Strategic subsidies for green goods

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Resources for the Future and *FEEM*

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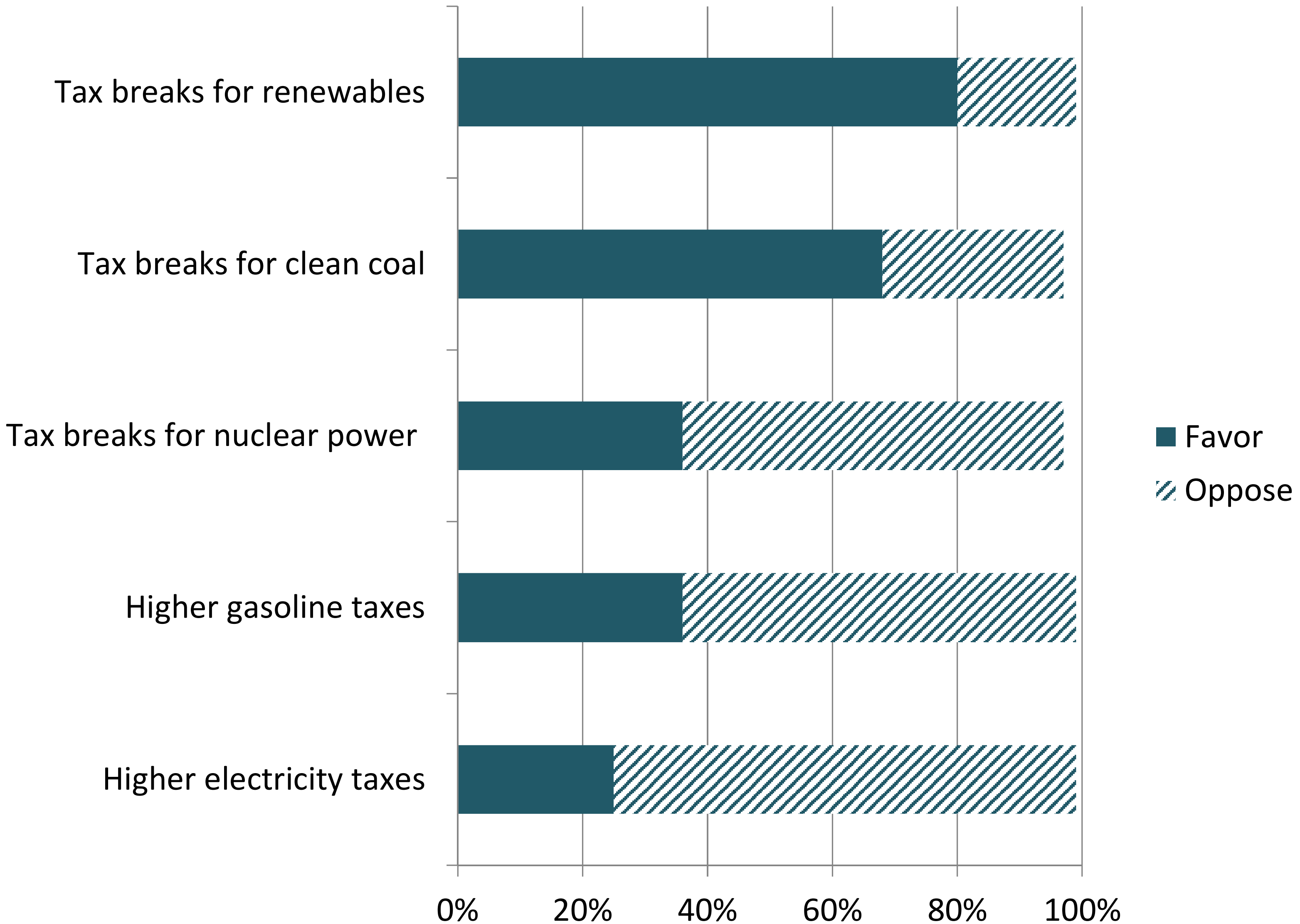
Background

- Environmental economists advocate pricing externalities
  - The climate change problem calls for a worldwide uniform price on carbon, ideally
  - However, politically difficult
- In practice, subsidies for green goods are far more popular than taxing bads
  - Subsidies or mandates for renewables
  - Subsidies or standards for energy efficient technologies

RFF/Stanford/NYT Poll (2015)



Popularity of Renewable Energy Incentives

Countries with national or provincial renewable energy policies or targets in place, as of early 2015 (Source: REN21 2015)

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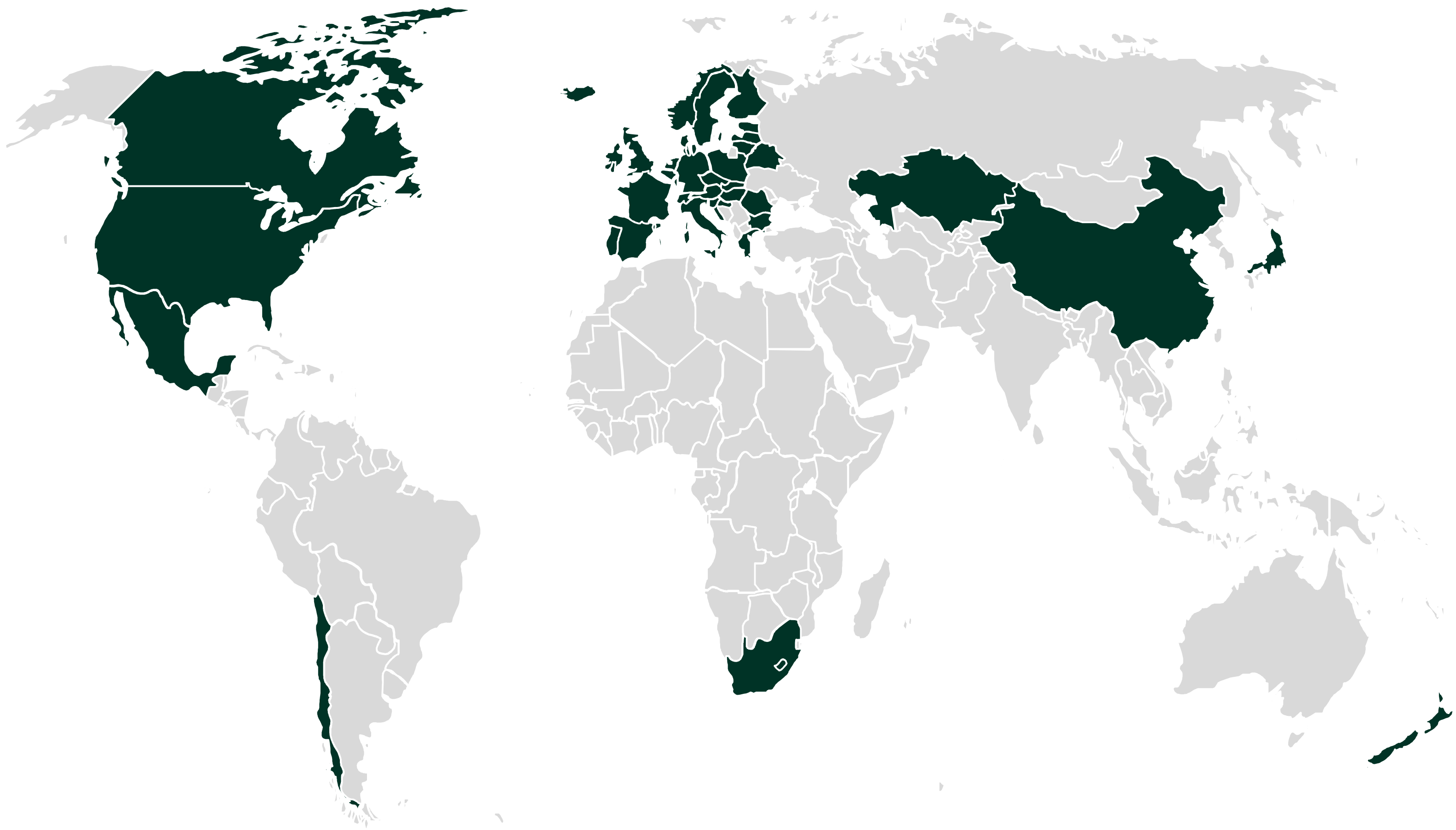
Popularity of Carbon Pricing



Countries with a national or provincial ETS or carbon tax implemented or scheduled, as of early 2015 (Source: World Bank 2015)

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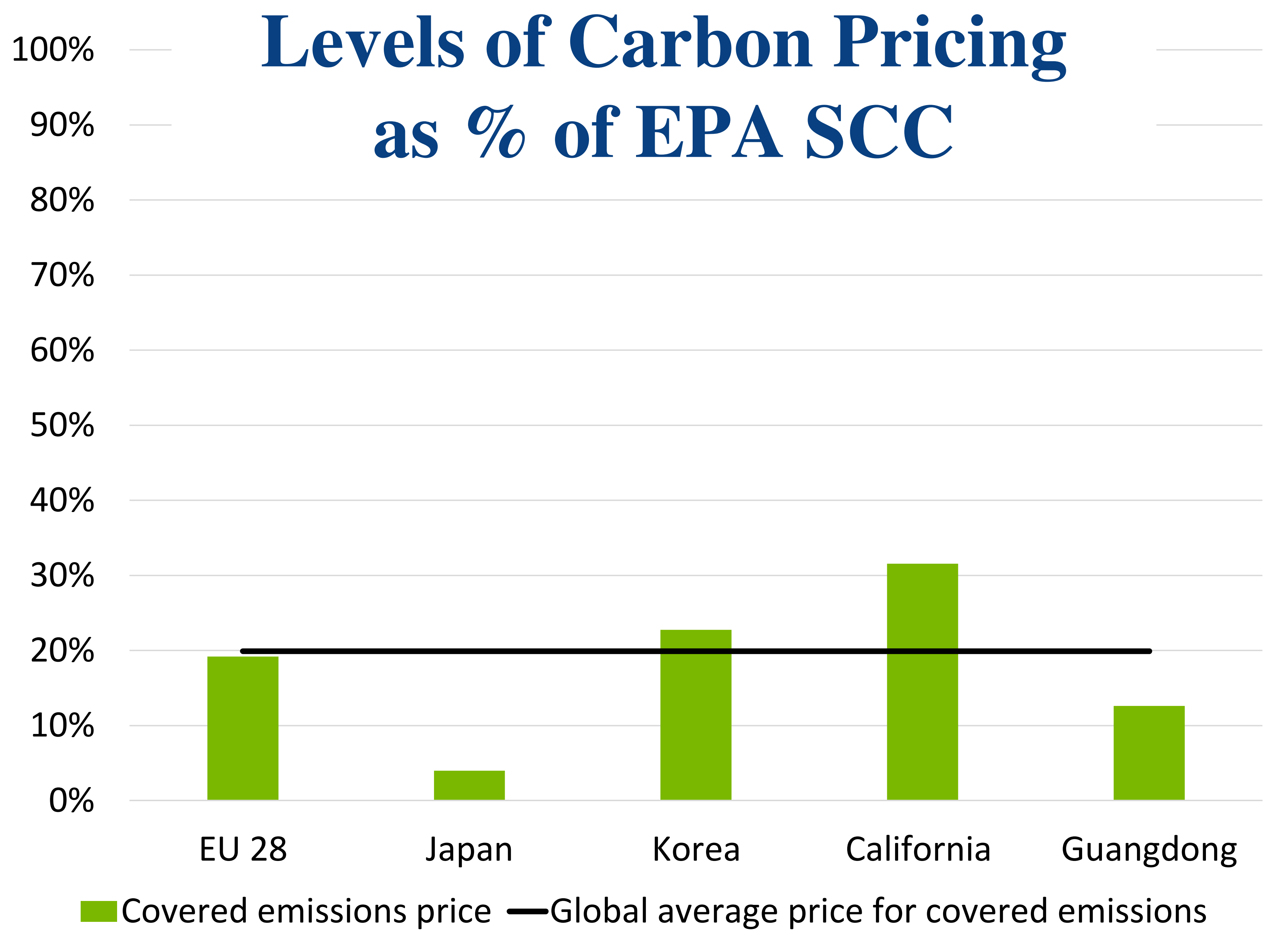

