Carbon dating: When is it beneficial to link ETSs?

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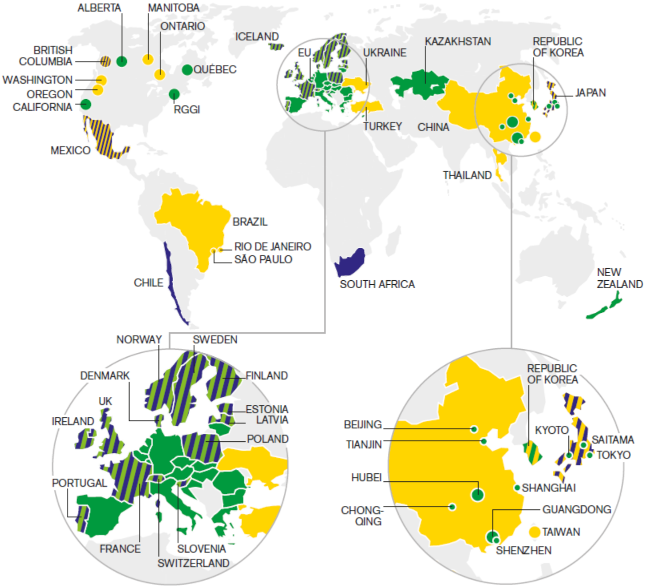
Centre for Climate Change Economics and Policy
LSE
The London School of Economics and Political Science

Figure 1 Overview of existing, emerging, and potential regional, national, and subnational carbon pricing instruments (ETS and tax)



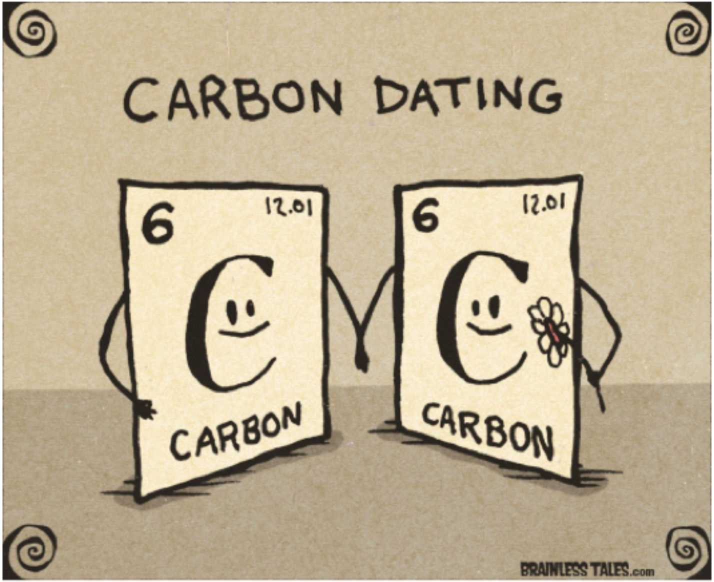
Source: World Bank (2015)

"The ability to link regional, national, and sub-national climate policies will be essential to enhancing the cost-effectiveness of such a system [emerging post COP21]– and thus the likelihood of achieving significant global emissions reductions." **Stavins (2015)**

"Linking the EU ETS with other cap-and-trade systems offers several potential benefits, including reducing the cost of cutting emissions, increasing market liquidity, making the carbon price more stable, leveling the international playing field and supporting global cooperation on climate change." **European Commission (2015)**

"The Agreement [in COP21] should support countries interested in using international market linkages to achieve more ambitious emissions reductions. Networked carbon markets perform better, environmentally and economically, enabling nations and businesses to better manage the transition to a cleaner economy" **IETA (2015)**

Looking for a carbon date...?



