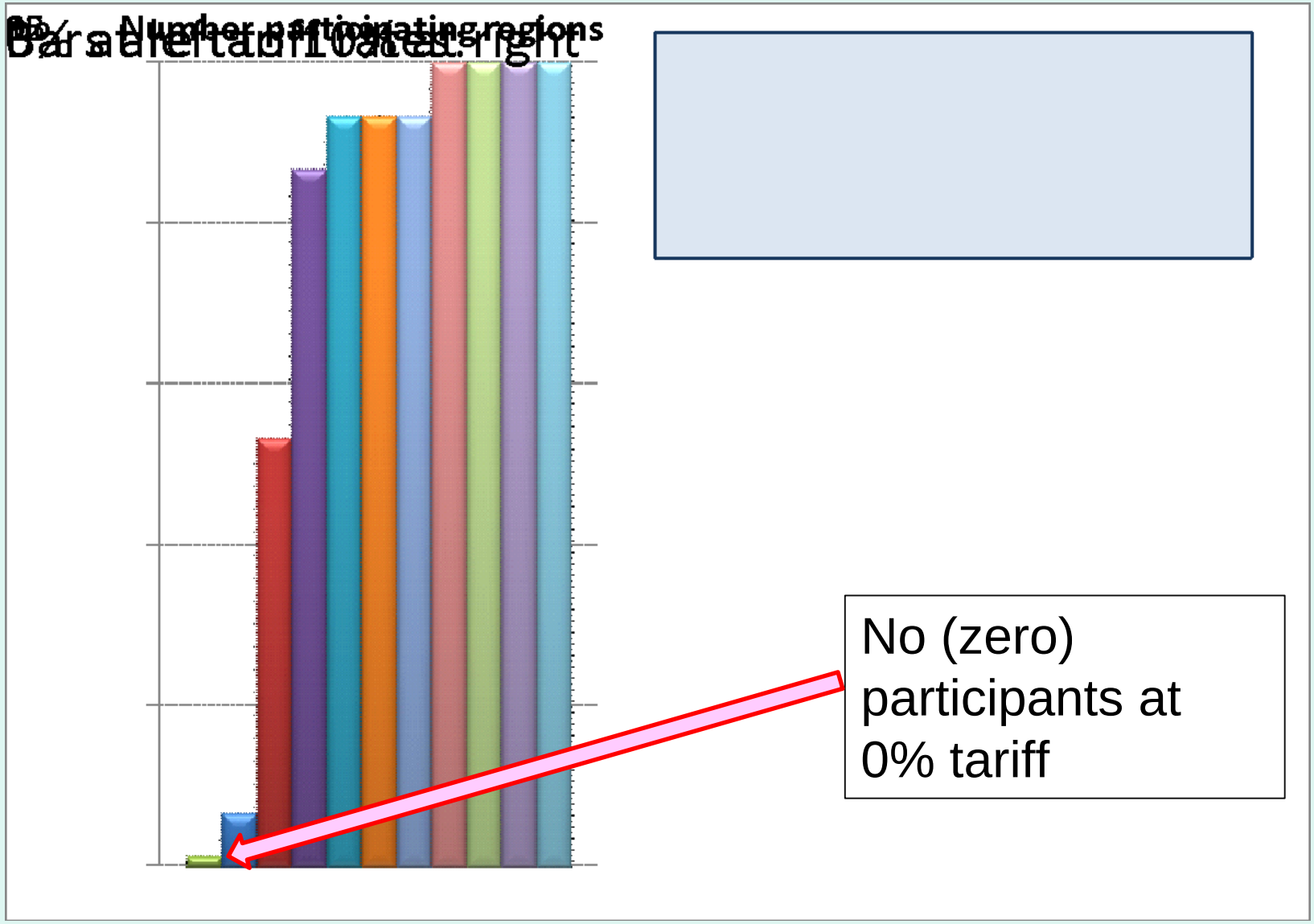
- Penalty tariffs are uniform on all non-participants
- Rates from 0% to 10%
- Global social cost of carbon $12½ , $25, $50, $100