Levels of Carbon Pricing
as % of EPA SCC
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
EU 28
Japan
Korea
California
Guangdong
Covered emissions price
Global average price for covered emissions

Many forms of renewable energy support

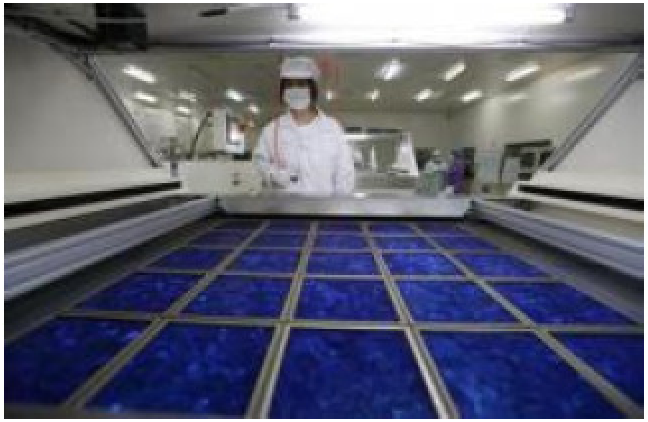
- Deployment incentives
  - Production subsidies, feed-in tariffs, renewable portfolio standards
  - Investment incentives
- Technology production incentives
  - Tax incentives, preferential finance, land, etc.
  - Local content requirements
- R&D support

REUTERS

EU says China guilty of giving illegal aid to solar industry

Tue, Aug 27 2013

By Robin Emmott



BRUSSELS (Reuters) - The European Union has warned Beijing it has evidence Chinese solar companies benefit from illegal subsidies, people close to the issue said on Tuesday, but Brussels says it will not take action for now following a deal to defuse the row.

European companies accuse Chinese rivals of benefiting from unfair state aid allowing them to dump about 21 billion euros (18 billion pounds) worth of solar panels at below cost in Europe last year, putting European firms out of business.

The solar dispute, by far the biggest between China and the EU, threatened a wider trade war in goods from wine to steel until Brussels and Beijing agreed a minimum price for panels from China in late July and eased tensions.

But a nine-month investigation by the European Commission into China's solar industry has found Beijing broke World Trade Organisation rules by handing out cheap loans, land, interest-free credit lines and tax breaks to companies, people with knowledge of the situation told Reuters.

"There are clear indications that (Chinese) government policy influences the decision-making of the banks when deciding on the terms of financing to solar companies," said one person who declined to be named because the findings are not public.

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China and Europe make up after averting trade war

BY [ROBIN EMMOTT]

BRUSSELS Thu Oct 24, 2013 3:58pm EDT

- Brussels initially moved to impose punitive duties on Chinese solar panels but Beijing threatened sanctions on goods including German cars and French wine. Both sides agreed a minimum price for panels from China in July.

REUTERS

U.S. solar industry harmed by China, Taiwan imports – ITC

WASHINGTON Wed Jan 21, 2015

The U.S. International Trade Commission said on Wednesday imports of solar products from China and Taiwan injure U.S. producers, clearing the final hurdle for import duties on the goods.

ITC commissioners voted in favor of the complaint brought by the U.S. arm of German solar manufacturer SolarWorld AG in a bid to close a loophole that let Chinese producers sidestep duties imposed in 2012.

The decision gives the U.S. Commerce Department the green light to impose anti-dumping duties as high as 165.04 percent for Chinese goods and 19.5 percent for Taiwanese goods. Separate anti-subsidy duties of up to 38.72 percent apply for Chinese goods.

Recent WTO renewable energy disputes

- European Union — Certain Measures on the Importation and Marketing of Biodiesel and Measures Supporting the Biodiesel Industry (Complainant: Argentina, 2013)
- India — Certain Measures Relating to Solar Cells and Solar Modules (Complainant: United States, 2013)
- European Union and Certain Member States — Certain Measures Affecting the Renewable Energy Generation Sector (Complainant: China, 2012)
- Canada — Measures Relating to the Feed-in Tariff Program (Complainant: European Union, 2011)
- Canada — Certain Measures Affecting the Renewable Energy Generation Sector(Complainant: Japan, 2010)
- China — Measures concerning wind power equipment (Complainant: United States, 2010)

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Trade literature on subsidies

- Spencer and Brander (1983), Brander and Spencer (1985)
  - 2 Cournot producer countries with 3rd party export market
  - Focus on export / production subsidies, not in tandem with consumption subsidies
- Find that joint profits would be maximized with *lower* upstream subsidies than a Nash equilibrium obtains
  - Thus recommend negotiating restrictions on subsidies
- Ignores that global welfare is maximized with *higher* subsidies…

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More trade literature on subsidies

- Extensions of Brander and Spencer:
  - Eaton and Grossman (1986) for Bertrand competition
  - Dixit (1984) for multiple firms
  - Krugman (1984) for increasing returns to scale
  - Leahy and Neary (1999) for R&D spillovers
- Questions of global welfare or correcting market failures are de-emphasized or ignored
  - Key aspects of international environmental policy

Some rationales for subsidizing green goods

- Upstream market failures
  - Imperfect competition
    - New industries
    - Patented technologies
  - Network / scale / learning externalities
- Downstream market failures
  - Unpriced emissions
  - E.g., benefits of displacing fossil-based electricity with renewables

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Related recent work

- Greaker and Rosendahl (2008)
  - individual country may impose an excessively stringent environmental policy to reduce the mark-up of technology suppliers and increase diffusion
- Fischer, Greaker and Rosendahl (2014a&b)
  - On abatement technologies and strategic trade
  - On subsidies and trade in a context of renewable energy targets
- This paper generalizes and deepens these results and offers some quantitative evidence of their importance with an application to renewable energy

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Environmental literature on strategic trade

- More focus on how regulatory stringency responds to trade than industrial policy
- Buchholz and Konrad (1994), Stranlund (1996)
  - underinvestment in R&D credibly commits countries to low emissions reductions in the future, making other countries increase their mitigation effort.
- Golombek and Hoel (2004)
  - opposite effects when spillovers from industrialized countries' R&D investments could spur abatement in developing countries.
- Abstract from the fact that abatement technology is produced in a market separate from that of adopters

Theoretical model: Quantity-oriented framework

- Keeps roots in early trade literature
- Market failures are related to quantity (underprovision)
  - Environmental benefits of green good consumption
  - Imperfect competition as Cournot
    - Some evidence for this behavior among renewable energy technology markets: Wind turbine manufacturing is highly concentrated; solar markups are positively associated with firm size (Pillai and McLaughlin 2013)
  - Scale economies
- Policies related to quantities; goods perfect substitutes
- Allows parameterization to renewable energy case

Model setup

- 2 producer regions and 3rd consumer region
  - E.g., technology leaders and follower / developing region; all are major energy consumers
- Policies (Only in producer regions)
  - Deployment subsidies η
  - Manufacturing subsidies γ
  - (Later: carbon price τ)
- Individual and global welfare, with external benefit of v:

$$W_1 = \Pi_1 + CS_1 + TR_1 + v_1 E_G$$

$$W_2 = \Pi_2 + CS_2 + TR_2 + v_2 E_G$$

$$W_3 = CS_3 + v_3 E_G$$

$$W_G = W_1 + W_2 + W_3 + (v_G - v_1 - v_2 - v_3) E_G$$

Downstream consumption of the green good

- Linear demand function
  - Market share weight of *m* to explore demand heterogeneity

$$x_i = m_i\left(a - (P - \eta_i)\right)/b; \quad \sum_i m_i = 1$$

- Leads to linear inverse demand function for upstream producers of

$$P = A - BX = a + \overline{\eta} - bX$$

- External benefits related to consumption
  - Region-specific avoided emissions factors μ

$$E_G = \mu_1 x_1 + \mu_2 x_2 + \mu_3 x_3$$

Upstream market structure

- Imperfect competition: Cournot
  - n_i symmetric firms with unit cost c in country i

$$y_d = \frac{A - c + \gamma_d + N(\gamma_d - \overline{\gamma})}{B(N+1)}; \quad Y^C = \frac{N(A-c) + \overline{\gamma}}{B(N+1)}$$

- Competitive markets
  - Continuum of heterogeneous price-taking firms with limited capacities (as in Laffont and Tirole 1996). leading to upward-sloping supply curve in each region:

$$y_d = \frac{h(A - c + \gamma_d) + B(\gamma_d - \gamma_f)/2}{2h(B+h)}; \quad Y = \frac{A - c + \overline{\gamma}_D}{B+h}$$

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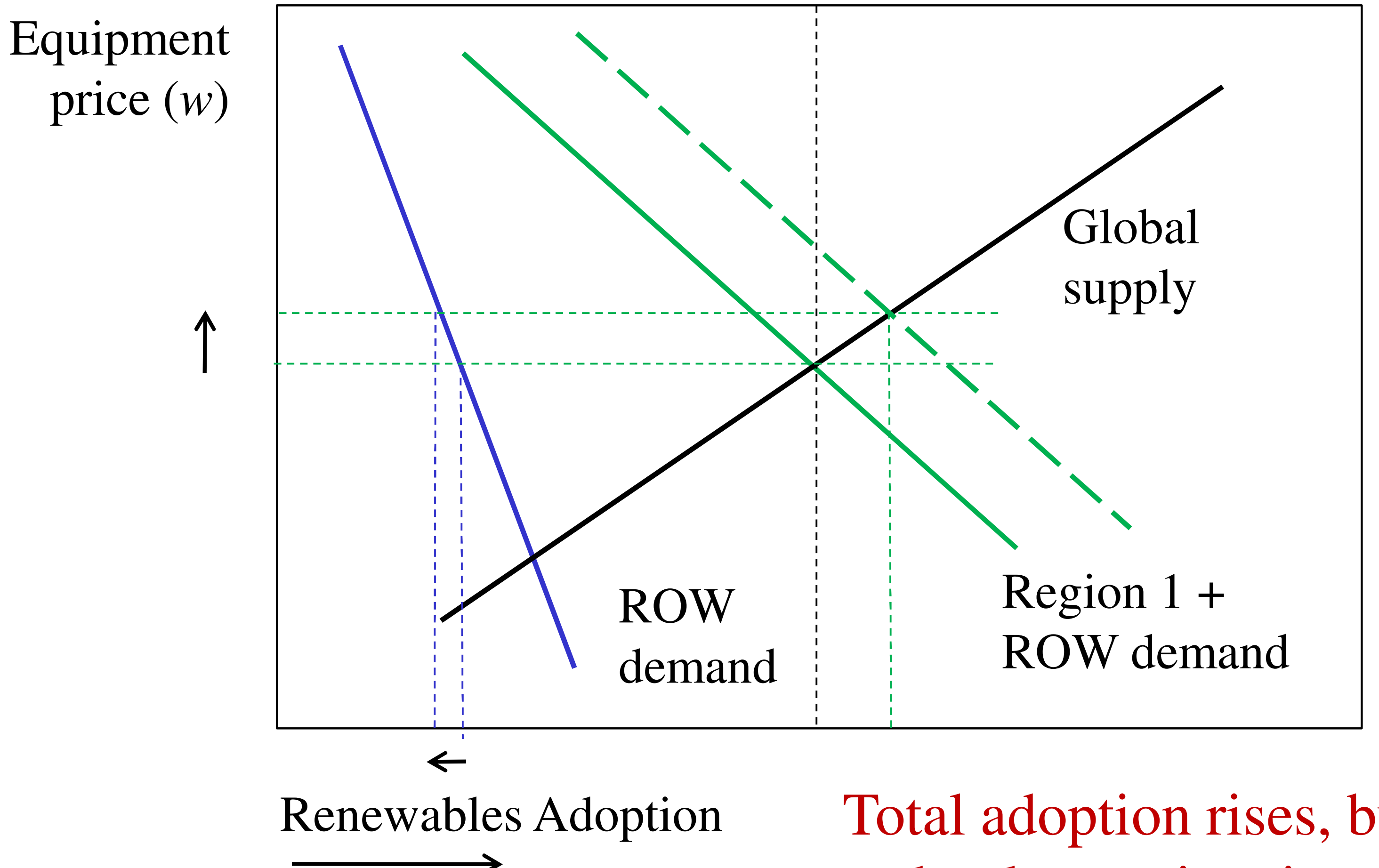
Renewable Technology market: Downstream subsidy



