Pricing Carbon: A Global Perspective

Michael G. Pollitt

Cambridge Judge Business School

ISCI/UAI

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My starting point

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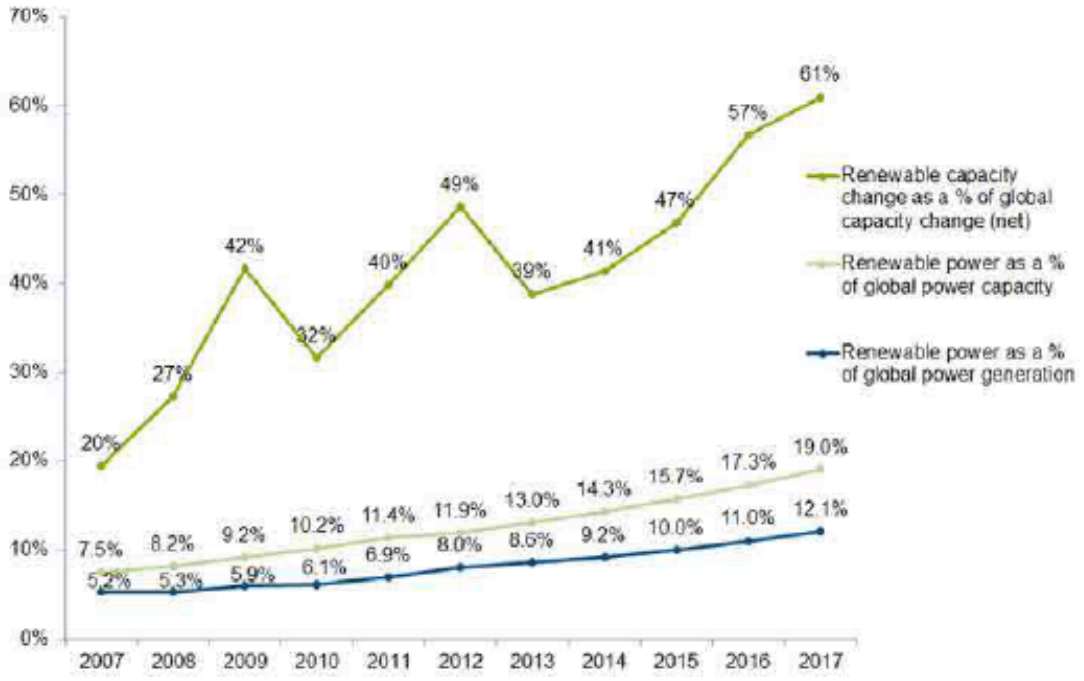
With thanks to
Geoffroy Dolphin

Outline

- The spread of carbon pricing
- A global carbon market?
- The EU ETS: Progress and Prospects
- The Australian Carbon Tax Lessons
- Progress in the US and China
- Issues

An energy transition: global trends in power sector investment

FIGURE 23. RENEWABLE POWER GENERATION AND CAPACITY AS A SHARE OF GLOBAL POWER, 2007-2017, %



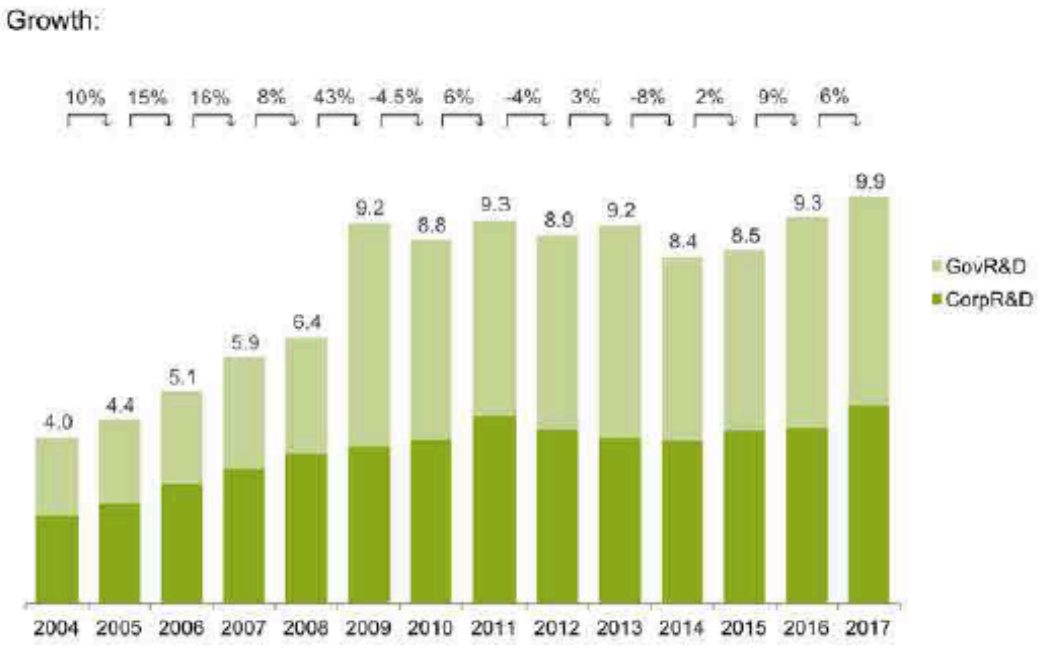
Renewables figure excludes large hydro. Capacity and generation based on Bloomberg New Energy Finance totals.

Source: UN Environment, Bloomberg New Energy Finance

Source: UNEP/BNEF (2018) *Global Trends in Renewable Energy Investment*, 2018, p.32.

An energy transition: Global R&D in Renewables

FIGURE 48. R&D INVESTMENT IN RENEWABLE ENERGY, 2004-2017, $BN



Source: Bloomberg, Bloomberg New Energy Finance, IEA, IMF, various government agencies

Source:
UNEP/BNEF (2018) *Global Trends in Renewable Energy Investment*, 2018, p.72.

Fossil Fuel subsidies globally, $260bn in 2016.

Renewable power subsidies globally, $140bn in 2016.

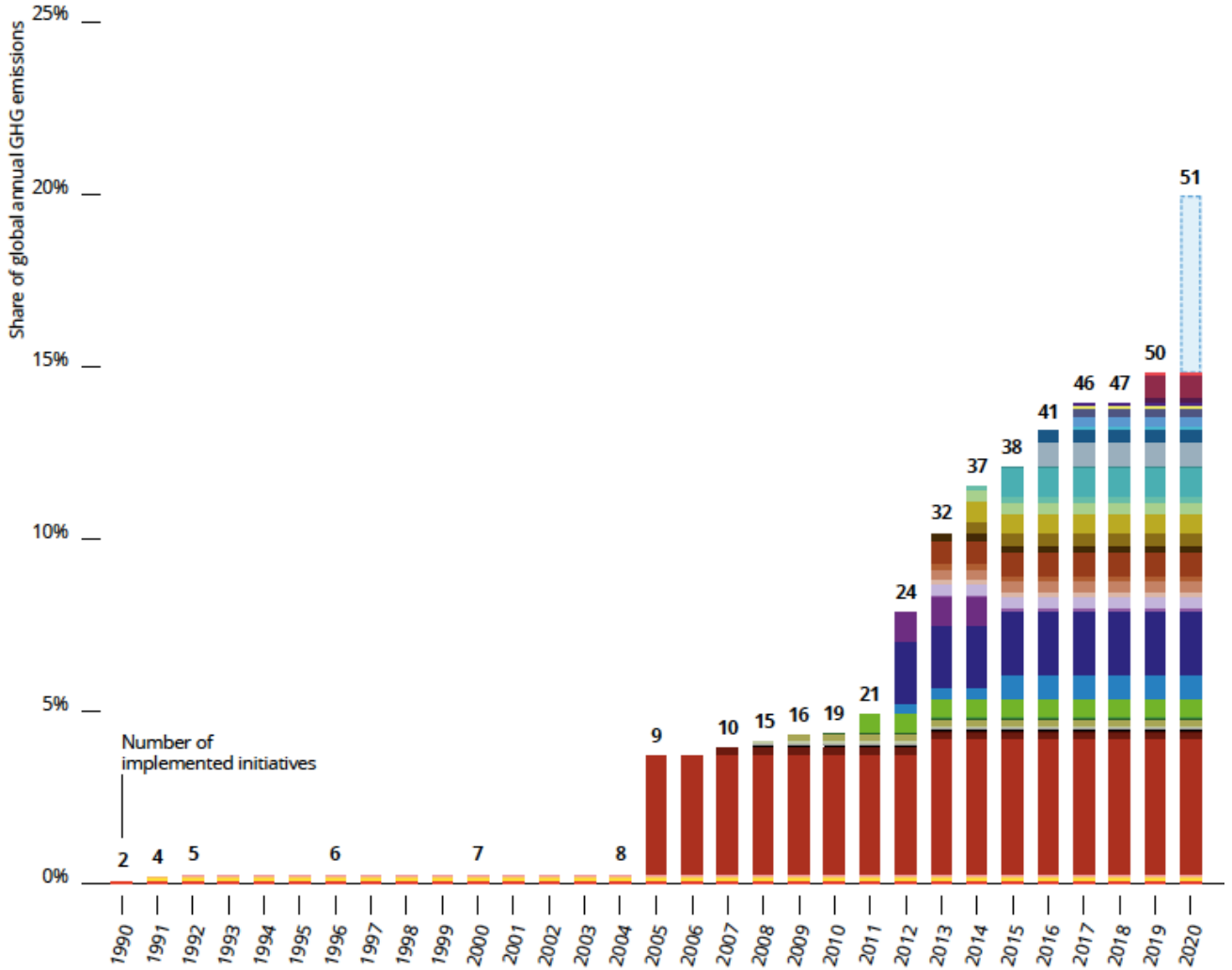
Source: IEA (2017) WEO.

Basic Thesis

- The policy solution to excessive emissions of GHGs is well established:
  - In theory
  - In (*very* large scale) experiments
- The policy community (a.k.a. climate scientists) should stop suggesting that we do not know what to do about climate change. In 2017 we spent est. $9.9bn p.a. on RES RD+D and in power global RES investment is closing in on global fossil investment (UNEP/BNEF, 2018).
- We should (simply!) implement a reasonably comprehensive set of quantity restrictions on CO2e, building on EUETS experience.