Participation by tariff rate for $50 carbon price

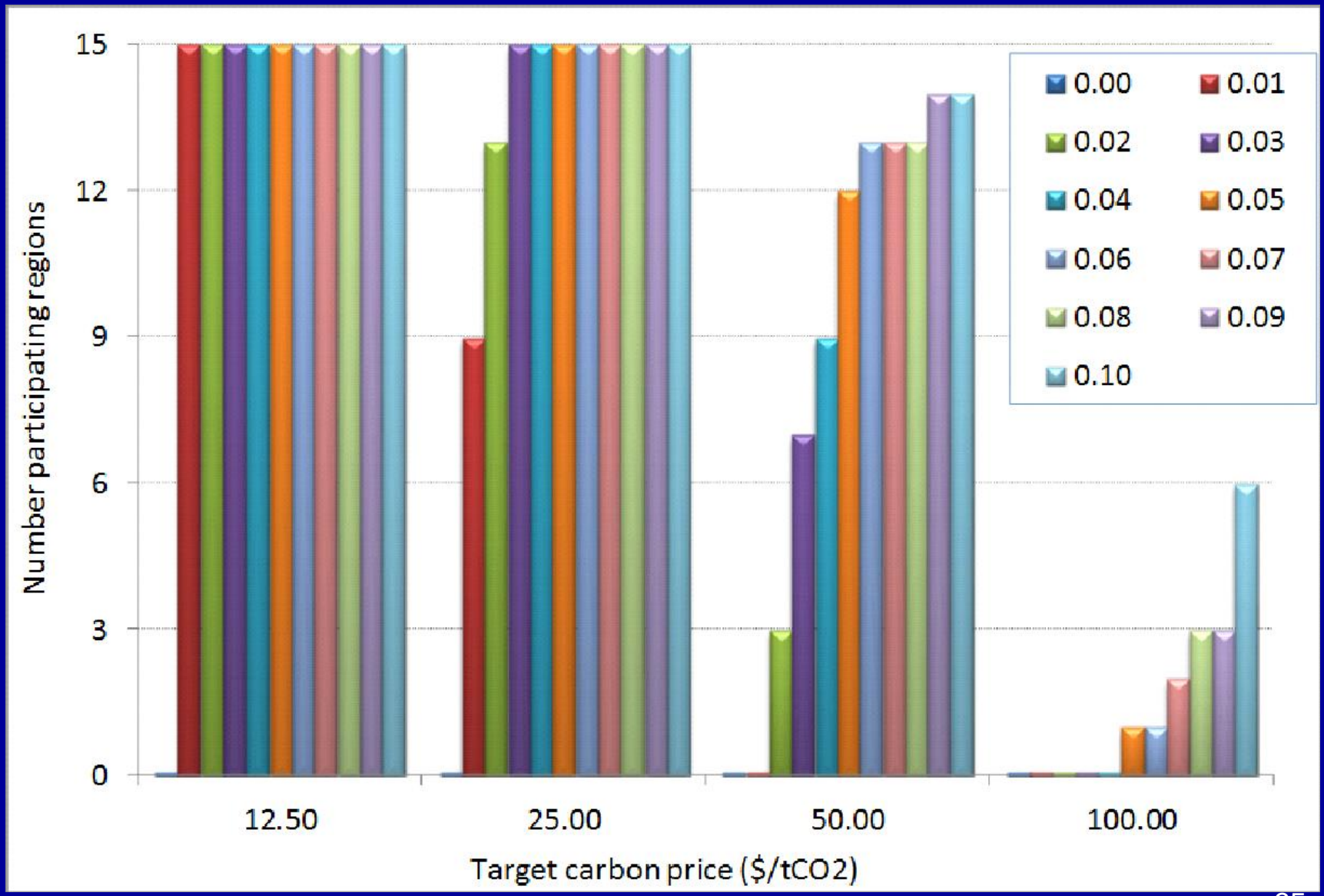
Tariff rate	Number participants (of 15 regions)
0%	0
1%	1
2%	8
3%	13
4%	14
5%	14
6%	14
7%	15
8%	15
9%	15
10%	15

Today's free-riding!