Total adoption rises, but technology price rises too and foreign adoption falls

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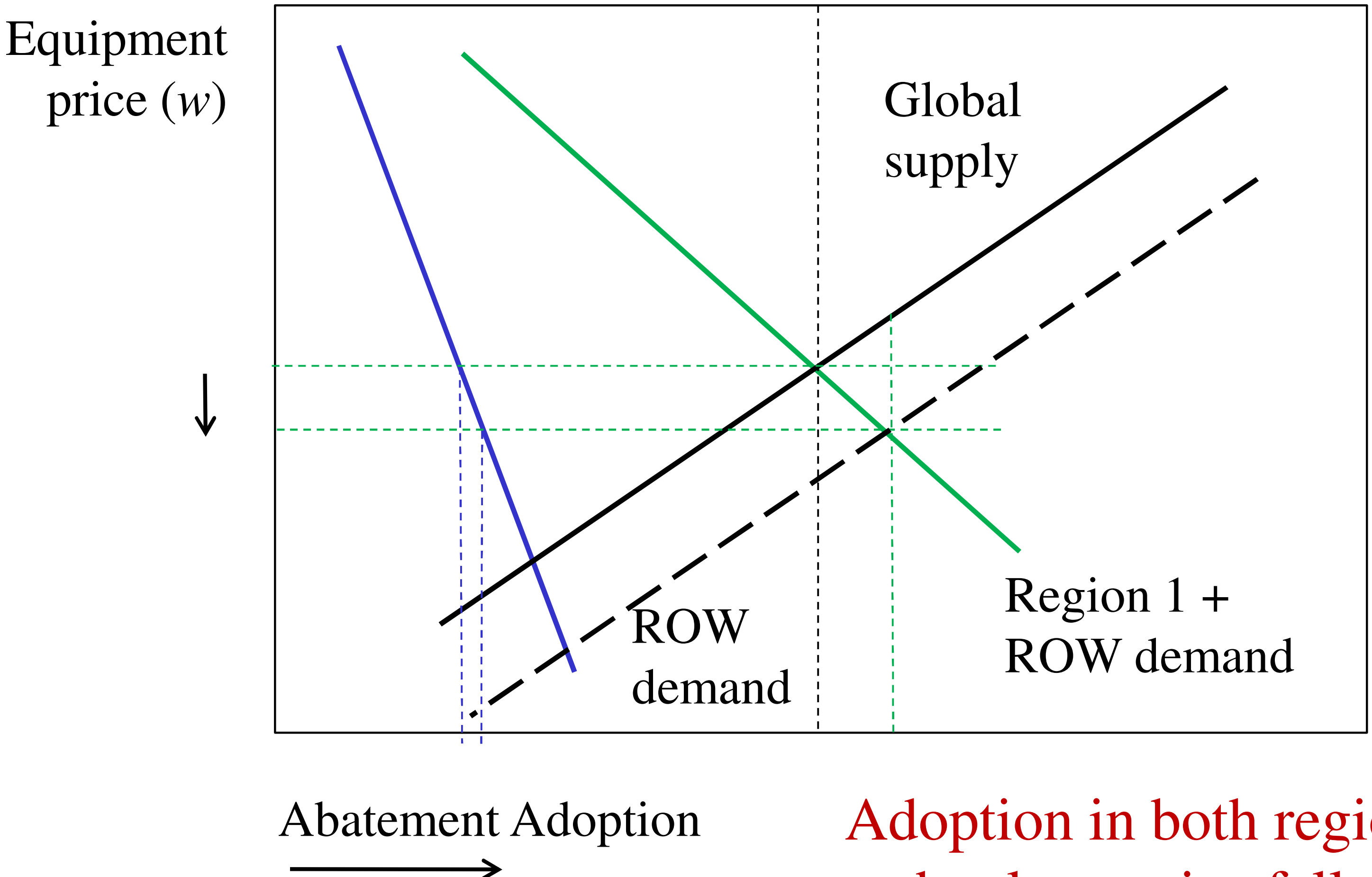
Renewable technology market: Upstream subsidy



Adoption in both regions rises, technology price falls

Planner and Nash equilibria

- Planner maximizes global welfare w.r.t. upstream / downstream subsidies in each producing region
  - Upstream subsidies symmetric

$$\{\partial W_G / \partial \gamma_1 = 0, \partial W_G / \partial \eta_1 = 0, \partial W_G / \partial \gamma_2 = 0, \partial W_G / \partial \eta_2 = 0\}.$$

- Nash game: each producer country maximizes its own welfare, taking other's subsidies as given, knowing its effects on the international market

$$\{\partial W_1 / \partial \gamma_1 = 0, \partial W_1 / \partial \eta_1 = 0, \partial W_2 / \partial \gamma_2 = 0, \partial W_2 / \partial \eta_2 = 0\}$$

- (Also some scenarios with policy constraints)

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Cournot (imperfect) competition: strategic equilibrium results

- Social planner subsidizes only upstream;

$$\gamma_C^* = (a-c)/(2n), \quad \eta_C^* = 0$$

- Nash: regions subsidize both up- and downstream;

$$\gamma_C^{\text{Nash}} = \frac{(a-c)(1+2n(1-m_3)+m_3(2-m_3))}{2n(1+2n+2m_3)} > 0$$

$$\eta_C^{\text{Nash}} = \frac{(a-c)m_3}{2n(1+2n+2m_3)} \geq 0.$$

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Cournot (imperfect) competition: strategic equilibrium results

- Social planner subsidizes only upstream;
  Nash: regions subsidize both up- and downstream;
- Without 3rd market, Nash equilibrium replicates the social optimum
  - sum of up- and downstream subsidies equal
- With 3rd market, the sum of the Nash subsidies are less than the planner's subsidy.
  - Also if only one subsidy tool is available
  - Joint-profit maximizing subsidies are even lower

Competitive markets without environmental benefits

- Optimal policy is to have no subsidies, but the Nash equilibrium has producer countries taxing upstream and subsidizing downstream by an equivalent amount, to the extent that they are net exporters
  - Both behaviors improve terms of trade

$$\gamma_i^{\text{Nash}} = -\eta_i^{\text{Nash}} < 0$$

$$\eta_i^{\text{Nash}} = hm_3 \frac{b(a-c)}{(b+h)^2 + m_3(2(b+h) - hm_3)} > 0$$

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Competitive markets without environmental benefits

- Optimal policy is to have no subsidies, but the Nash equilibrium has producer countries taxing upstream and subsidizing downstream by an equivalent amount, to the extent that they are net exporters
  - Both behaviors improve terms of trade
- In a symmetric-country duopoly, strategic subsidies are zero.
- Also in this case, no excess upstream subsidies from strategic trade

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Downstream external benefits (of consuming the green good)

- Global planner sets subsidies so the sum = MEB in all regions $\left\{\gamma_i^* = v_G \mu_3;\ \eta_i^* = v_G(\mu_i - \mu_3)\right\}, i = \{1, 2\}$
- *Sum* of the Nash subsidies equals the MEB as valued by that country $\gamma_i^N + \eta_i^N = v_i \mu_i,\ i = \{1, 2\}$
- Without 3rd market, Nash duopoly replicates the social optimum *if* they value at the global SCC
- With 3rd market, insufficient upstream subsidies and lower environmental gains

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External scale effects

$$\pi_d = \left(P + \gamma_d - (c + hy_d - g(Y_d + \beta Y_f))\right) y_d$$

- Optimal policy is to subsidize upstream
- Nash equilibrium has producer countries subsidizing downstream and subsidizing or taxing upstream, depending whether spillover scale effects dominate individual decreasing returns
- Without cross-country spillovers, strategic countries under-subsidize in total (the sum of the subsidies is less than the planner's) to the extent there is a third-country downstream market

Summary of theory

- These kinds of market failures suggest that restrictions on upstream subsidies are counterproductive for the environment and global welfare
- Quantitatively, how important are they?

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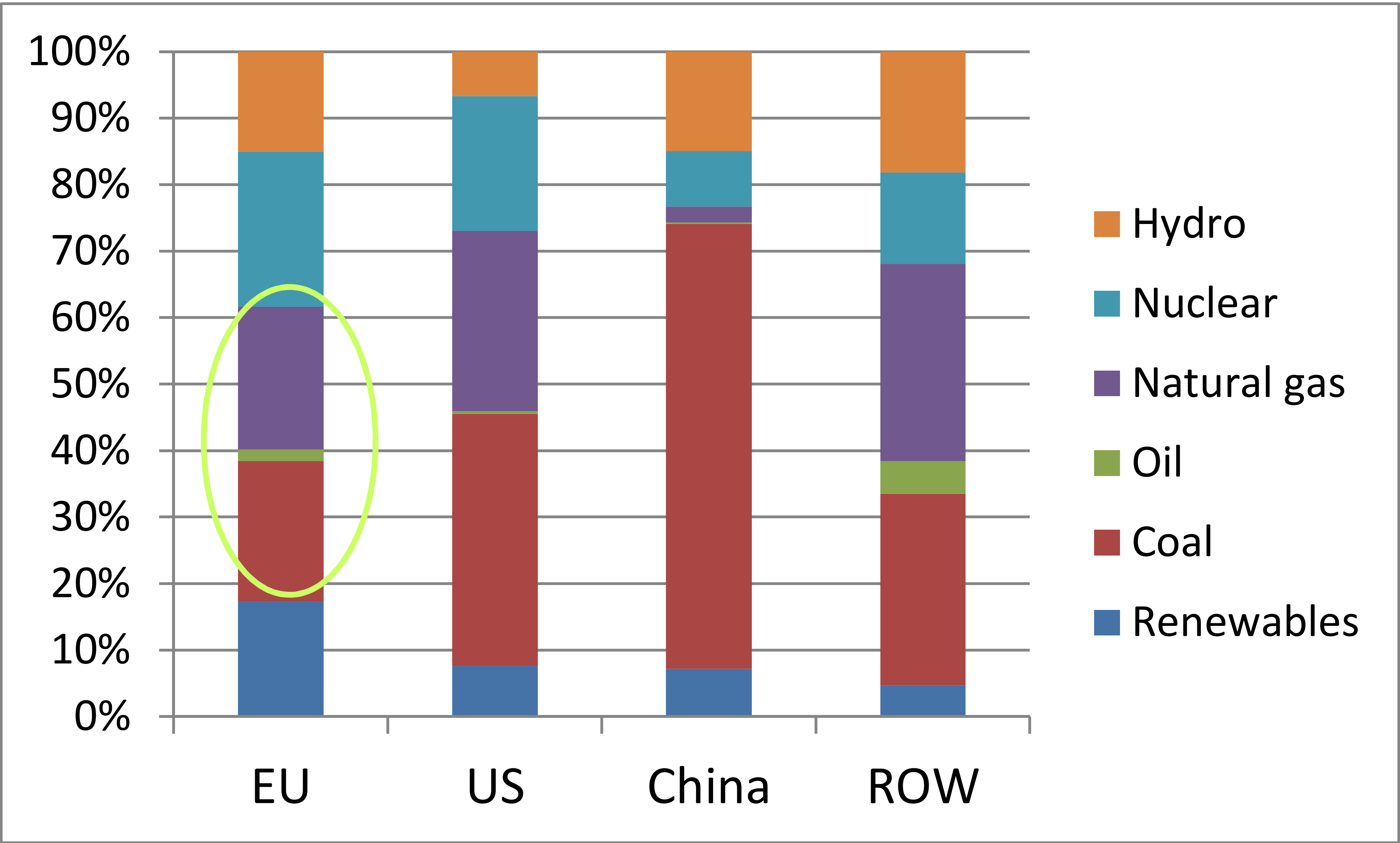
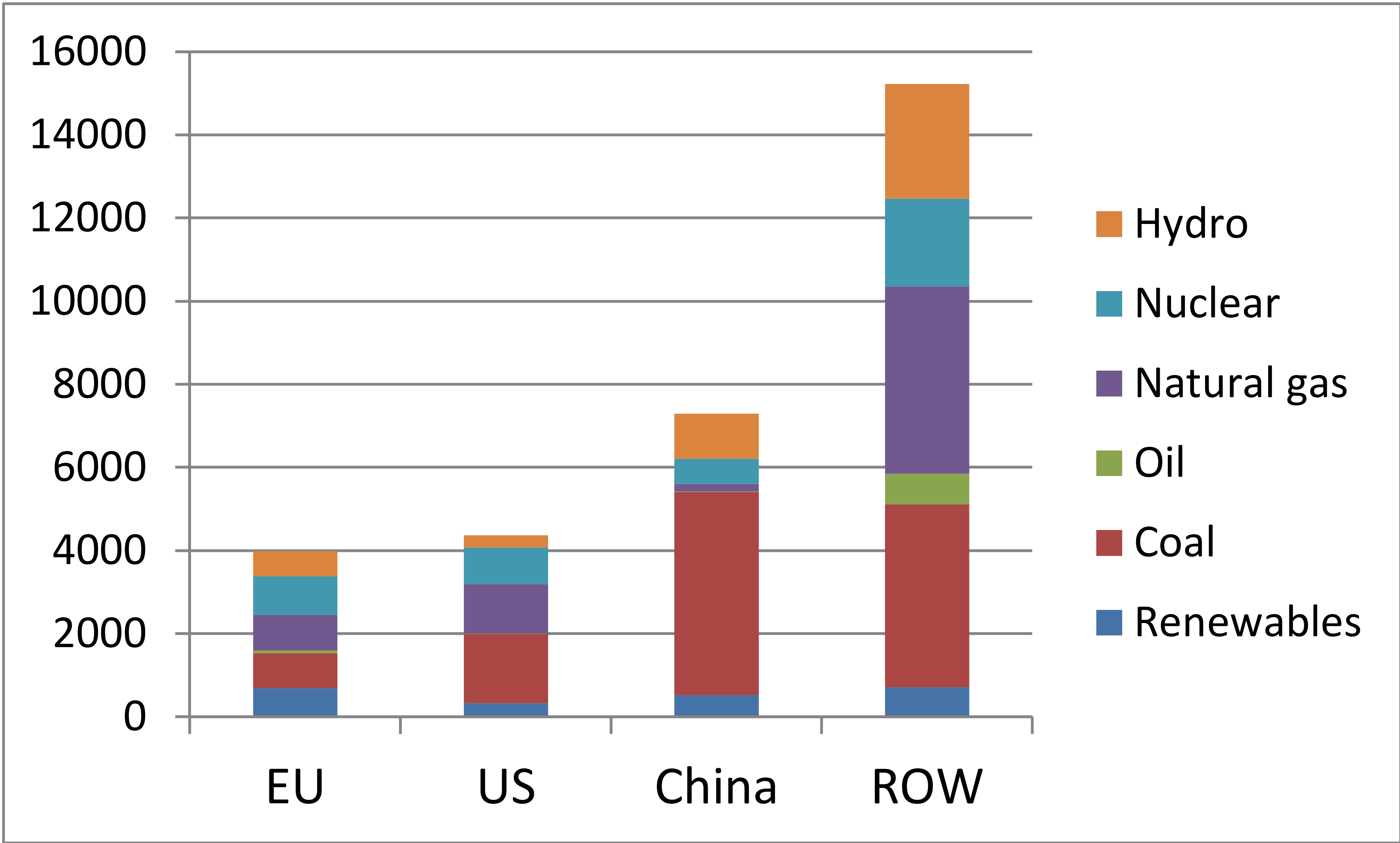
Numerical simulations: an application to renewable energy