The spread of carbon pricing

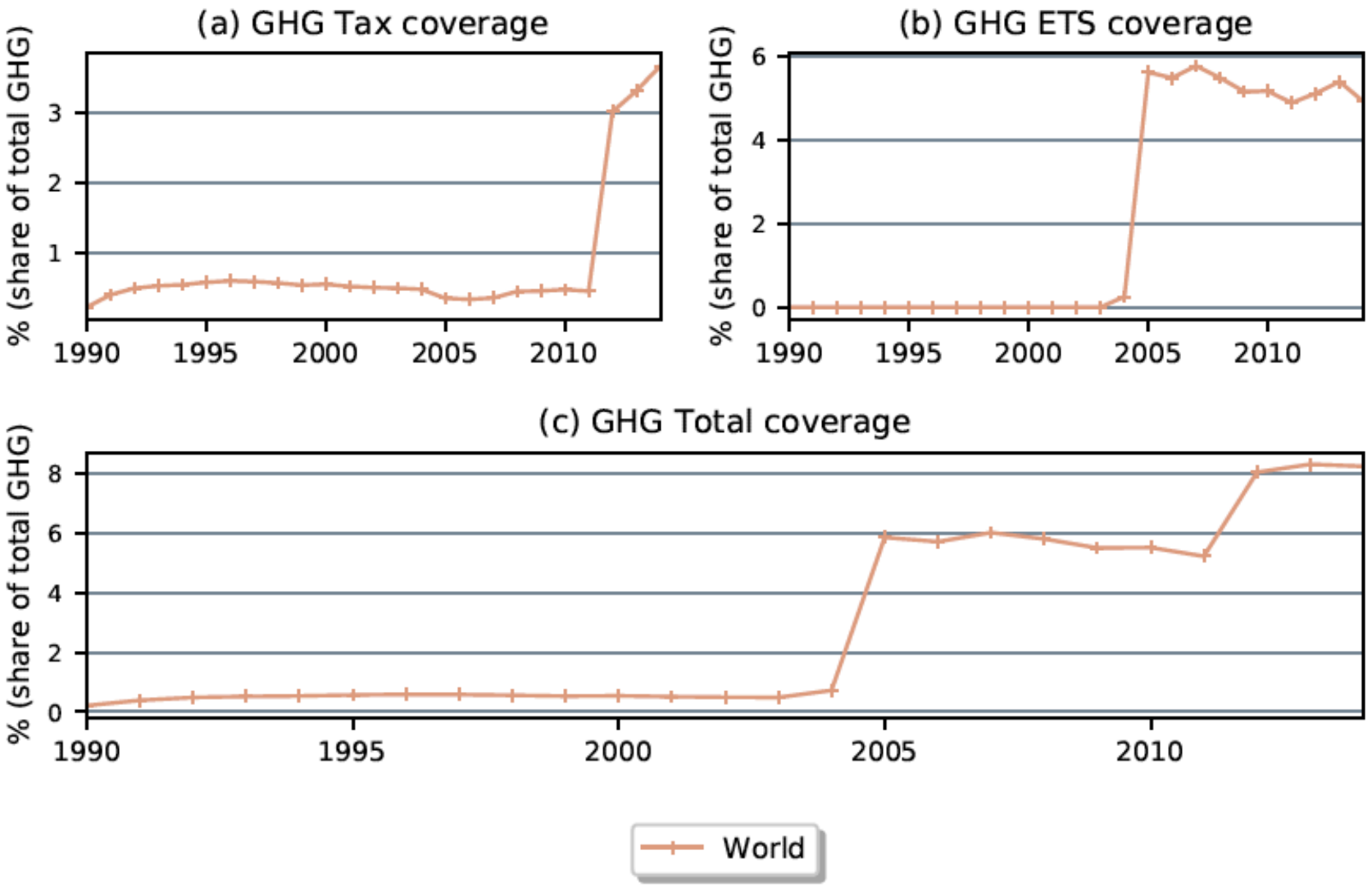
Figure 2 / Regional, national and subnational carbon pricing initiatives: share of global emissions covered



Expected in 2020: China national ETS.

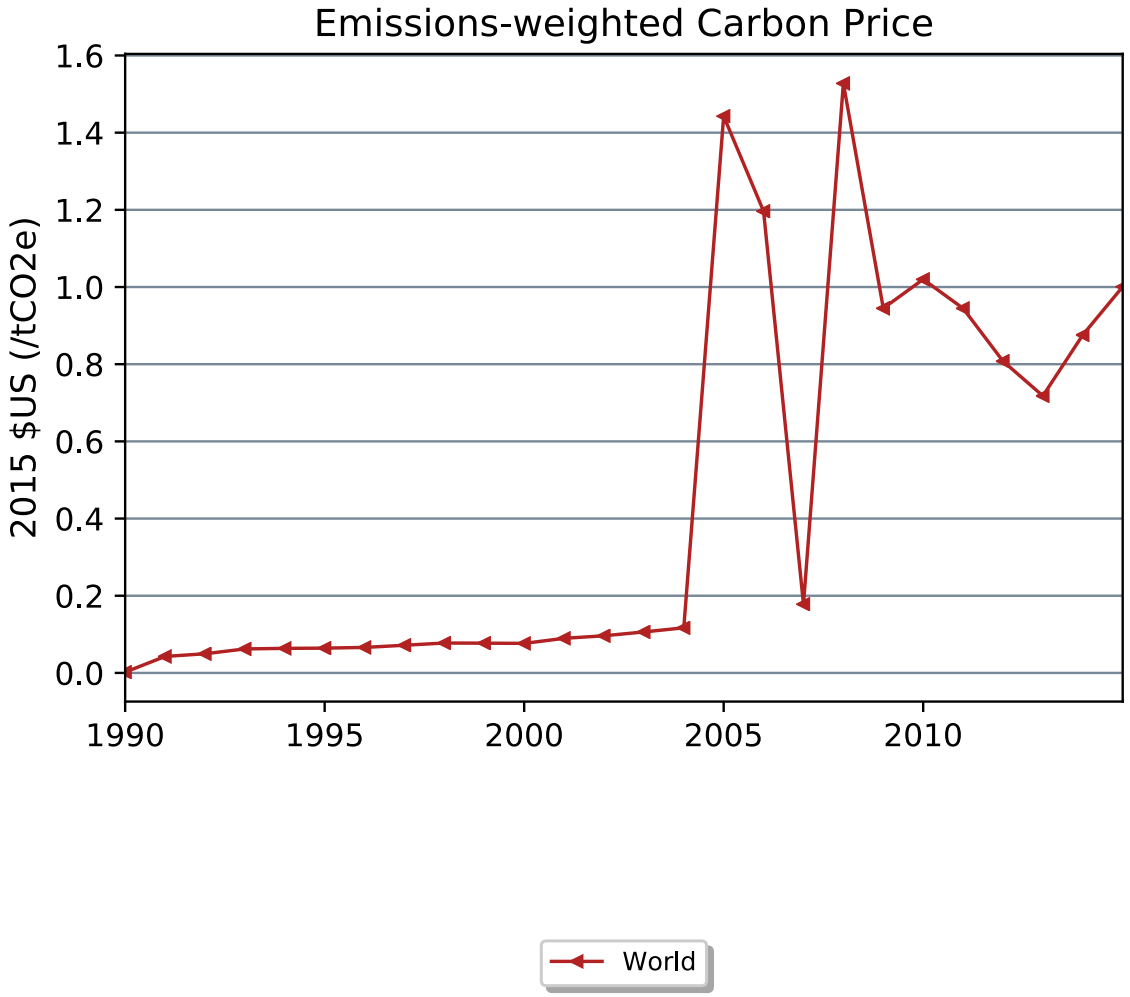
Source: World Bank, 2018, p.12.

Coverage of carbon pricing



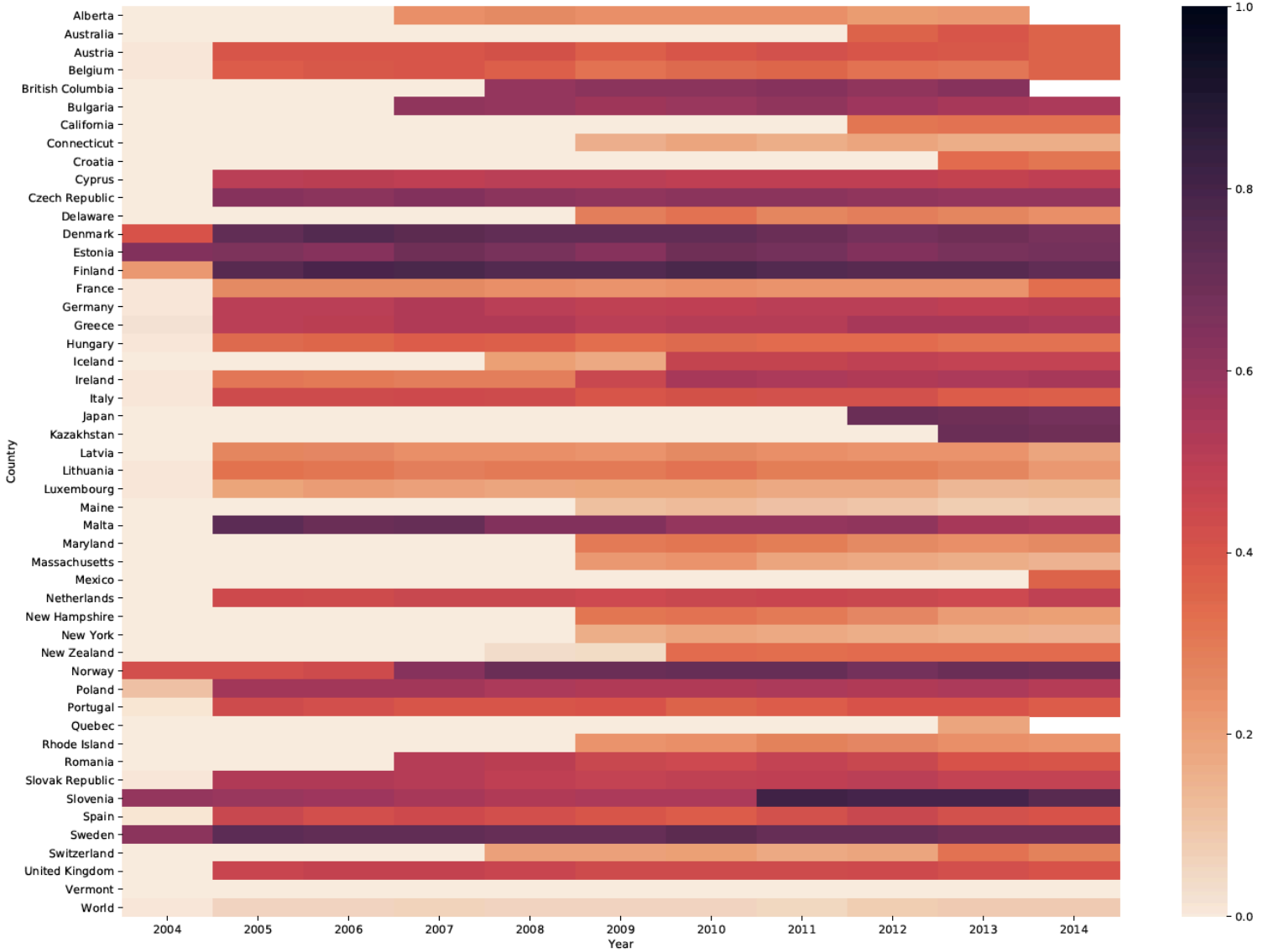
Source: Dolphin et al., 2016.