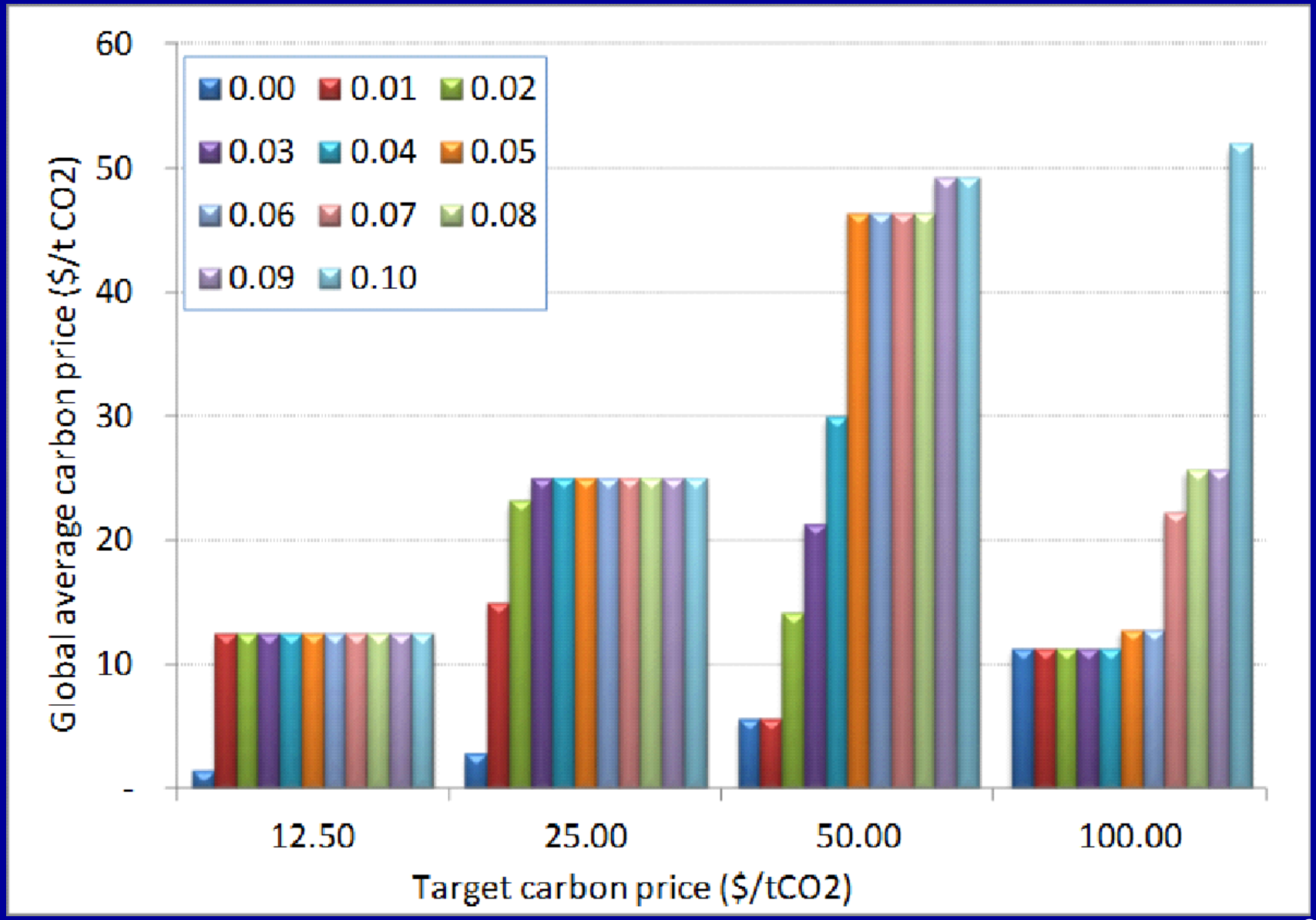
Participation by tariff rate for $50 carbon price