- Downstream electricity markets with linear supply curves for fossil and renewable energy
  - 2020 projections from International Energy Outlook
  - Market equilibrium derives renewables as function of the policy variables
- Slope parameters based on other exercises
  - Fischer, Newell and Preonas (2013) for US
  - Fischer, Huebler and Schenker (2014) for EU
  - No dynamics here; 2015-2020 stage
  - China and ROW assumed to have same supply elasticities at the baseline point

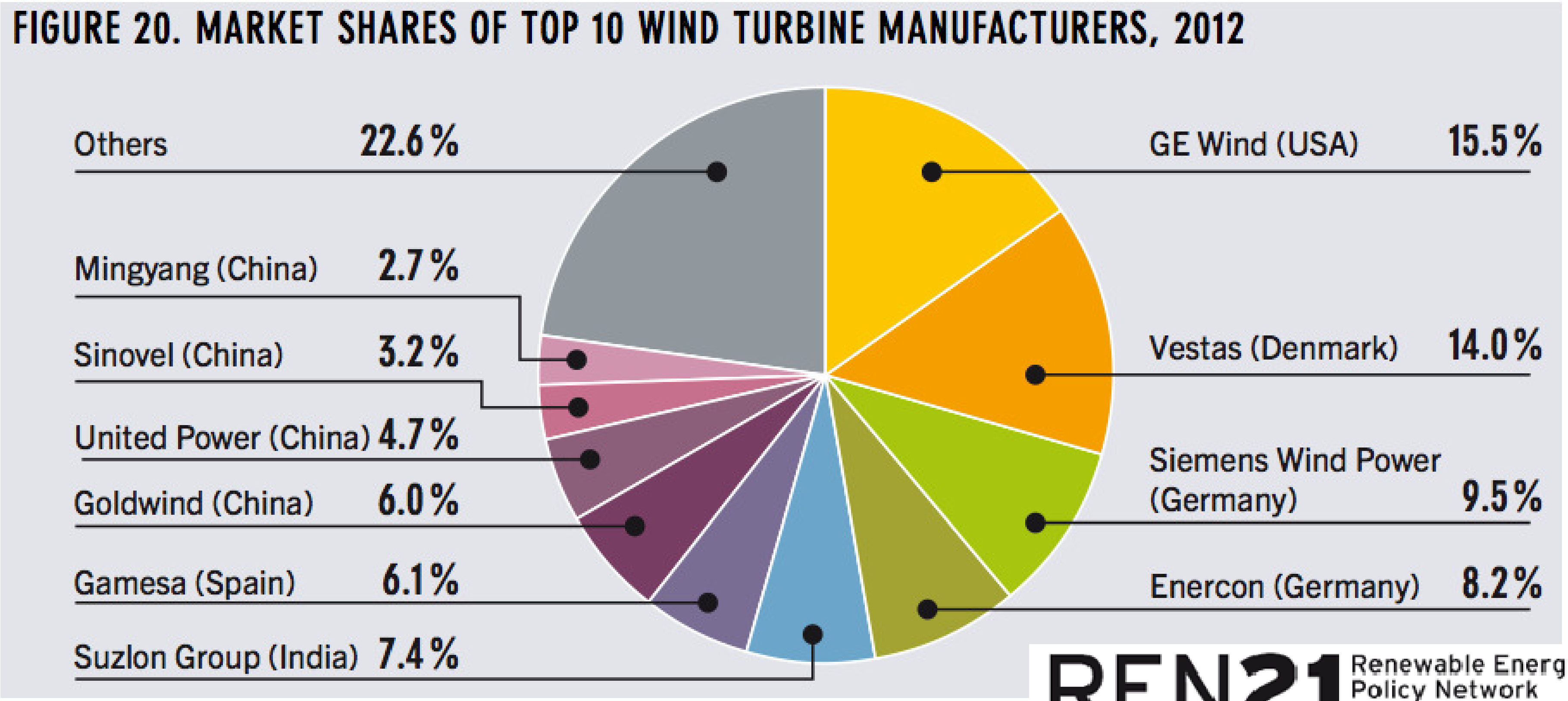
Energy shares in 2020 baseline
(IEO 2014)



Generation in 2020 by source



Upstream market stylized for wind



REN21 Renewable Energy Policy Network for the 21st Century

- By region:
  - US 16%; EU 38%; China 16%
  - Together, 70% of the market

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Upstream market stylized for wind

15.5%	GE Energy	USA
14.0%	Vestas	Denmark

- Imply 7ish firms in Cournot setup
- Market share of top EU producers is 38%
- Assumptions
  - Imperfect competition (IC):
    2 firms in US & China, 4 in EU
    - Still working on including China…
  - Perfect competition (PC):
    200 in US & China, 400 in EU

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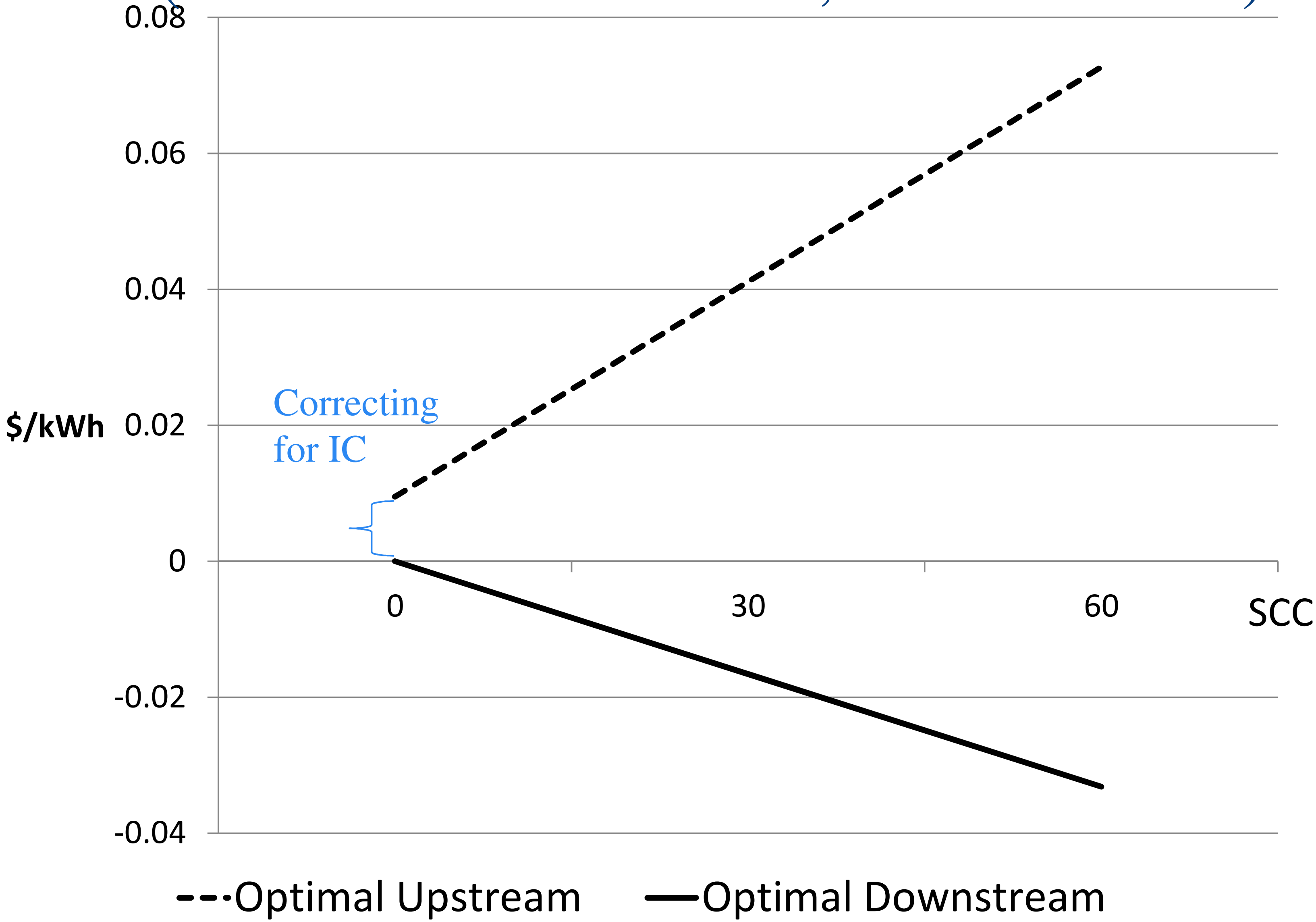
Scenarios