Emissions-weighted Global Carbon Price



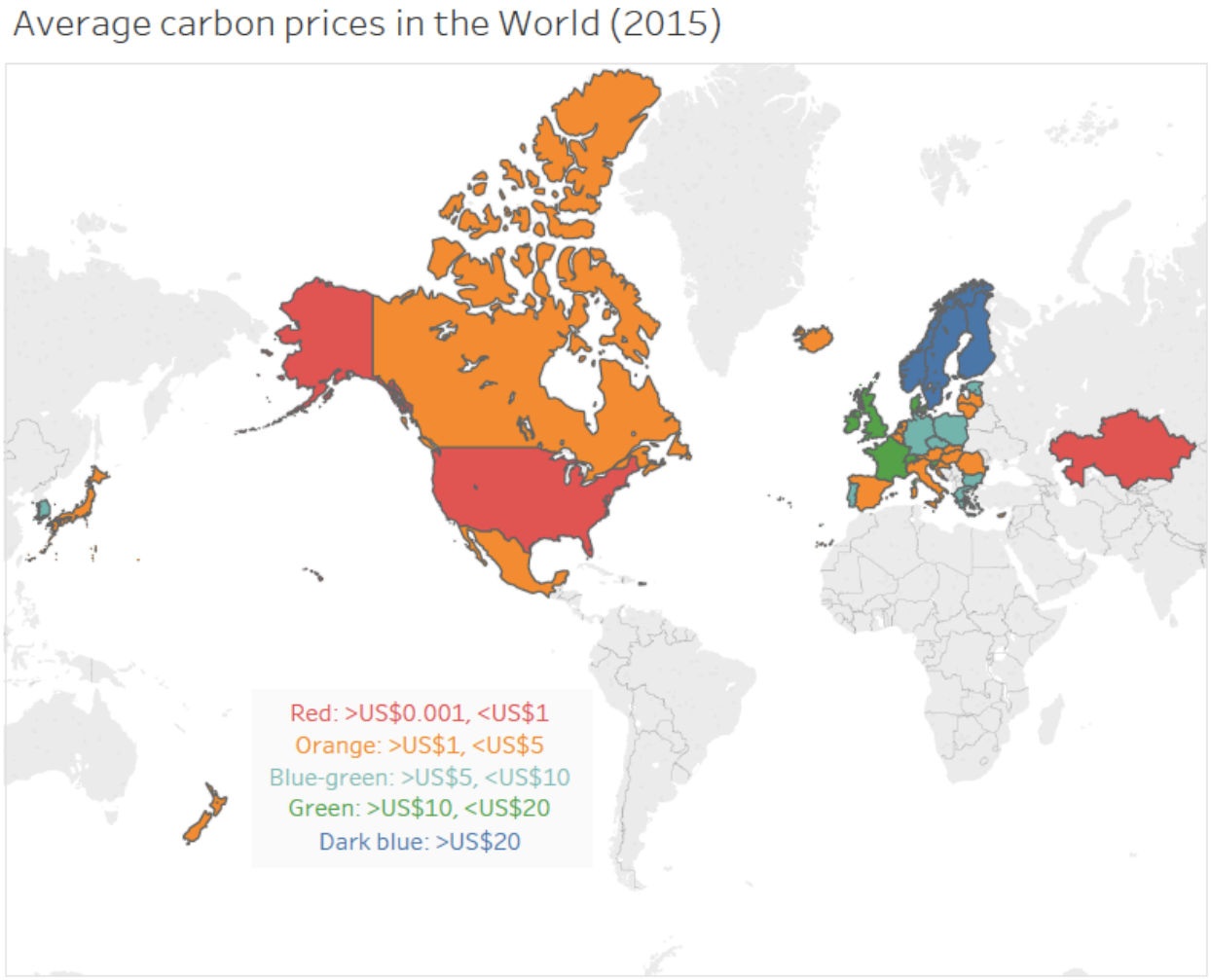
Source: Dolphin and Pollitt, 2018.

Heat map of GHG emissions pricing coverage



1 = 100% coverage. Source: With thanks to Ryan Rafaty from Dolphin and Pollitt data.

Heat map of effective carbon price 2015



Source: Dolphin and Pollitt data.

Basic facts of carbon markets

- Carbon markets have most value in the early stages of decarbonisation. They help with:
  - the mix of sectors to decarbonise
  - the mix of existing low carbon technologies per sector
  - the mixing demand side reduction and substitution
  - guiding consumer and climate NGO pressure.

- They are about identification of low cost decarbonisation within a general equilibrium (i.e. multiple interconnected markets) setting.

Basic facts of carbon markets

- Many don't like carbon markets precisely because they deal so effectively with the general equilibrium issues.
- They are transparent and highlight:
  - Differences between included and non-included parties
  - Incidence of final costs and prices, especially to consumers
  - Financial flows within and between countries
  - The cost impact of political interventions
  - Lowest cost interventions and restrain special interests
- Basically, political opposition to the use of carbon markets is based on the fact that they do work in a predictable way.

A global carbon market?

- What are the characteristics of a global market?
- All that needs to be true is that markets are interconnected enough for major price differences between significant regions to be arbitraged.
- This does not require a single trading platform or integrated regional platforms (as for oil, or foreign currency).
- It can involve a combination of markets and administered prices (i.e. taxes).
- Over time price convergence is likely, though not certain, if costs of non-alignment are large.

A Global Carbon Market?

Basic parameters:

- Global carbon market:
- 49,000 m tonnes CO2e in 2014
- *$100 per tonne CO2e (true cost of carbon?)
- =$4900 bn per year
- *In reality perhaps 10,000 m tonnes at $80 per tonne, with 10% traded = $80 bn p.a. traded (memo: Global development aid budgets: $145bn)*
- For comparison: Global oil market:
- 85 million barrels per day
- * 365 days * $100 per barrel
- = $3102 bn per year

Top ten emitters of GHGs globally (excl. LUFC) 2016

Table 1: Top ten emitters of GHGs globally (exc. Land use change and forestry (LUCF)) 2016

China	26.5%
United States	13.1%
European Union	9.0%
India	7.4%
Russian Federation	4.5%
Japan	2.8%
Brazil	2.3%
Indonesia	1.9%
Canada	1.8%
Iran	1.7%
Total	**71%**

Source: Olivier et al, 2017, p.46.

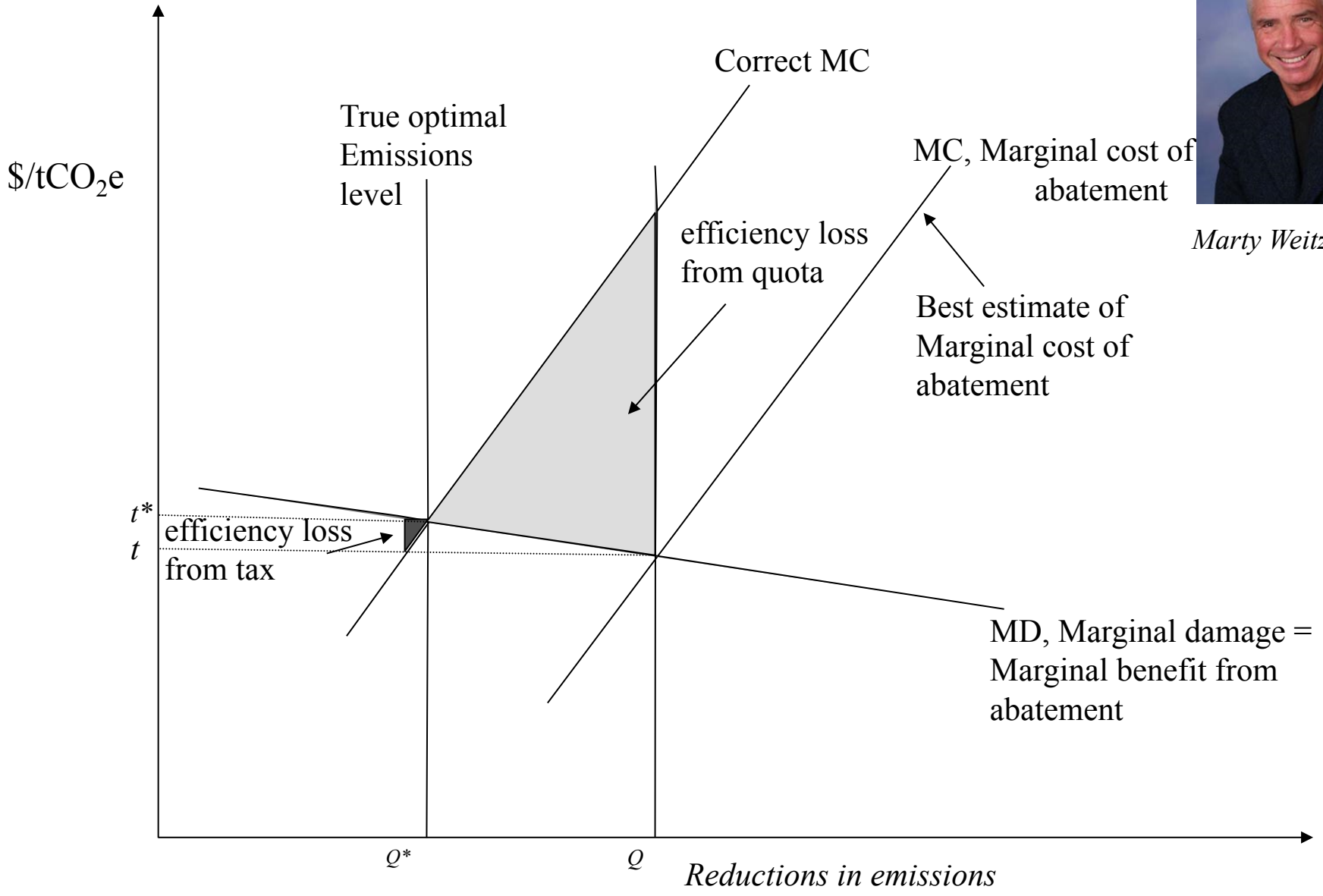
Basic Numbers for carbon markets

- There are c.190 states in the world
- G20 + Spain = 85% of world GDP
- G20 + Spain = 77% of world CO2e (exc LUCF)
- Plus next 10 country emitters =85% of world CO2e