Overview

Evaluate economic advantage of linking over autarky

$$E[\Delta] = E[\delta_1] + E[\delta_2]$$

as a function of pair characteristics

$$\{(\psi_1, \sigma_1), (\psi_2, \sigma_2), \rho\}$$

where $\psi_i =$ *size* , $\sigma_i =$ *variability* and $\rho =$ *correlation*

Analytical results:

- Covariance matrix of shocks and ETS sizes are crucial
- Unilateral distortions matter (if sufficient time)

Empirical application

- Calibrate pair-characteristics to country emissions data over 1950-2012
- Substantial empirical variation in $E[\Delta]$ and $E[\delta_i]$

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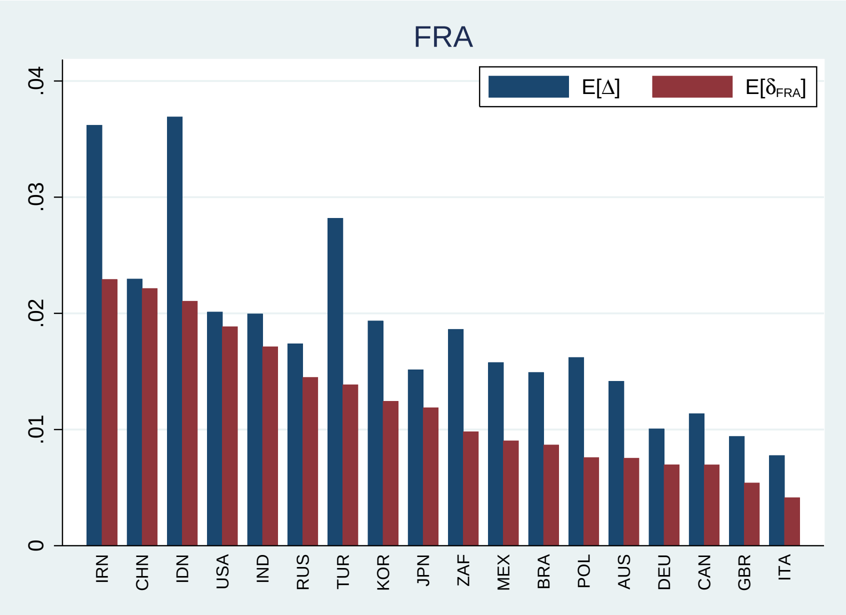
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ZAF
MEX
BRA
POL
AUS
DEU
CAN
GBR
ITA

Two-country model ($i = 1, 2$)

Benefits of emissions

$$B_i(q_i, \theta_i) \quad = \quad b_0 + (b_1 + \theta_i) q_i - \frac{b_2}{2\psi_i} q_i^2$$

Shocks: e.g. business cycles, energy prices, weather, etc.

$$\mathbb{E}(\theta_i) = 0$$

$$\mathbb{V}(\theta_i) = \sigma_i^2 \geq 0 \qquad Corr(\theta_1, \theta_2) = \rho \in [-1, 1]$$

Damages from emissions

$$D_i(q_1 + q_2) \quad = \quad d_0 + d_1(q_1 + q_2) + \frac{d_2}{2}(q_1 + q_2)^2$$

Assume

i) identical countries except in ψ_i and σ_i

ii) same (second best) quotas under both autarky and linking

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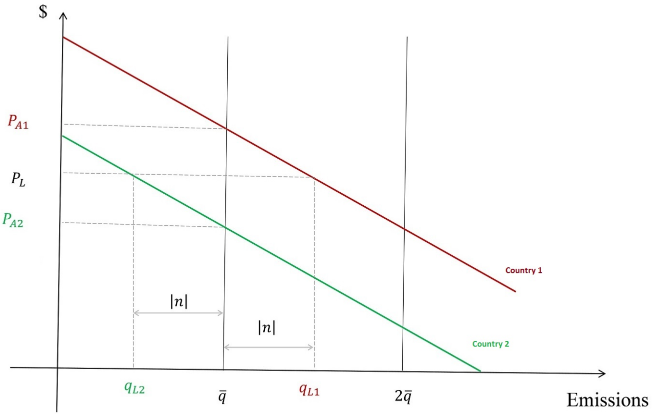
Interior autarky & linking equilibria ($\psi_1 = \psi_2$)