- Value of social cost of carbon (SCC), including by producer countries
  - Sensitivity to downstream market failure
- Pricing of carbon in producer countries
  - Sensitivity to downstream regulations
- IC vs. PC
  - Sensitivity to upstream market failure
- With and without ROW
  - Sensitivity to size of export market

Optimal subsidies in the EU and the SCC

(All value MEB at SCC; No CO2 taxes)



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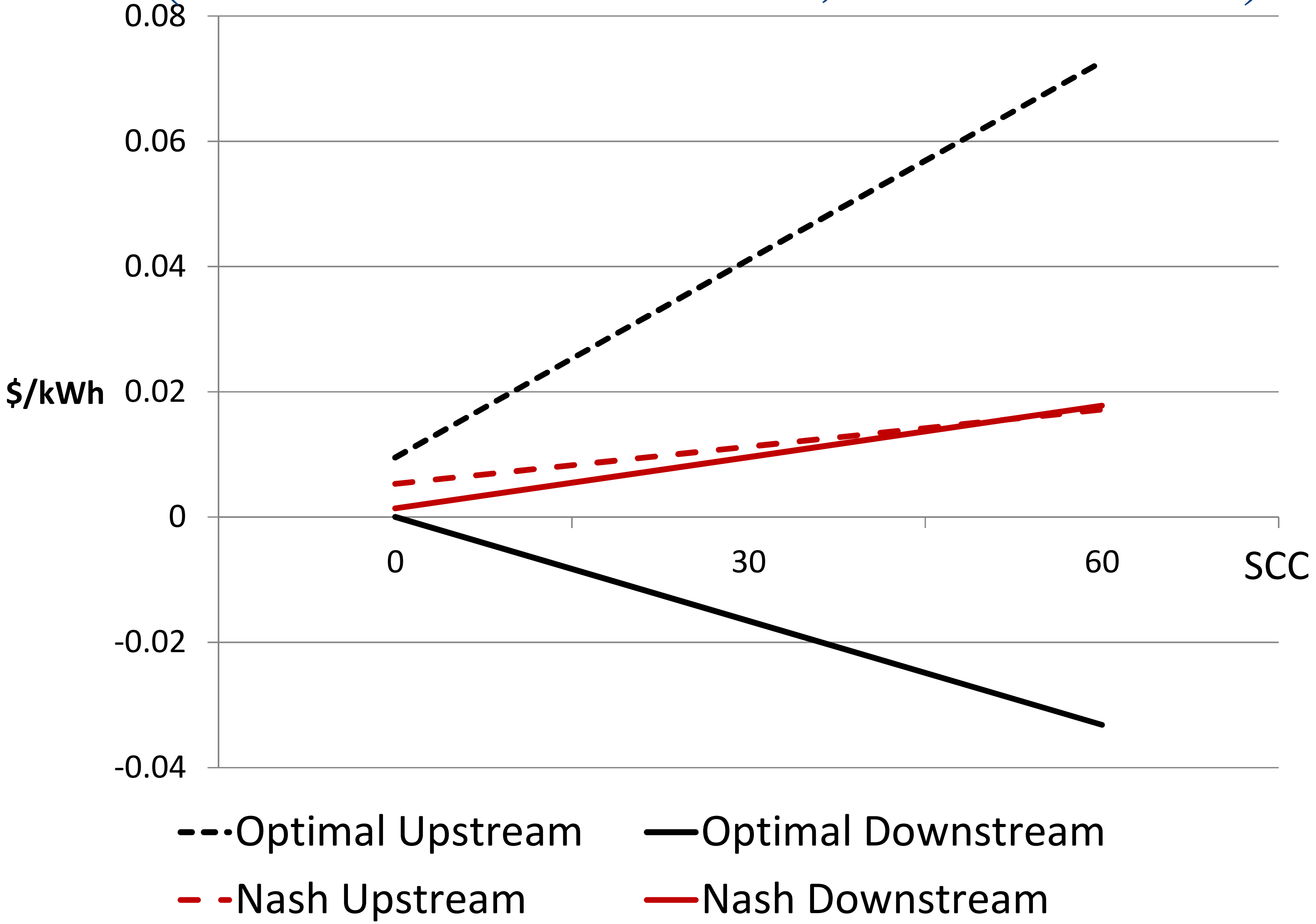

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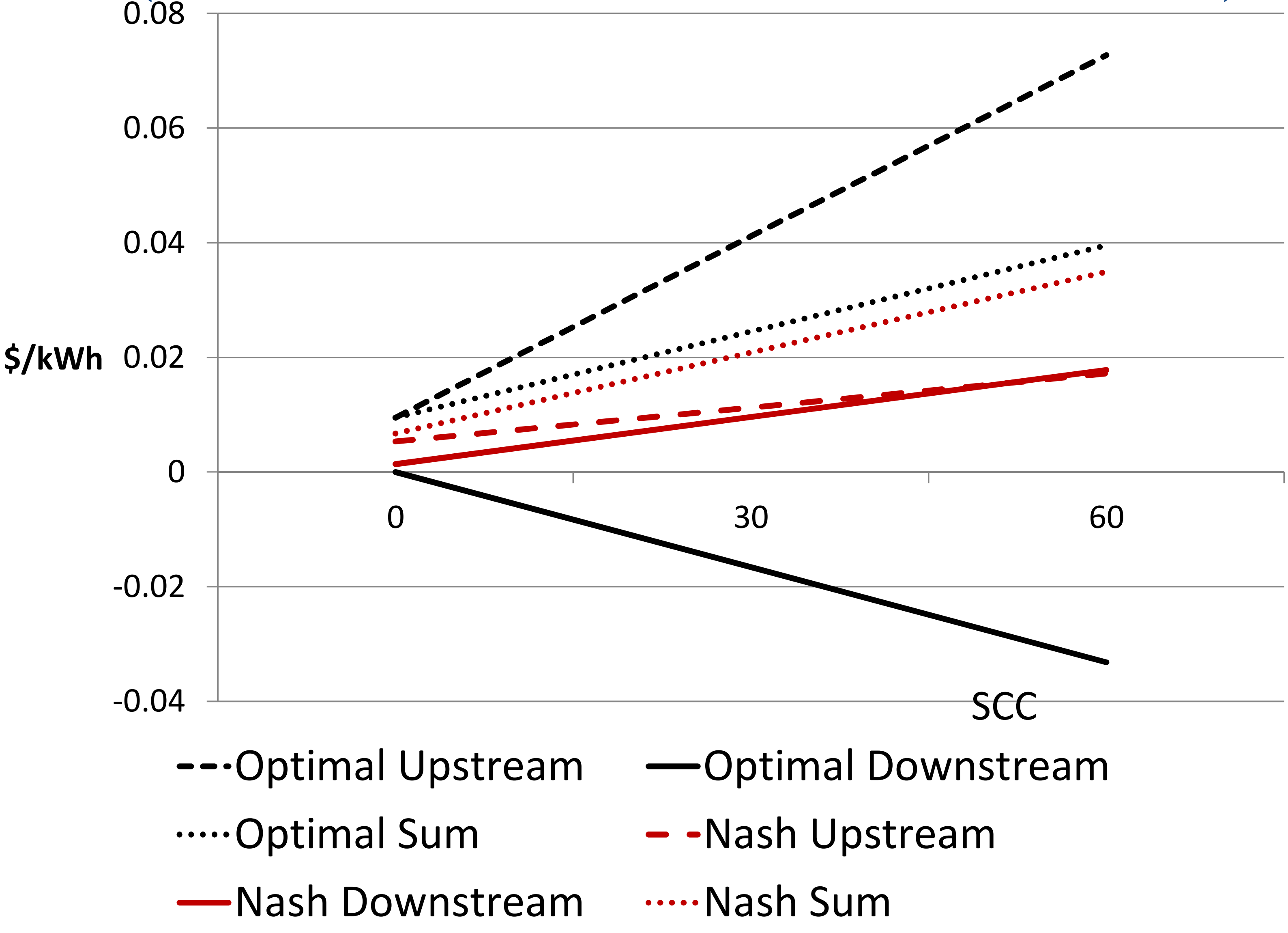
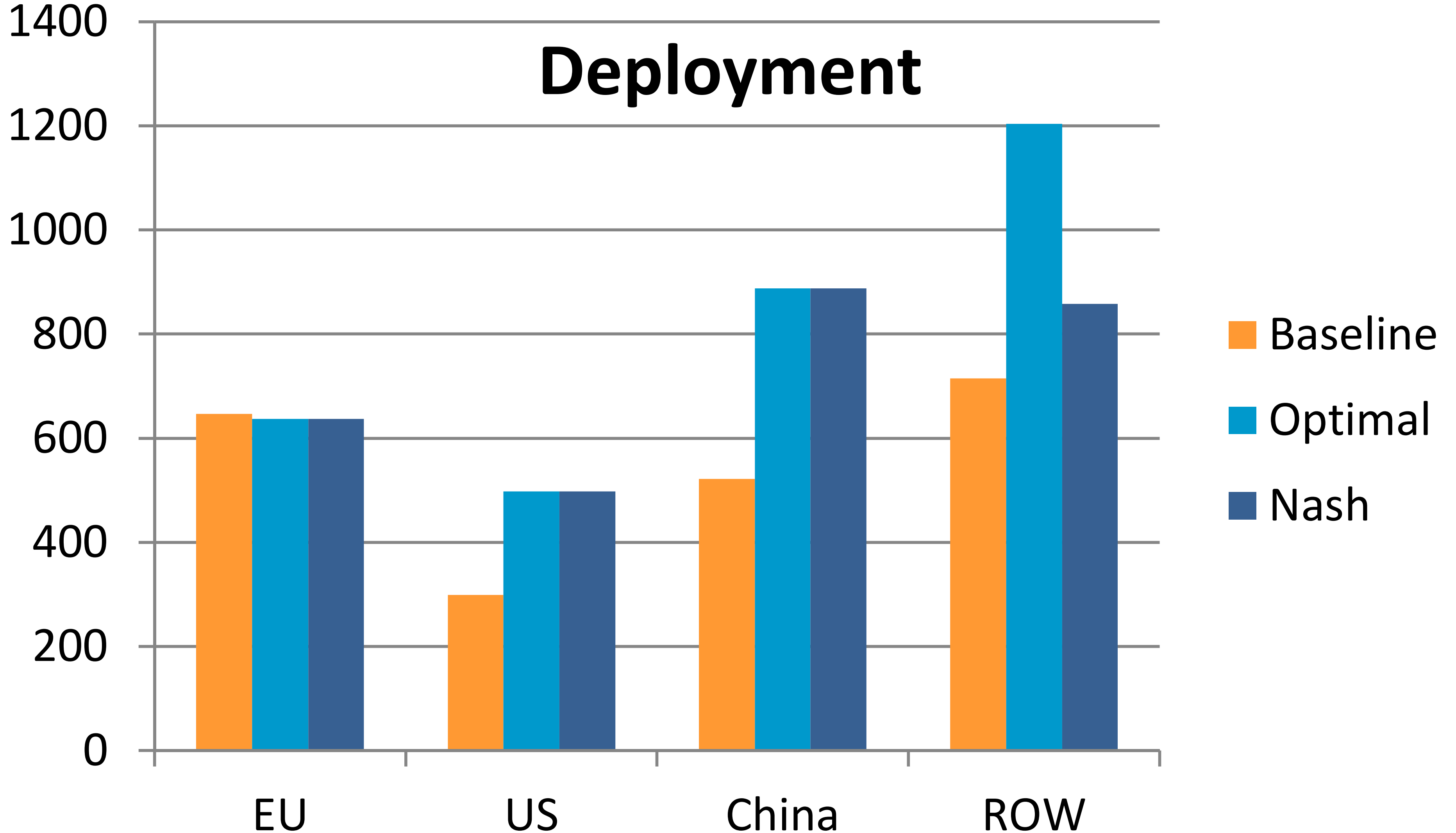
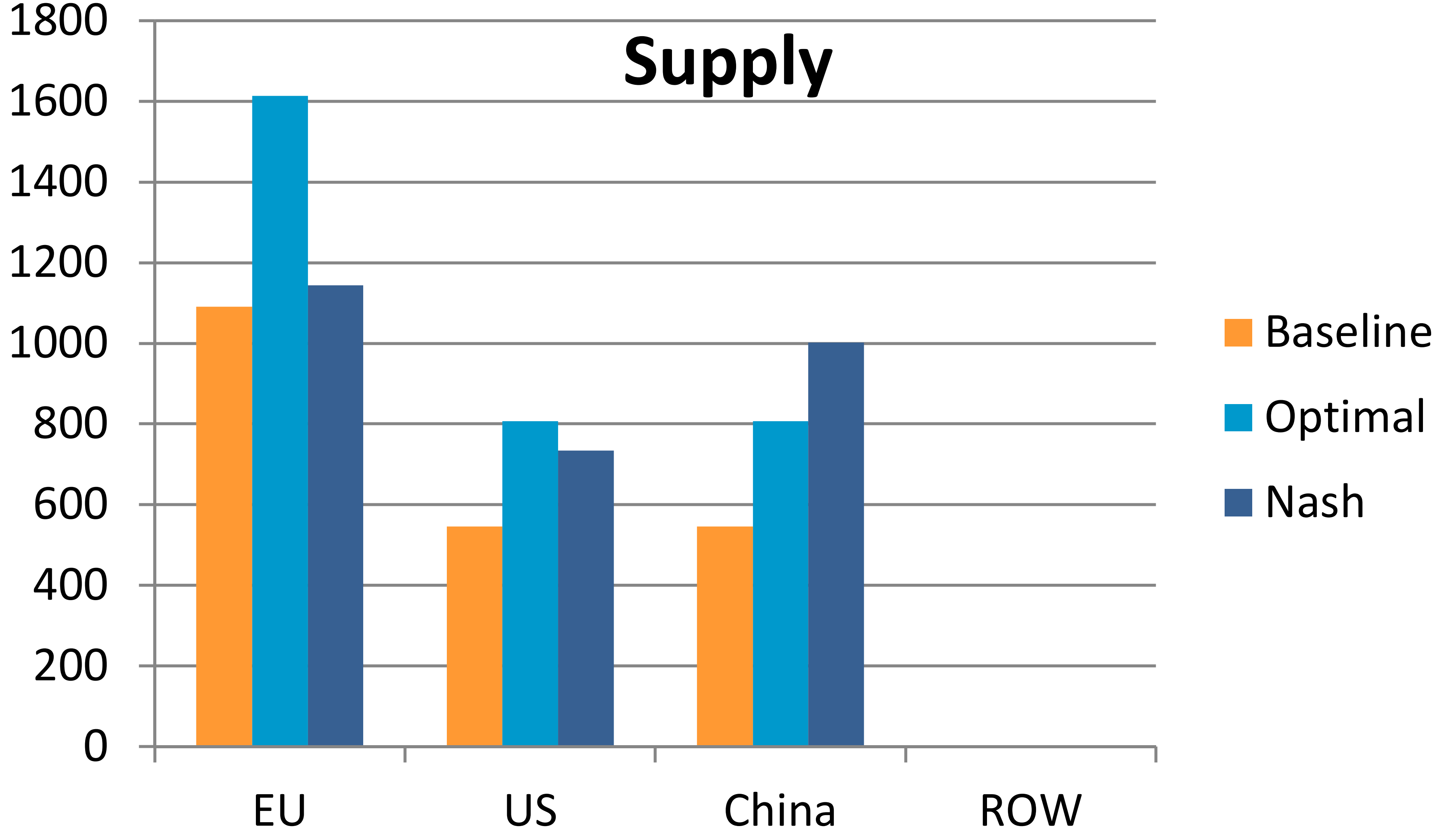