- The EUETS has 31 countries participating.
- Of the G21, 6 (inc. EU) are in the EUETS.
- Of the OECD-34, 21 are in the EUETS.
- Of the rest many are in the spheres of influence of the largest 31 emitting countries.
- This is not primarily a problem of negotiation.

Carbon Taxes or Carbon Markets? Weitzman argument: Costs of errors setting quantities

Marty Weitzman



Is coordinating on price is better than on quantities?

- If the slope of the marginal cost (MC) of abatement curve is steeper than the slope of the marginal benefit (MB) of abatement curve, then better to set tax than set quantity if there is uncertainty in MC curve (Weitzman, 1974).

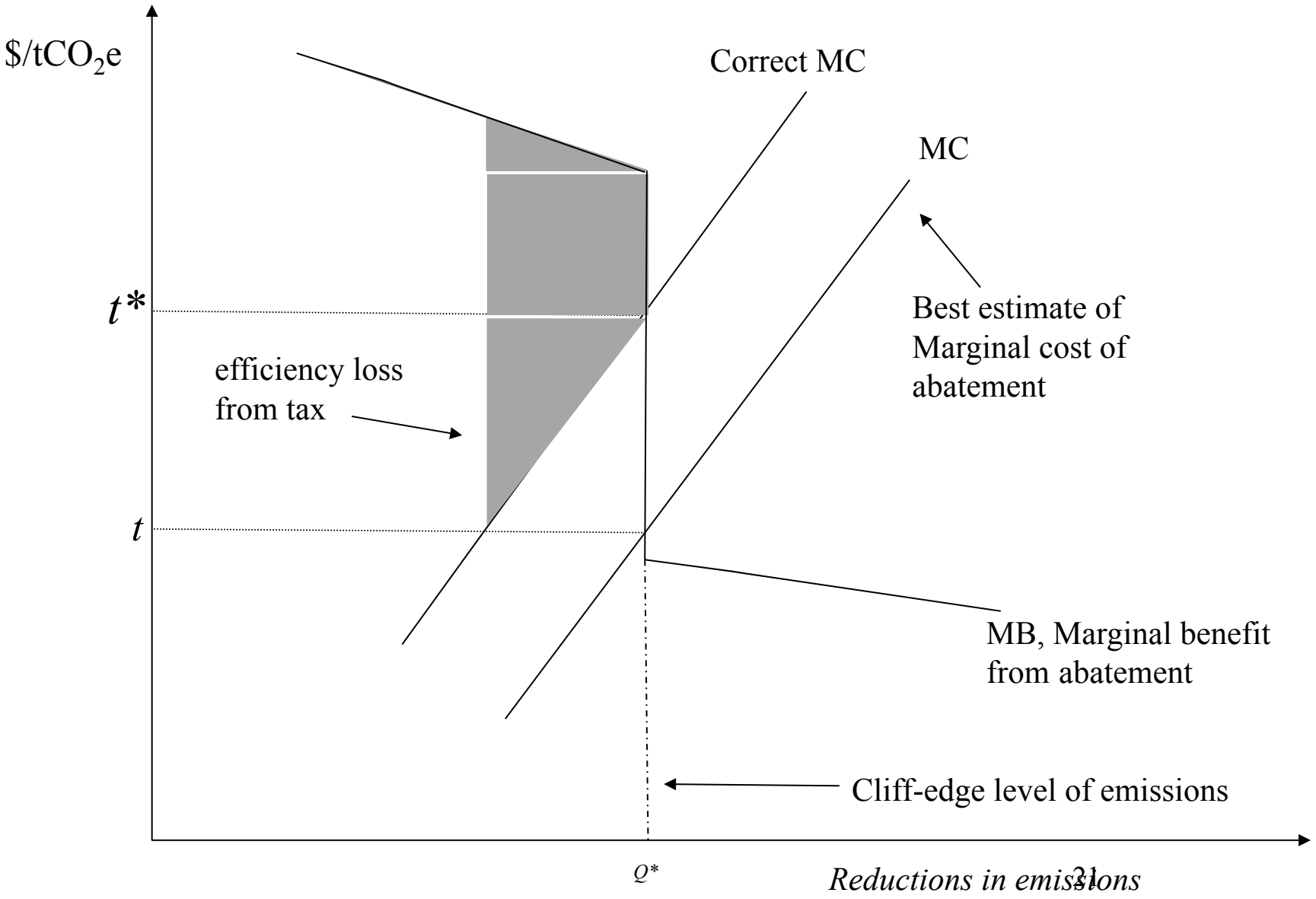
- ***But…***
- The Weitzman result depends on relative slopes of two curves and he suggests extreme cases where relative costs of setting taxes is high is more 'likely' than extreme cases where setting quantities is bad.
- If there is no uncertainty in the MC curve but only in the MB curve then cost of mistakes same under both.
- If the MB curve is kinked (due to 'tipping points' in costs of climate change) then better to set quantities.

Is coordinating on price is better than on quantities?

- ***Implies that…***
- If there is a lot of uncertainty in the marginal benefit curve (i.e. we don't know where the climate damage effects exactly kick in or how world society would adjust if they did) and…
- If the marginal cost of abatement is actually well defined / lower than we predict then unlikely that mistake in quantity worse than in price.
- In fact, quantities would be tightened over time, leading to incorporation of learning on position of curves.

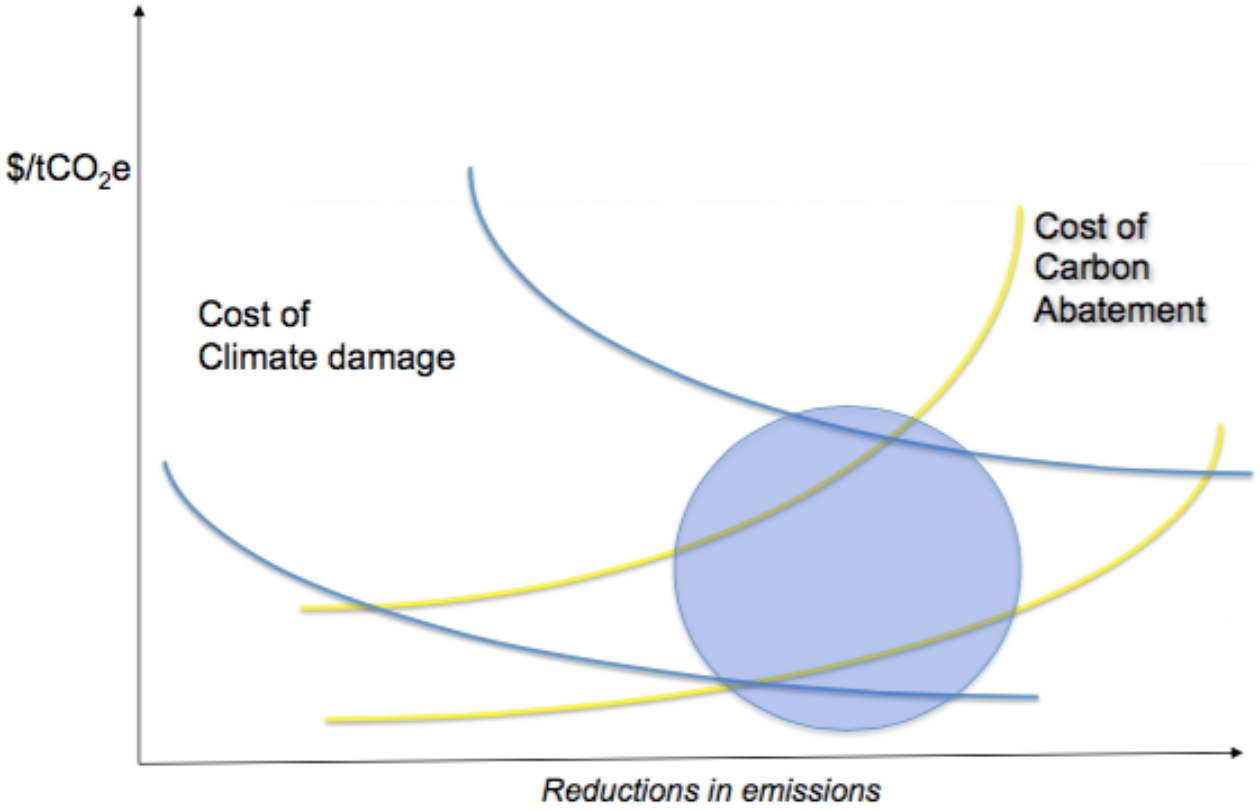
- Basically the theoretical argument against permit markets is they might be too ambitious!!!