* Autarky prices p_{Ai} depend on own shock
* Linking price p_L depends on average shock with $n = \frac{\theta_2 - \theta_1}{2b_2}$
* Define *IAE* when $p_{Ai} > 0$ and *ILE* when $n \in (-\bar{q}, \bar{q})$

Economic advantage of linking over autarky

Country-specific advantage of linking

$$\begin{aligned}\tilde{\delta}_i &= [B_i(q_{Li},\theta_i) - p_L q_{Li} - D_i(q_{L1}+q_{L2}) + p_L\bar{q}_i - \psi_i\varepsilon] \\ &\quad -[B_i(q_{Ai},\theta_i) - p_{Ai}q_{Ai} - D_i(q_{A1}+q_{A2}) + p_{Ai}\bar{q}_{Ai}]\end{aligned}$$

In *interior equilibria*

$$\begin{aligned}\delta_1 &= B_1(\bar{q}_1 - n,\theta_1) - B_1(\bar{q}_1,\theta_1) + p_L n - \psi_1\varepsilon \\ \delta_2 &= B_2(\bar{q}_2 + n,\theta_2) - B_2(\bar{q}_2,\theta_2) - p_L n - \psi_2\varepsilon \\ \Delta &= \delta_1 + \delta_2\end{aligned}$$

where

$$n = \frac{1}{b_2}\frac{\psi_1\psi_2}{(\psi_1+\psi_2)}(\theta_2-\theta_1)$$

Remark: Sunk cost are independent of $\{\sigma_1^2, \sigma_2^2, \rho\}$

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Analytical results: Decomposing economic advantage

Proposition

Fix pair characteristics $\{(\psi_1, \sigma_1), (\psi_2, \sigma_2), \rho\}$ *and let* $\varepsilon \geq 0$. *Define pair size effect (PSE), volatility effect (VE) and dependence effect (DE) as*

$$\begin{aligned} PSE(\psi_1, \psi_2) &\equiv \frac{\psi_1 \psi_2}{2 b_2 (\psi_1 + \psi_2)} \\ VE(\sigma_1, \sigma_2) &\equiv \sigma_1^2 + \sigma_2^2 \\ DE(\sigma_1, \sigma_2, \rho) &\equiv -2 \sigma_1 \sigma_2 \rho \end{aligned}$$

Then in interior equilibria

$$\begin{aligned} E[\Delta] &= PSE(VE + DE) - (\psi_1 + \psi_2)\varepsilon \\ E[\delta_1] &= \frac{\psi_2}{\psi_1 + \psi_2} PSE(VE + DE) - \psi_1 \varepsilon \\ E[\delta_2] &= \frac{\psi_1}{\psi_1 + \psi_2} PSE(VE + DE) - \psi_2 \varepsilon \end{aligned}$$

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Empirical strategy

1) Calibrate ψ_i to observed CO_2 emissions in 2012

Assume in each country i

- No climate change policy
- Identical technologies
- $\theta_i = E[\theta_i] = 0$

$$\psi_i = \frac{b_2}{b_1} q_{i,2012}$$

2) Calibrate $\{\sigma_i, \sigma_j, \rho\}$ using HP decomposition of e_{it}

Assume θ_i drive the cyclical component $e^c_{it} = e_{it} - e^t_{it}$. Then Then

$$\sigma(\theta_i) = \frac{b_2}{\psi_i}\sigma(e^c_{it}) \qquad \rho(\theta_i, \theta_j) = Corr(e^c_{it}, e^c_{jt})$$