Downstream outcomes by scenario

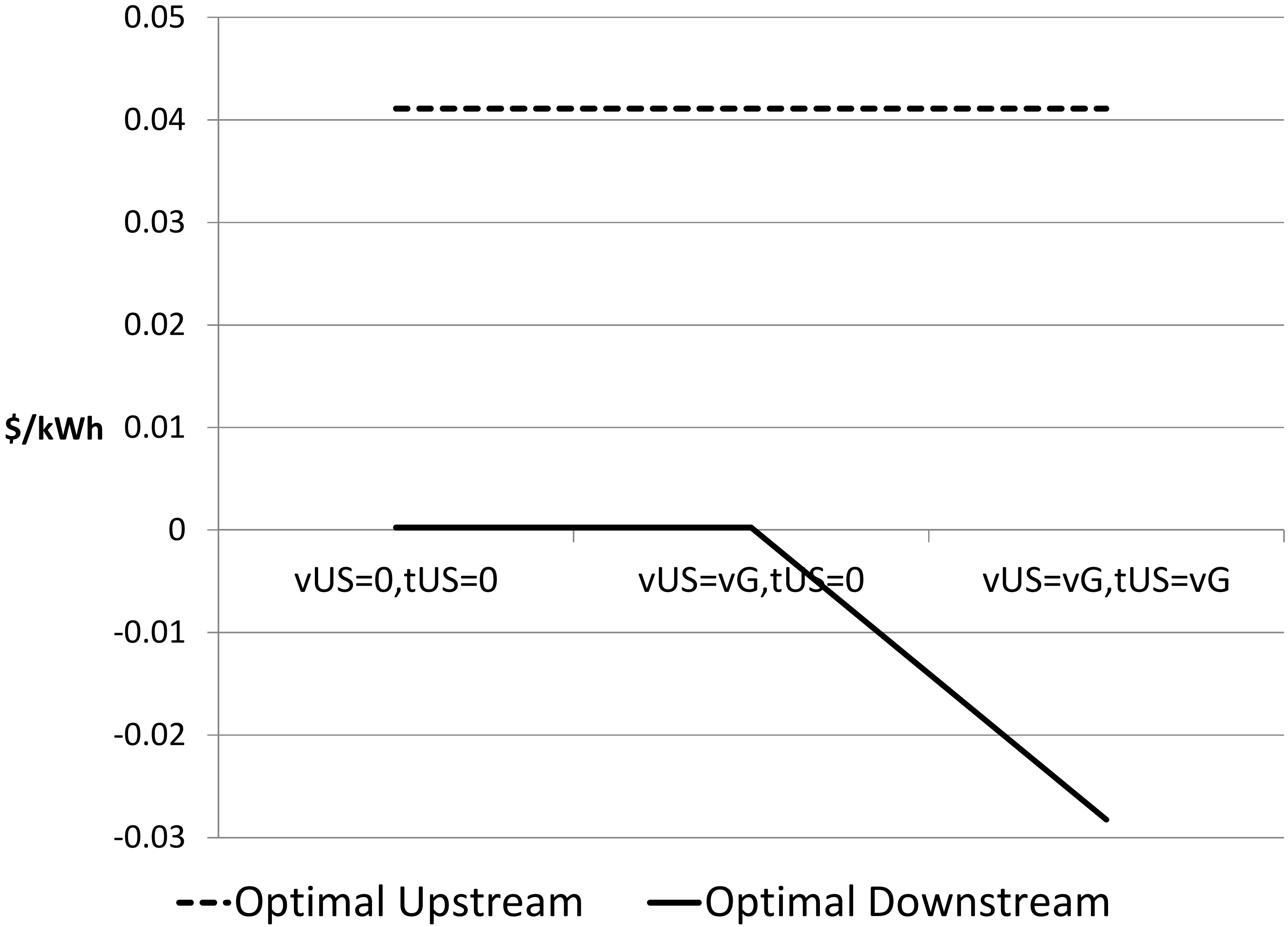


Upstream outcomes by scenario



Optimal subsidies, valuation, CO2 pricing

(SCC = EU $30/ton CO2 price)



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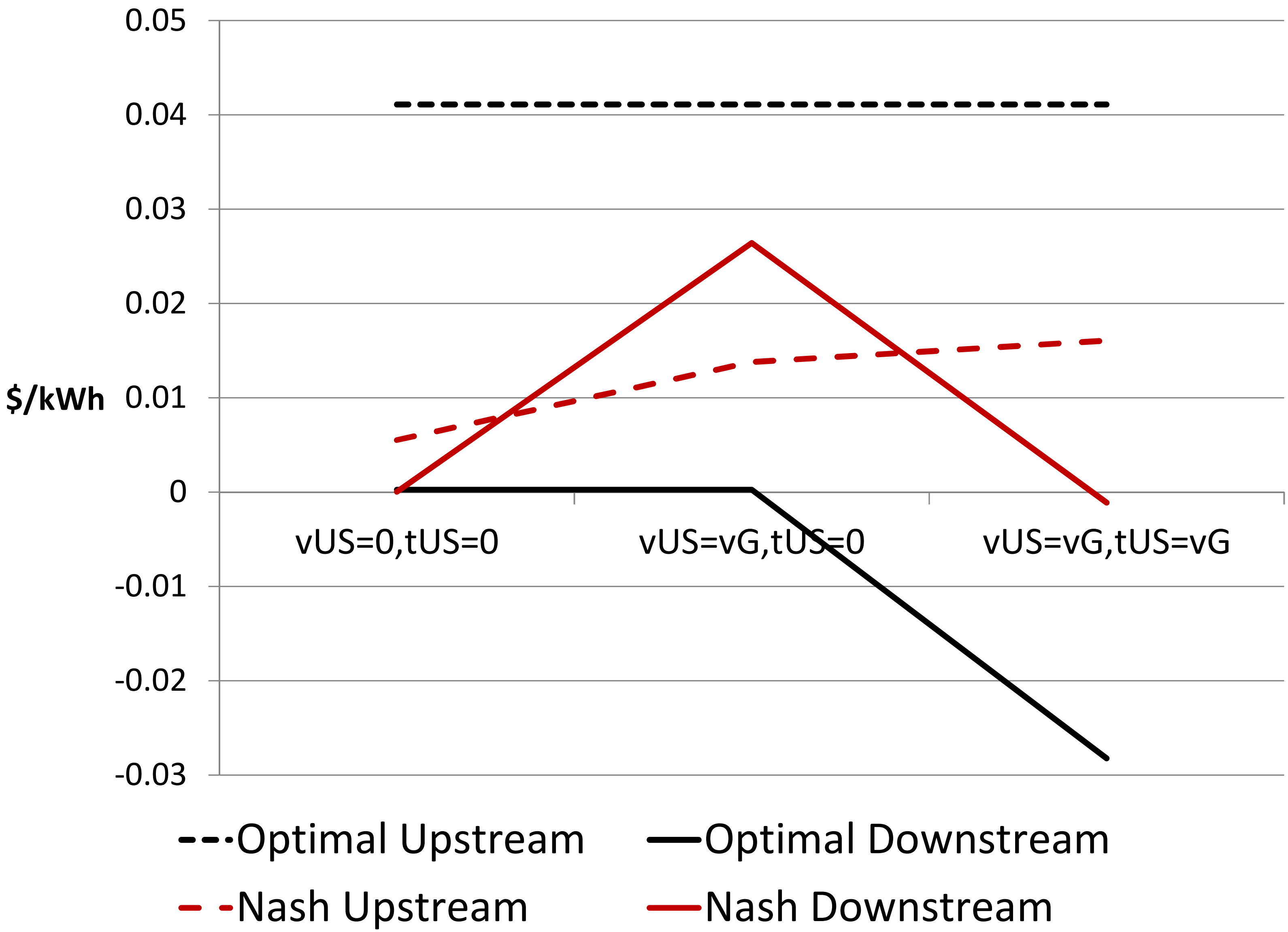