Costs of errors setting prices or quantities: Cliff-edge effects in quantity



The reality…

Figure 2: A Better Argument?
Prices Harder to Identify than Dangerous Quantity



Source: Grubb and Newbery (2008, p. 282)

Additional arguments for a global carbon tax

- Better distributional properties because (Goulder and Schein, 2013):
  - fossil fuel producers with market power can shift rents under carbon trading by reducing supply resulting in lower carbon prices.
    - *Response: carbon trading reduces fossil fuel producers market power and additionally solves the green paradox associated.*
- Better incentive alignment because (Weitzman, 2015):
  - revenues are nationally collected with a tax
    - *Response: Not in the EU ETS.*
  - negotiating one price is easier than negotiating on quantities
    - *Response: No evidence for this claim in reality.*
  - governments will coordinate upwards on taxes, rather than seeking higher quantities within trading system.
    - *Response: This is only true at low tax rates.*
- Reduced price volatility because (Cramton et al., 2015):
  - carbon taxes are less volatile than prices within a trading system.
    - *Response: Need to be careful to distinguish between sources of volatility, may be more risk and less uncertainty with carbon trading..*

Why coordinating on quantities is better than on prices

- *Some different theory:*

- *Climate Science* can and does frame the problem as being about the specific quantity of GHGs emitted (e.g. Max = c.1000 GTC) (e.g. Allen et al., 2009). Quantity limitation coordinates the economic framing and the scientific framing.
- *Legal precedents* especially on ownership and sovereignty must be respected. Tradable quantities with initial allocations of pollution rights are consistent with the current basis of property rights and trade in a way that a coordinated tax rate is not.

Why coordinating on quantities is easier than prices

- *A lot of evidence:*
- The EU could not agree on a carbon tax (proposed in 1992, withdrawn 1997) but could on a trading system.
- Taxes difficult to adjust and coordinate within countries.
- No example globally of any exact coordination on taxes.
- Energy taxation on different fuels shows wide variance within and between countries…
- Specifically vested interests find it easy to keep taxes at a low level or gain lots of exemptions, due to lack of transparency…
- Carbon taxation has had only limited application (often as revenue recycling measure) and proved domestically controversial…

The political economy of carbon pricing

- In Dolphin, Pollitt and Newbery (2016) we use from 1990-2015 on 136 countries and 63 subnational jurisdictions in the US and Canada.

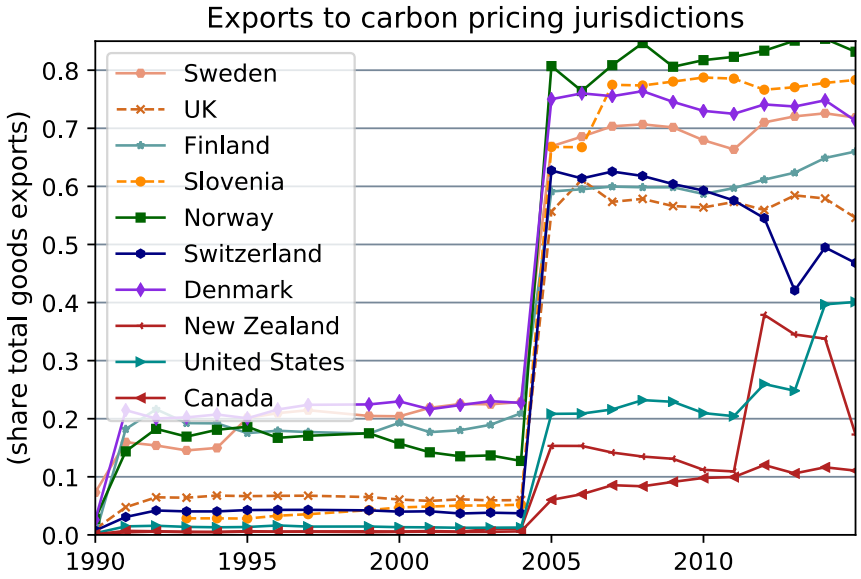
- We observe that coverage and headline carbon price matter for strength.
- We find that adoption of carbon prices more likely if democracy, GDP per capita higher, fossil fuel share in electricity lower and that the strength of carbon prices higher if GDP per capita higher and share of fossil fuels in electricity lower.

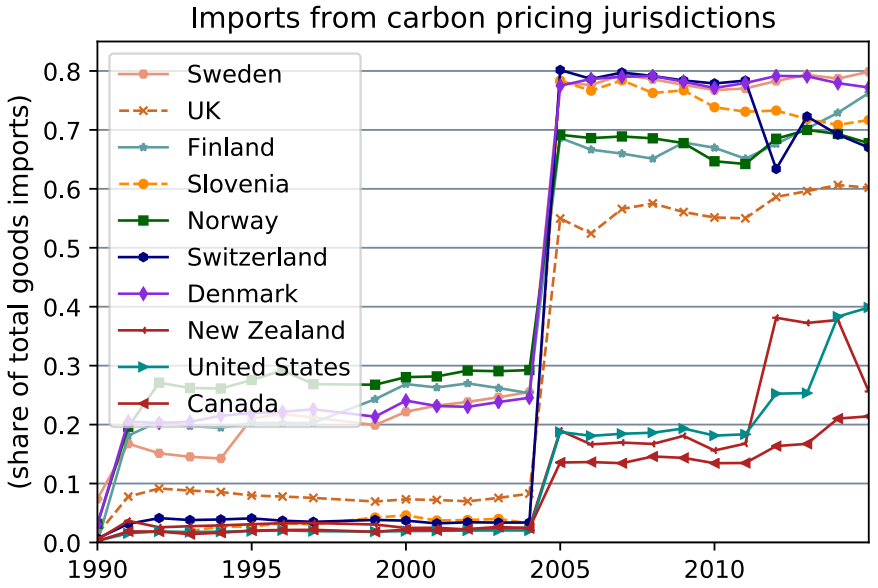
Explaining carbon pricing policy diffusion

- In Dolphin and Pollitt (2018) we use from 1990-2014 on 121 countries:

- We argue trade relationships are a catalyst for the adoption of carbon pricing and that technological transfer is important for lowering the cost of domestic climate policy.
- We find a link between both the adoption and strength of carbon pricing is related to embodied carbon prices in imports.
- Our results are in line with the earlier environmental literature (e.g. Copeland and Taylor, 1994ff), and the experience of the EU on both the EU ETS and renewables.

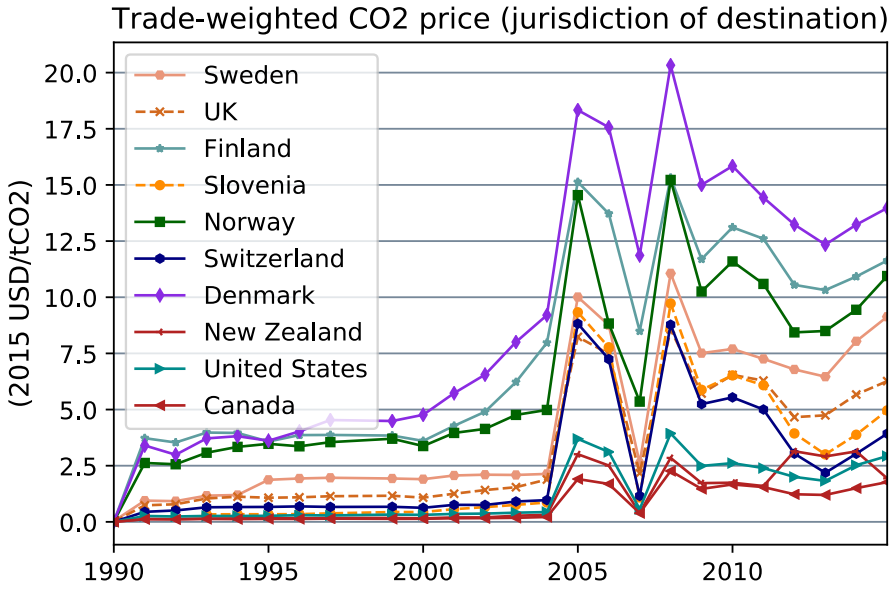
Trade exposure to carbon pricing (existence)



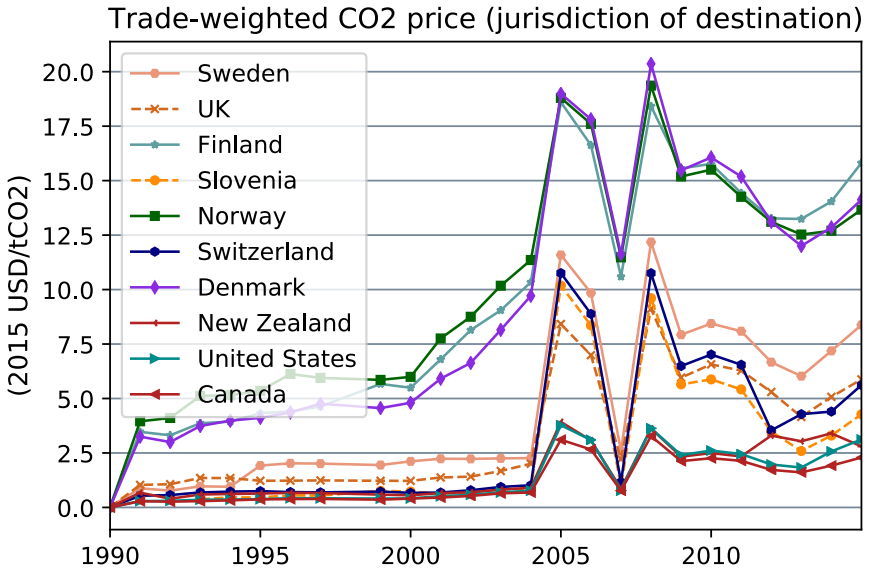


Source: Dolphin and Pollitt, 2018.