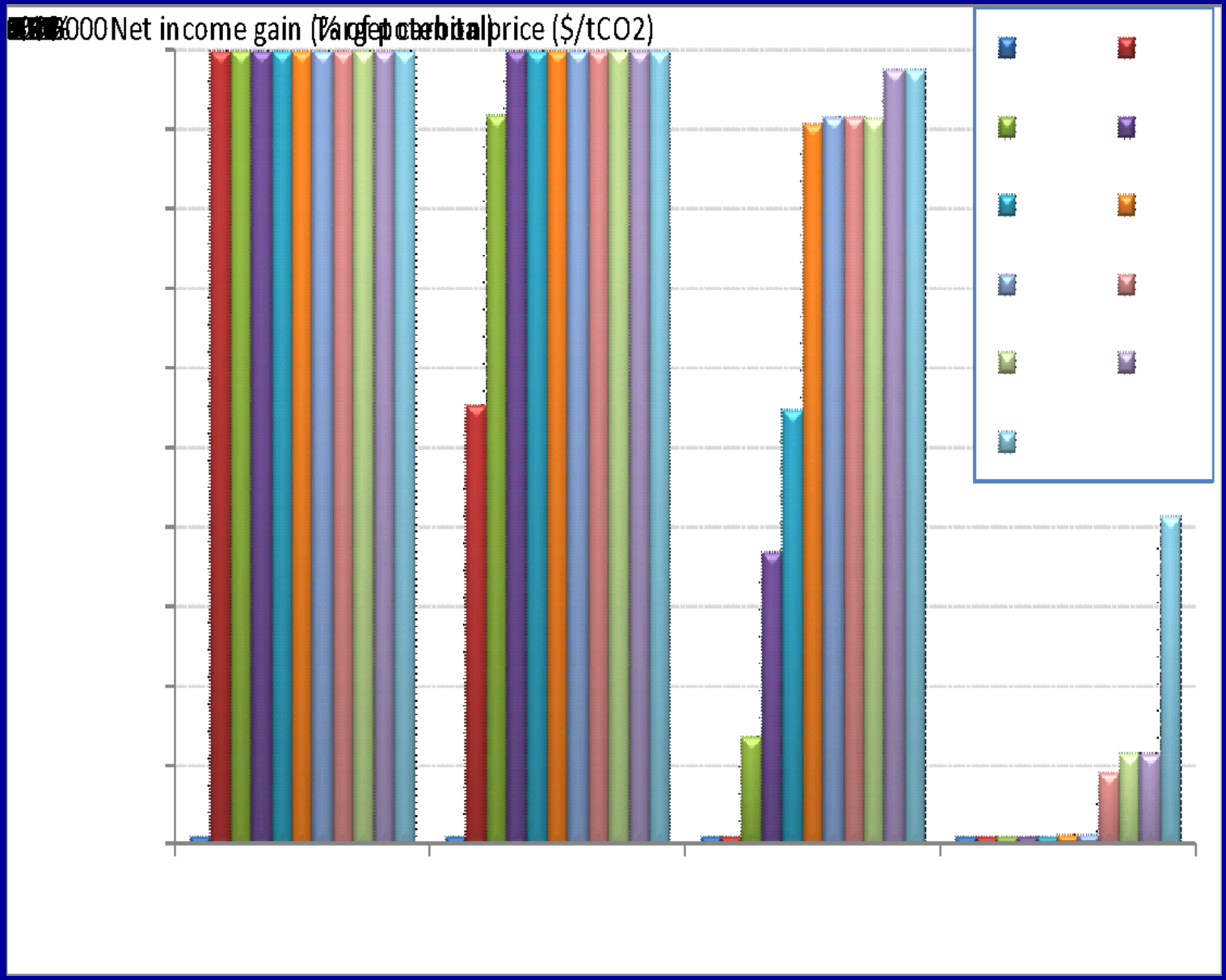
Number participants by tariff and carbon price



Carbon price by tariff and target price



Gain from regime (% of cooperative)



Where are the votes?

For heterogeneous countries with differing national SCC, abatement costs, and damages, what level of international target carbon price would then vote for?

What Climate Club would countries prefer?

Region	Global target carbon price that maximizes domestic welfare for club of 15 ($/tCO2)
Global averages	
Non-cooperative price	3
Global SCC	25
Median preferred price	28
Country preferred prices	
China	14
US	28
India	31
Canada	34
EU	46

Summary

1. Strong international free-riding leads to minimal abatement with Kyoto Protocol structure of no penalties.
2. Strong incentive-compatible agreements can be supported with penalties such as tariffs on non-participants.
3. Most important takeaway: With Club structure, countries acting in their national self-interest can produce (reasonably) efficient global climate policy.