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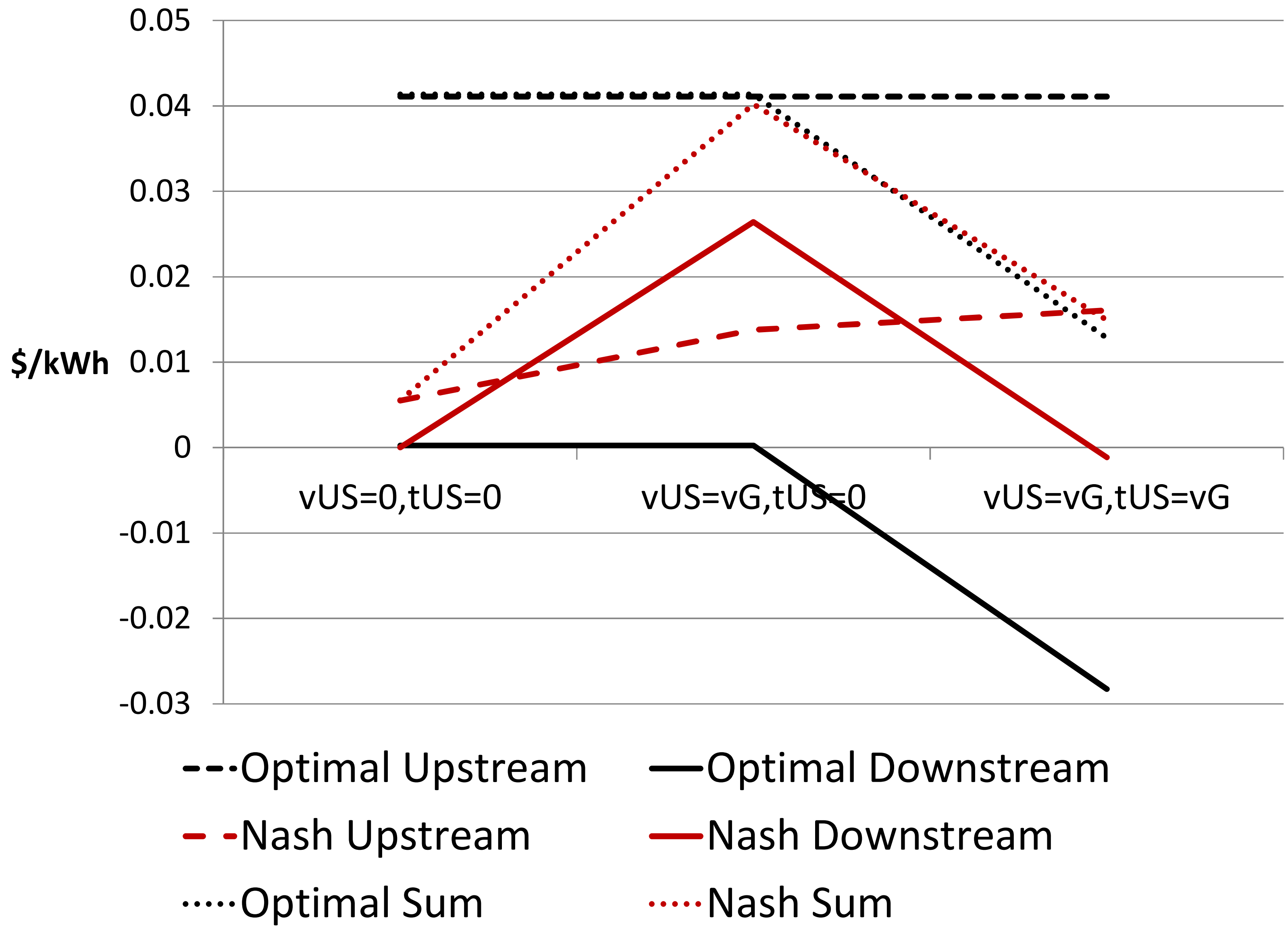
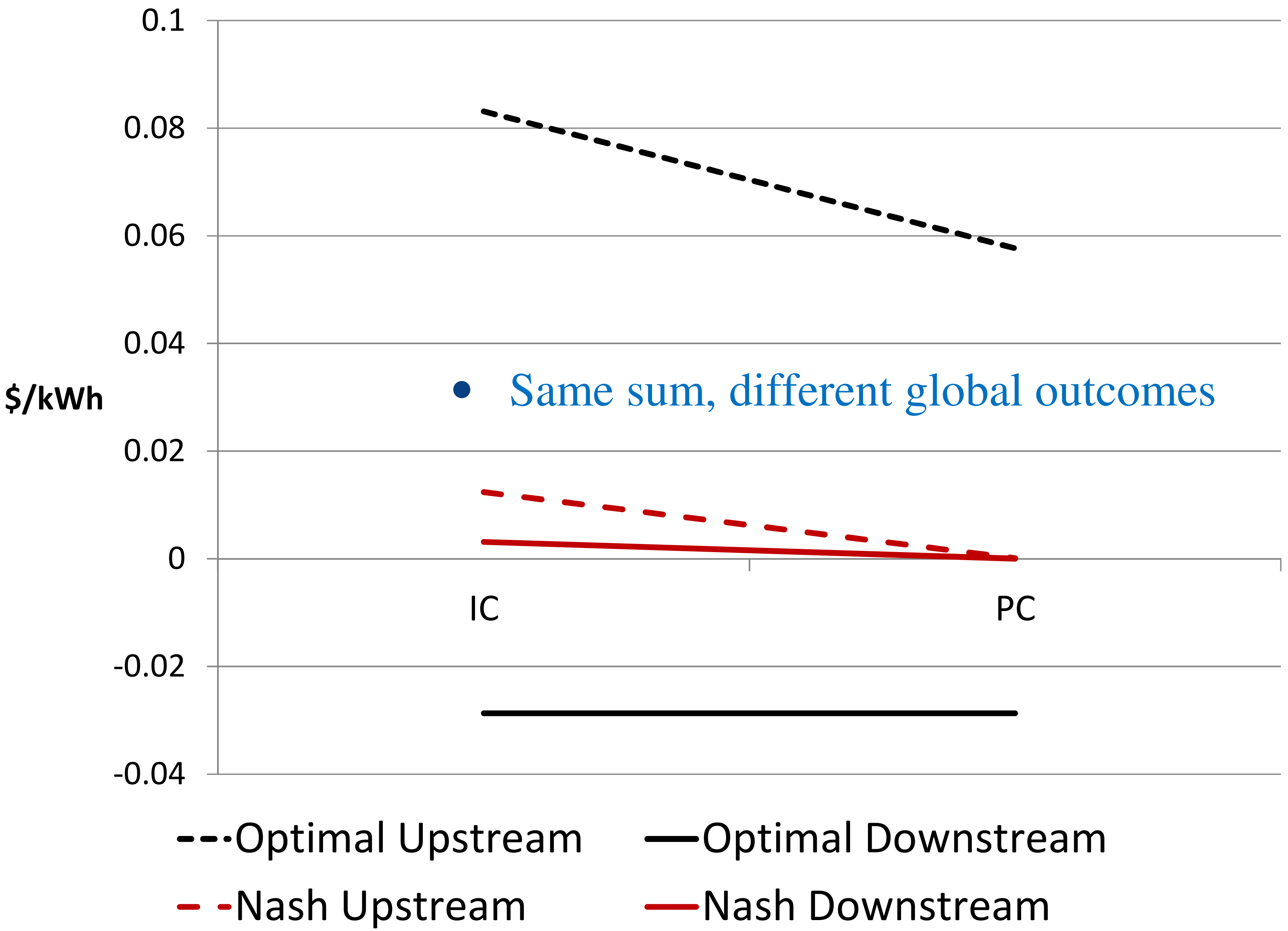


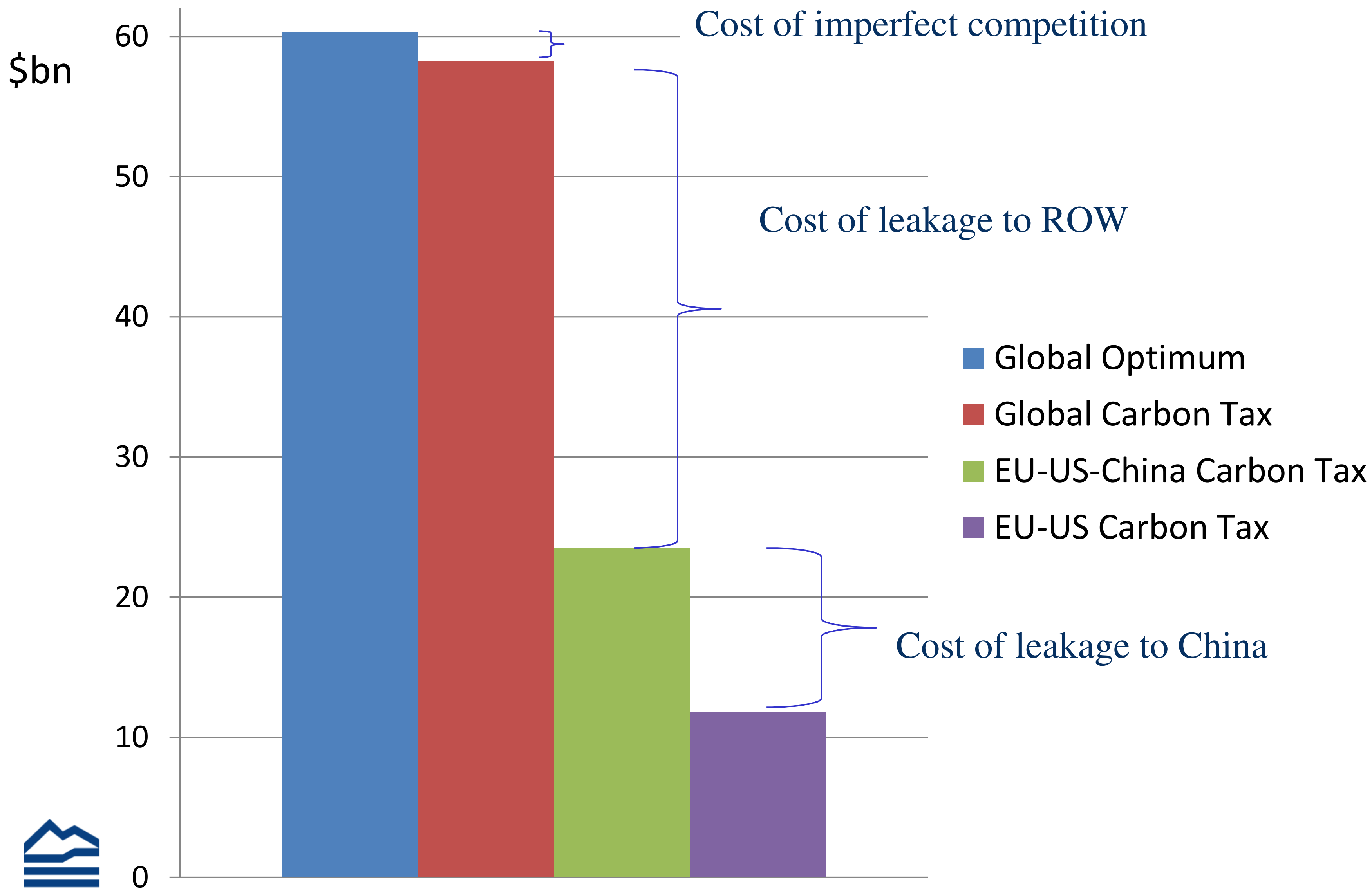
Optimal unilateral EU subsidies



- Same sum, different global outcomes

Global welfare change from No Policy

(IC and all value MB at SCC of $30)