Trade exposure to carbon pricing (price level)



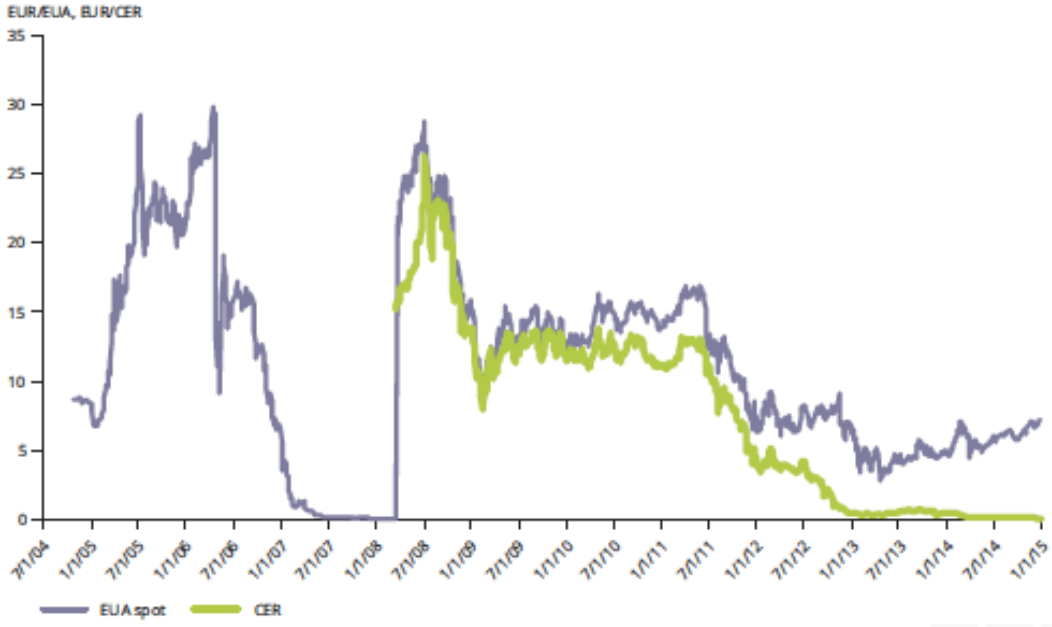
Exports:
Note divergence between Finland, Norway and Denmark



Imports:
Note similarity between Finland, Norway and Denmark

Source: Dolphin and Pollitt, 2018.

EU ETS – price history



Source: EEX (EUA price), 2015; ICE ECX (CER price), 2015.

Source: EEA (2015, p.22), https://sandbag.org.uk/carbon-price-viewer/.

Evolution of EU ETS rules

- Now an EU wide cap and allocation system, with allocations of auction shares to member states.
- Free allocations being reduced, 100% auctioned in power sector.
- Scheme extended to aviation.
- However substantial overhang of allowances (c.1.65bn in 2018 or 1 year's worth of permits).
- **But** Market Stability Reserve (MSR) to be introduced in 2019, taking 265m allowances out of circulation in first 8 months of 2019. MSR excess surpluses to be cancelled from 2023.
- Prices have gone up substantially recently.

EU 2030 Targets

- from EU Commission:
  - 40% reduction in GHG emissions (relative to 1990)
    = 25% reduction from 2020 target in 10 years
    ⇒43% reduction of ETS sector relative to 2005
  - EU-wide RE target of 27%
    - Unclear enforcement; Delivered by GHG reduction

    (with Energy price + premium and auctioning)
  - Energy Efficiency target of 27% relative to business as usual (up from 20% in 2020)

A setback in the outback: Australian carbon tax

- Introduced on 1 July 2012 at AUD 24.15 (c.16 Euros) per tonne CO2e, with view to move to cap and trade in July 2015. Coverage: 60%.

- Conservative led government wins with mandate to abolish carbon tax in September 2013. Abolished July 2014.

- Robson (2014) gives an interesting analysis of the failure of the Australian carbon tax, suggesting that other measures (such as subsidies to renewables) might have been more effective.

Impact of carbon tax on electricity prices…

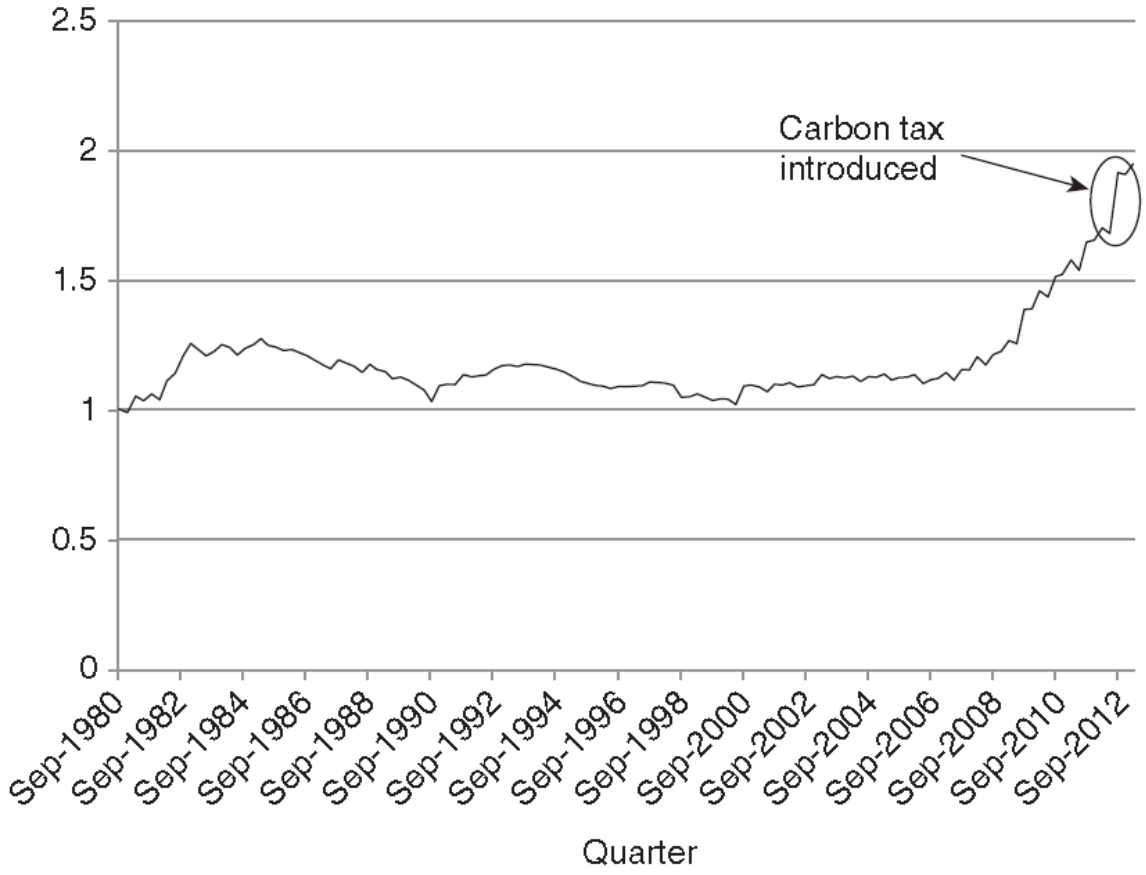


Figure 2: Inflation-adjusted household electricity prices (1980 = 1), 1980–2013.
Sources: Author's calculations; Australian Bureau of Statistics, Cat. No. 6401.0 Consumer Price Index, Australia, Table 7.[14]

Source: Robson (2014, p.39)

Impact on the effective marginal tax rate…

Table 1: New statutory income tax rates, old EMTRs and new EMTRs

Income level	Old EMTR	New statutory rate	New EMTR	Change in EMTR	Approximate number of taxpayers (million)
$0–$16,000	0	0	0	No change	0.28
$16,001–$18,200	0.15	0	0	Fall by 0.15	0.28
$18,201–$20,542	0.15	0.19	0	Fall by 0.15	0.28
$20,543–$30,000	0.15	0.19	0.19	Rise by 0.04	1.38
$30,001–$37,000	0.19	0.19	0.19	No change	1.19
$37,001–$67,000	0.34	0.325	0.34	No change	3.58
$67,001–$80,000	0.3	0.325	0.325	Rise by 0.025	0.83
$80,001–$180,000	0.37	0.37	0.37	No change	1.19
> $180,001	0.45	0.45	0.45	No change	0.18

EMTR, effective marginal tax rate.

Source: Williams (2011).

Source: Robson (2014, p.41)

No fiscal dividend: Fiscal impact negative…

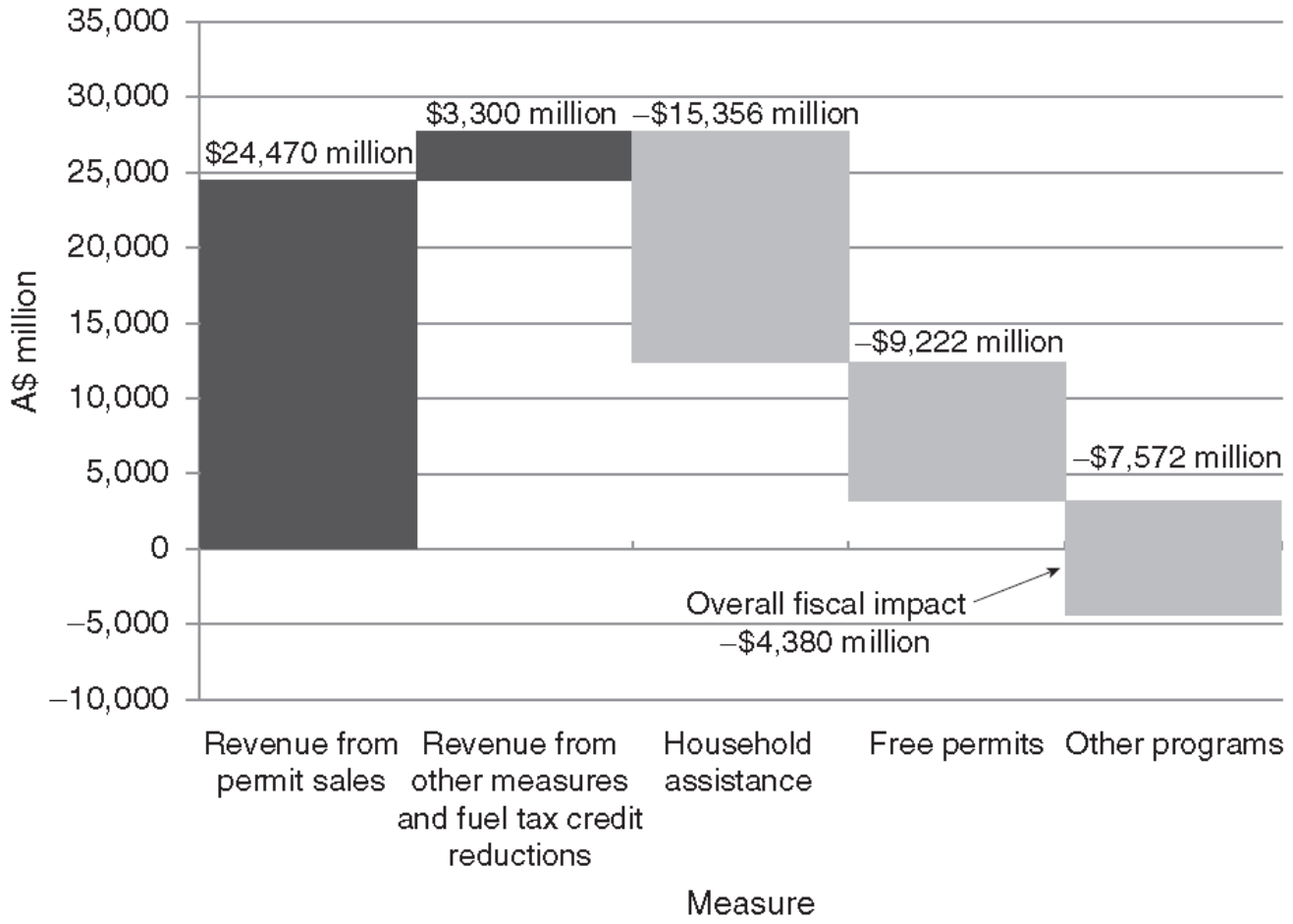


Figure 4: Expected cumulative fiscal impact of the carbon tax and associated policies, 2011–12 to 2014–15.
Source: Department of Climate Change and Energy Efficiency (2011, pp. 131, 135 (Table 1)).

Source: Robson (2014, p.42)

Lessons from Australia

- Taxes clearly NOT superior to cap and trade: no policy certainty and the basic economics was not effected by price volatility.

- Starting at low carbon prices has political advantages. The initial price was high for an energy intensive open economy.

- The fiscal transfers were poorly targeted.

US progress under Clean Air Act (Pollitt, 15a)

- 2007 Mass v. EPA – Supreme Court affirms EPA authority to regulate under Clean Air Act
- 2009 'Endangerment' and 'Cause or Contribute' Findings
- 2011 (I) Mobile source standards -- 5%/yr improvement to 35.5mpg fleet avg. in 2016; 54.5 mpg by 2025
- 2011 (II) Construction permitting -- implementation by the states
- 2014 (III) Stationary sources -- performance standards for new and existing (proposed) electricity generators (32% of emissions). Proposes State level Goals (Adjusted MWh-Weighted-Average Pounds of CO_2 per Net MWh) covering all Affected Fossil Fuel-Fired units (Clean Power Plan).
- In the meantime local, state and regional initiatives.

The EPA's Approach: Clean Power Plan

- Sets out conditions where a carbon market might emerge as the cheapest way to meet the emission standards it has set.
- It uses a number of technology building blocks to arrive at a Best System of Emission Reduction (BSER) standard for each state out to 2030.
- These technology building blocks suggest actions that each US state could take with respect to its existing fossil fuel plant fleet.
  - an improvement in the heat rate of coal fired power plants
  - an increase in the utilisation of national gas power plants
  - and increased use of zero carbon renewables.
- The Final Rule published in October 2015 shows projected power plant emissions reductions of 32% by 2030, relative to 2005.

The EPA's Approach

- At the state level, the BSER translates into proposed state level goals for adjusted MWh-weighted-average pounds of CO_2 per Net MWh covering all Affected Fossil Fuel-Fired units.
- Under the policy each state is to submit a plan for compliance. State level plans must be presented to the EPA by 2016 (with the possibility of a two-year extension) with the compliance period due to begin in 2022.
- The states are free to pursue multiple pathways to compliance using a CO_2 per unit of MWh (rate-based) or a total emissions (mass-based) standard.
- States could participate in multi-state emissions trading in order to achieve their emissions reduction goals.

US EPA Cost Benefit Analysis (2015)

Table 4: Summary of Estimated Monetized Benefits, Compliance Costs and Net Benefits for the Proposed Guidelines in 2030 (billions of 2011$)

	Rate-Based Plan 3% discount rate
Climate Benefits	20
Air pollution health co-benefits	14-34
Total compliance costs	8.4
Net Benefits (with climate benefits at 3% discount rate)	**26-45**

Source: Environmental Protection Agency (2015, p. 64680).

Current status of the Clean Power Plan (CPP)

- CPP a key part of US Intended Nationally Determined Contribution (INDC) at COP-21 and Presidential endorsement of Paris Agreement by President Obama.
- Legal challenges led to ruling in February 2016 from Supreme Court putting stay on implementation until lower courts rule on plan.
- Voting 5-4 in favour of stay, awaiting new appointments to Supreme Court.
- The US – under President Trump - has given notice of withdrawal from the Paris Agreement and consistent with this the EPA proposed, in October 2017, to repeal the CPP.
- As of August 2018, repeal of the CPP seems likely.
- See https://www.epa.gov/energy-independence.

US EPA Cost Benefit Analysis (2017)

Table 4a: Avoided Compliance Costs and Net Benefits of the Repeal associated with the Targeted Pollutant in 2030 (billions of 2011$)

	Rate-Based Plan 3% discount rate
Domestic Climate benefits	2.7
Energy Efficiency benefits	18.8
Total compliance costs	33.3
Net Benefits (with climate benefits at 3% discount rate)	**14.0**

Source Environmental Protection Agency (2017, p.12)

Chinese progress on carbon trading…

- China is now the World's biggest emitter of GHGs.
- The National Development and Reform Commission (NDRC) has stated that China's climate change-related goals for 2020 include the following:
  - reducing CO_2 per unit of GDP by 40-45% relative to 2005 (50% likely).
  - increasing the ratio of non-fossil energy to the consumption of primary energy to 15% (relative to 12% in 2015 against target 11.4%).
  - 13th FYP 2016-2020 goals are: to reduce CO_2 per unit of GDP by 18% relative to the end of the end of FYP 12, and to reduce national energy consumption per unit of GDP by 15% relative to the end of FYP 12.
  - During the 12th FYP, seven local pilot carbon trading schemes have been established, following approval from the NDRC in October 2011, and the intention is to move to full national carbon market by 2020.
- China's INDC commits to reducing CO_2 per unit of GDP by 60-65% relative to 2005 in 2030.

Chinese emissions trading pilots...

Table 5: Key characteristics of the Chinese Emissions Trading Pilots

	Shenzhen	Shanghai	Beijing	Hubei	Guangdong	Tianjin	Chongqing
Start of operation	2013	2013	2013	2014	2013	2013	2014
Carbon intensity target 2011-2015	-21%	-21%	-18%	-17%	-19.5%	-19%	-17%
Threshold	>20000 t CO_2	>20000 t CO_2	>20000 t CO_2	>60000 t CO_2	>20000 t CO_2	>20000 t CO_2	>20000 t CO_2
Initial Year Allowances	33mt	160mt	50mt	324mt	388mt	160mt	125mt
Entities covered	635	191	490	138	242	114	184
Emissions covered	38%	50%	50%	35%	42%	60%	35-40%
Offsets	10%	5%	5%	10%	10%	10%	8%
Free initial allocation	c.95%	100%	c.95%	c.90%	c.97%	100%	100%
Penalties	3X market price	10-100k CNY	3-5X market price	3X market price	3X market price	NA	2X market price

Source: World Bank 2014, p.122; Xiong et al., 2015, p.2511, 2513; Zhang, 2015.

Progress with national carbon market in China

- China now re-engaged in power market reform with a view to reducing reliance on coal (though coal use still set to increase by 2020), increasing gas, renewables and nuclear power (following No.9 Document March 2015).
- Seeking to reduce energy prices to industry, reduce coal use and air pollution.

- The Chinese power sector alone is responsible for more than 7% of global CO_2e emissions.
- It will initially be the only sector in China's proposed national emissions trading system.

COP-21 Paris Agreement

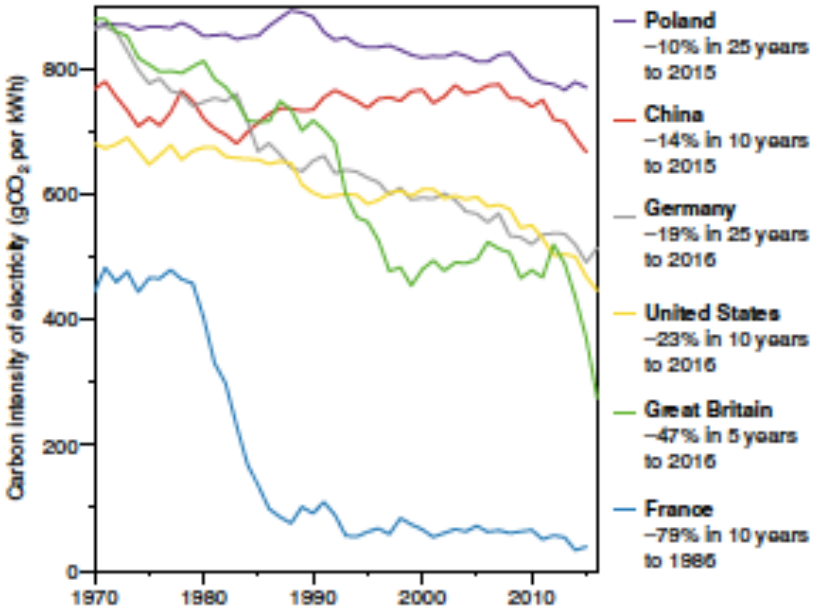
- In December 2015, c.191 countries, covering 98.2% of CO_2e emissions, agreed to limit global temperature rise 'of well below 2°C'. Ratification has already taken place covering 60% of emissions.
- Paris agreement does not specify mechanisms to achieve quantity reductions. But *'recognizes* the important role of providing incentives for emission reduction activities, including tools such as domestic policies and carbon pricing' (V.137).
- Analysis of INDCs (Boyd et al., 2015) suggests likely temperature rise still substantially above 2°C even fully implemented.

Hybrid tax and cap and trade approaches

- Caps, floors and additional carbon taxes can be combined with trading mechanisms.
  - Several trading mechanisms have floors and corridors to guard against extreme fluctuation, e.g. in RGGI has corridor, California has floor.
- Several countries have carbon taxes in addition to trading mechanisms, e.g. in the UK.