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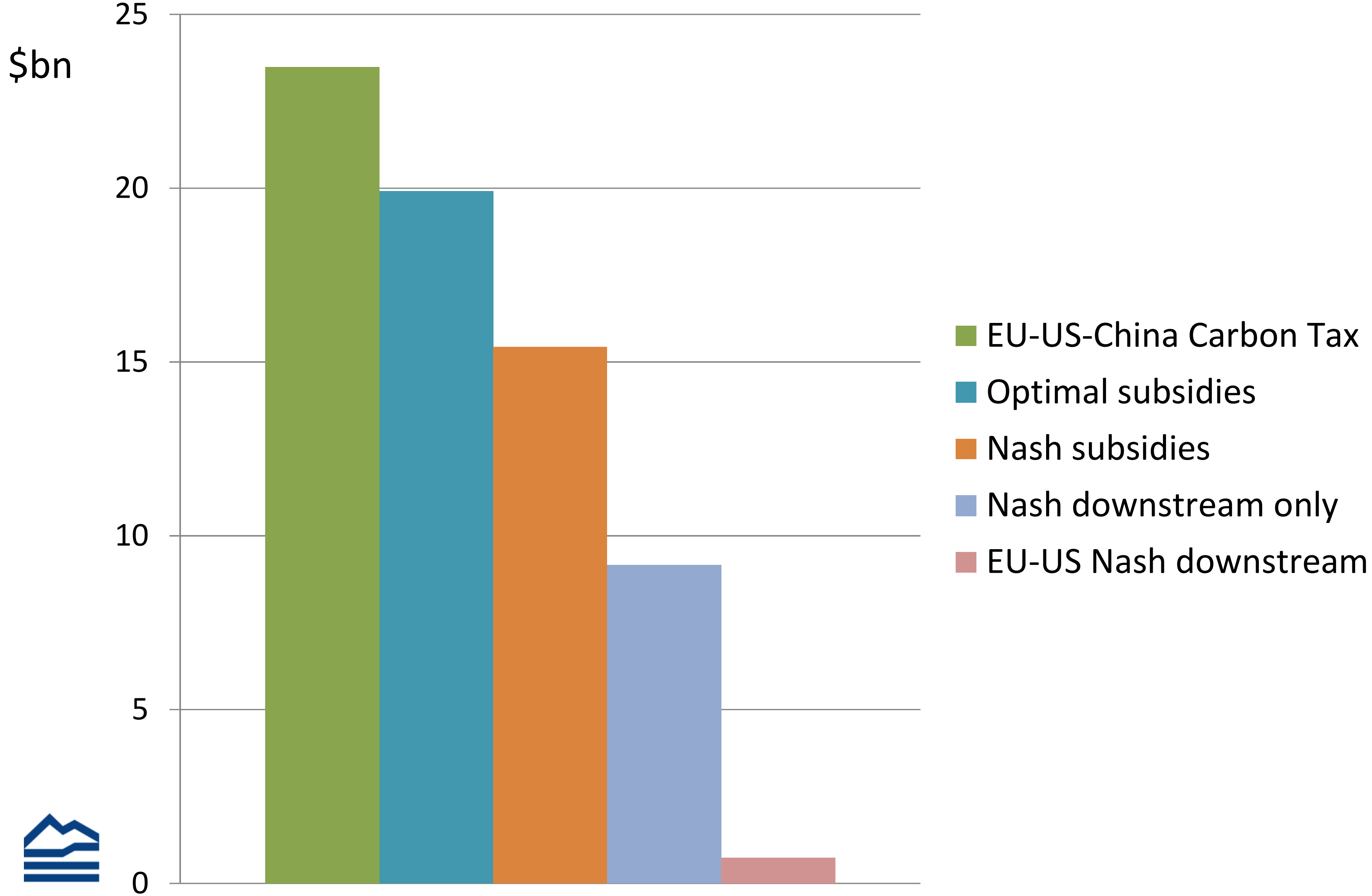
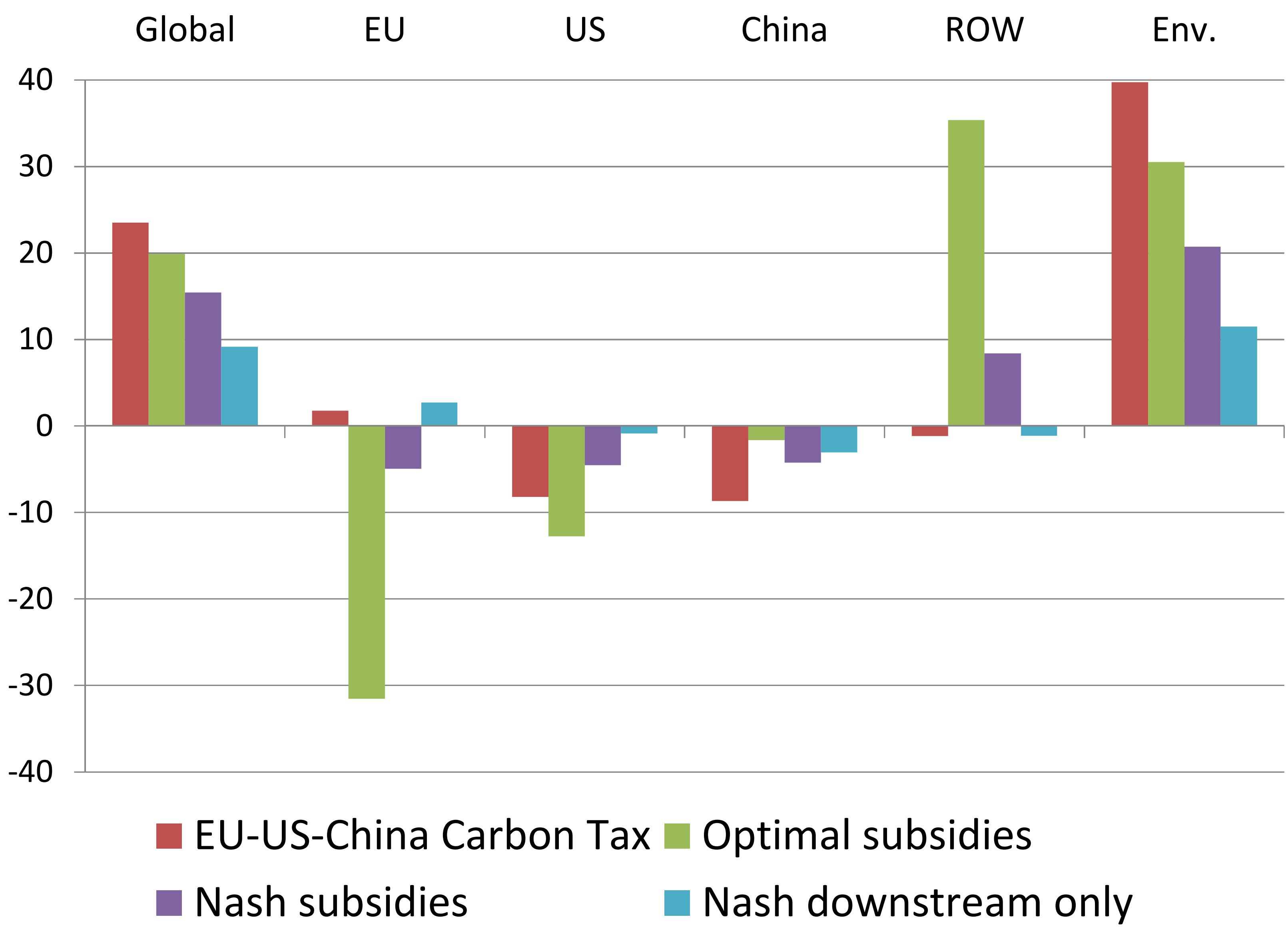


Distributional effects of producer policies



Conclusions

- Some legitimate rationales for subsidizing renewable energy—particularly upstream—even with other climate policies in place
  - Market power, barriers for new technologies
  - Leakage
  - Scope similar in range to optimal learning subsidies
- Leakage rationale depends on the policy context
  - Upstream more effective with carbon tax
  - But may expand emissions with binding RPS
- Need for thoughtful WTO rules for environmentally oriented manufacturing subsidies

Caveats

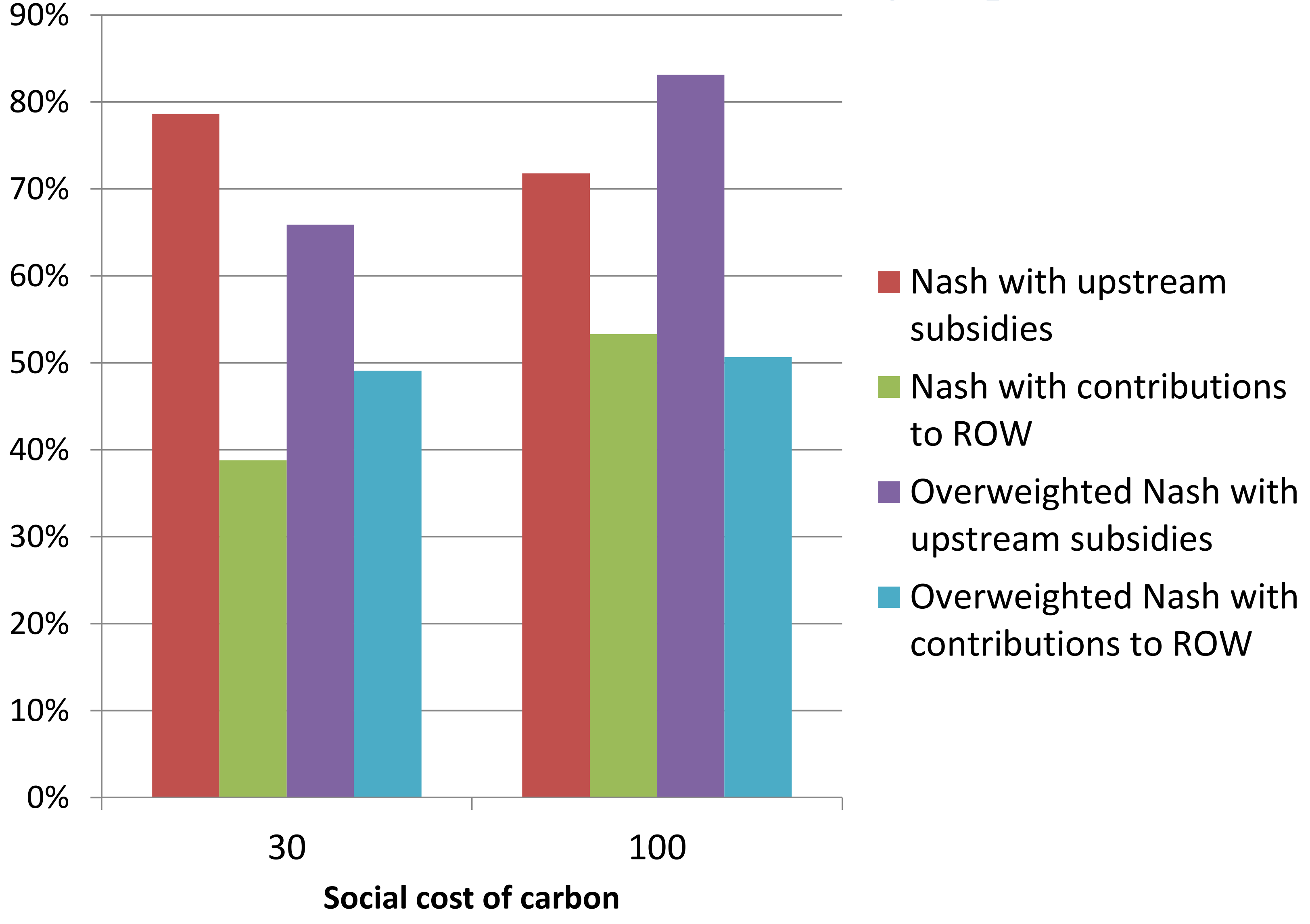
- May be other (unmodeled) reasons why we might worry about upstream subsidies
  - MCPF
    - But countries should take this into account
  - Entry deterrence and dynamic inefficiencies
    - Allegations in solar industry
  - Rent-seeking by industries
    - If governments are convinced to overweight upstream industries profits, do they subsidize too much?

Alternative policies

- Get producer countries to subsidize deployment in ROW
  - E.g. CDM, climate finance
- If upstream subsidies are restricted, are producer countries willing?
  - Helps alleviate leakage and raises export demand
  - Free riding problem

Global welfare change from No Policy compared to Optimal Subsidies

(IC and all value MB at SCC of $30; double weight upstream industry)



Extensions

- Knowledge spillovers
  - Do policy recommendations change with endogenous R&D and learning and international spillovers?
  - Is global supply downward sloping in short or long run?

Thanks!

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