- In the UK frustration with low prices in the EUETS combined with ambitious national commitments led to the Carbon Price Floor (CPF) in 2013 – an additional tax on fossil fuel used in electricity. This was significant in 2016 at 21 Euros per tonne of CO2.

- Newbery et al. (2018) propose a similar EU-wide top up levy floor at 20-25 Euros rising at 3-5% p.a. in the electricity sector.



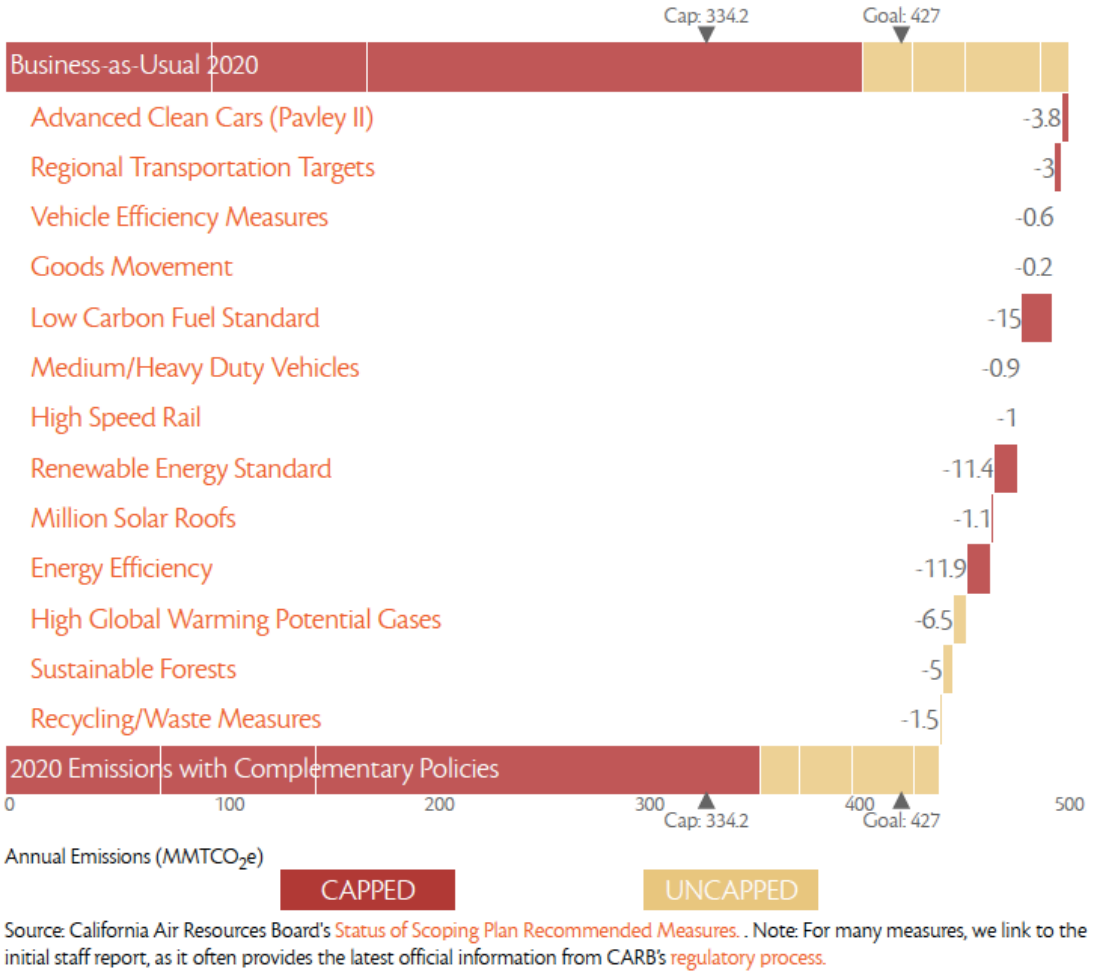
Source: Wilson and Staffell (2018, p.366)

Conceptualising Cap and Trade in California

Cap and trade can be seen as a back-stop policy for delivering emissions reduction.

Coverage Initially 85% of GHG emissions (EU ETS 45%).

In California cap and trade is expected to deliver 22% of emissions reduction, *but will have to do more if other policies do not deliver.*



Source: California Air Resources Board's Status of Scoping Plan Recommended Measures. . Note: For many measures, we link to the initial staff report, as it often provides the latest official information from CARB's regulatory process.

Source: http://calcarbondash.org

Conclusions

- The idea of using the market to deliver carbon reductions is an potent one relative to the alternatives (of subsidies to low carbon technologies).

- It has had significant *apparent* setbacks in the EU ETS and in Australia.
- However now hopeful signs of progress in US and China.

- Increasingly carbon cap and trade and taxation being combined.

- The policy instrument to solve the climate problem is not rocket science; economists worked out the policy answer to excessive emissions years ago…

Issues with carbon markets…

- Does the extension of carbon markets need some external motivation as part of more general free trade agreements?
- Are carbon markets going to be just about residual fossil fuel switching?
- Are carbon markets adequately designed to cope with fluctuations in the price of fossil fuels?
- As costs of alternatives to comprehensive carbon pricing become clear maybe there will be increased interest in role of carbon markets?

Issues with carbon pricing generally…

- Are we just playing with (or being played by) carbon markets, as a sop to economic rationality and 'greenwash'?
- Will incumbents successfully frustrate carbon pricing, as they have done over fuel taxes?
- Is some carbon pricing worse than no carbon pricing?
- Will the energy transition proceed anyway, with relatively limited impact from carbon pricing, as so far?

A global carbon market?

- Should we work for it? Yes.
- Is it likely to happen? No.
- Is it 'Good' Energy Policy? (Pollitt, 2015b) To be so, it must address multidisciplinary issues of:

- *Perception*
- *Quantitative justification*
- *Human well-being*
- *Public trust*
- *Role for the state*
- *Competence in delivery*

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Social Cost of Carbon

Table 2: US EPA - Social Cost of CO_2, 2010-2050 (2014 \$US/tCO_2)

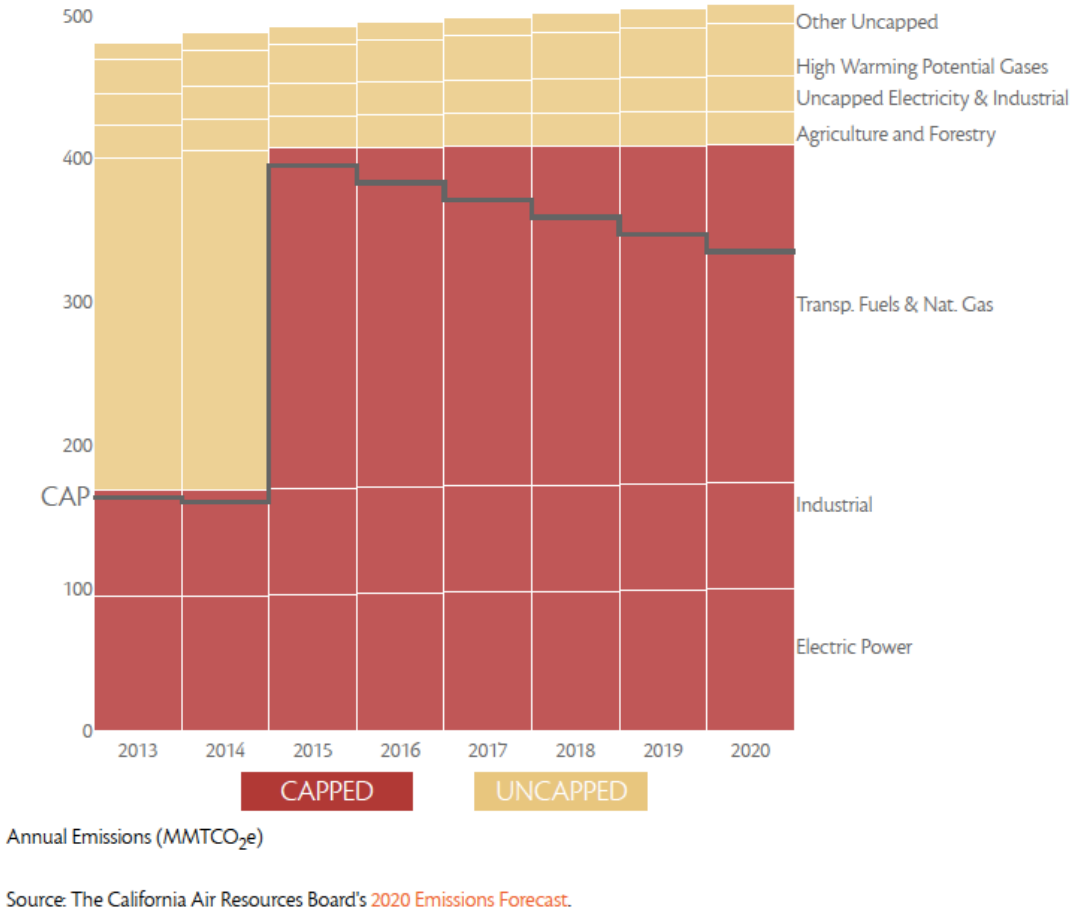
Discount Rate Year	5% Avg	3% Avg	2.5% Avg	3% 95th
2010	11	35	57	98
2015	13	41	64	120
2020	14	48	71	140
2025	16	53	78	158
2030	18	57	83	173
2035	21	63	89	192
2040	24	69	96	209
2045	26	74	102	225
2050	30	79	108	242

Source: Interagency Working Group on Social Cost of Carbon (2013).
Note: For each year and each discount rate, SCC values are calculated by combining distribution estimates of five different scenarios from three Integrated Assessment Models (i.e. DICE, FUND and PAGE). Each scenario and model receive equal weight, producing an "average" distribution of the SCC. The average (mean) of that distribution is the value reported in the first three columns of the above table. The fourth column reports the 95th percentile value of that distribution for a 3% interest rate.

Source: Dolphin et al., 2016.

Cap and Trade in California

Coverage Initially 85% of GHG emissions (EU ETS 45%)



Source: http://calcarbondash.org