3) Data on e_{it} for top 20 emitters for 1950-2012

4) Normalizations: $\psi_{CHN} = 1$ & $b_2 = 1/2$

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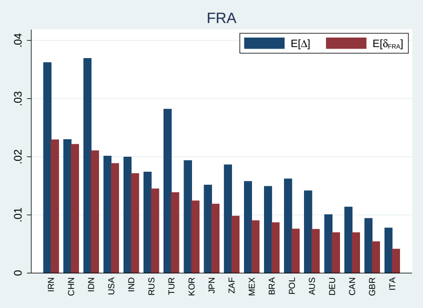
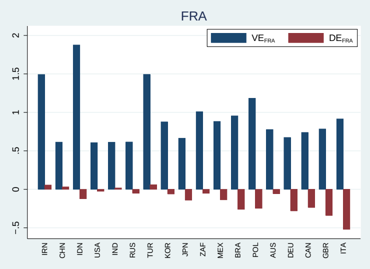
Empirical results: Overview

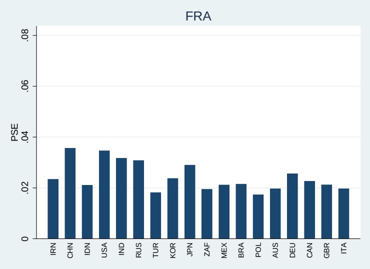
	190 pairs incl. SAU				171 pairs excl. SAU			
	mean	**sdev**	**min**	**max**	**mean**	**sdev**	**min**	**max**
$E[\Delta]$	0.042	0.079	0.001	0.438	0.018	0.013	0.001	0.061
			RUS-USA	CHN-SAU			RUS-USA	CHN-IDN
PSE	0.038	0.033	0.017	0.355	0.039	0.035	0.017	0.355
VE	1.527	2.585	0.008	10.064	0.682	0.480	0.008	2.159
DE	-0.084	0.254	-2.153	0.560	-0.056	0.112	-0.520	0.439

Note: Summary statistics for $\sigma(e_{it}^c)$ and $Corr(e_{it}^c, e_{jt}^c)$

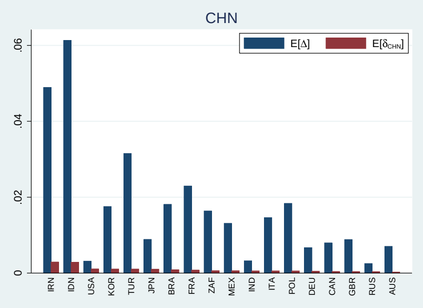
Empirical results: France

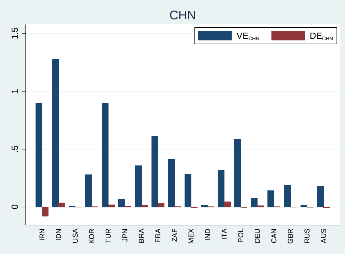


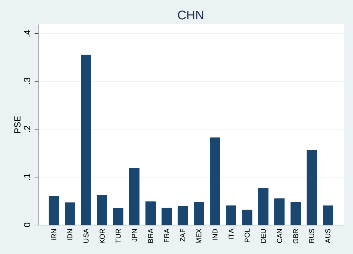




Empirical results: China







DEU GBR SAU

Analytical results: Unilateral tax distortions

Proposition

Maintain the conditions in Proposition 1 but assume $\psi_1 = \psi_2 = 1$. *Let* $\delta_i(\tau^x, \tau^m)$ *denote the economic advantage of linking in country* $i = 1, 2$ *when country* 1 *unilaterally imposes* (τ^x, τ^m). *Then in interior equilibria* $\exists(\bar{\tau}^x, \bar{\tau}^m) \in \mathbb{R}^2_{++}$ such that

$$\mathbb{E}[\delta_1(\bar{\tau}^x, \bar{\tau}^m)] > \mathbb{E}[\delta_1(0,0)]$$

$$\mathbb{E}[\delta_2(\bar{\tau}^x, \bar{\tau}^m)] \lesseqgtr 0$$

$$\mathbb{E}[\delta_1(\bar{\tau}^x, \bar{\tau}^m)] + \mathbb{E}[\delta_2(\bar{\tau}^x, \bar{\tau}^m)] < \mathbb{E}[\delta_1(0,0)] + \mathbb{E}[\delta_2(0,0)]$$

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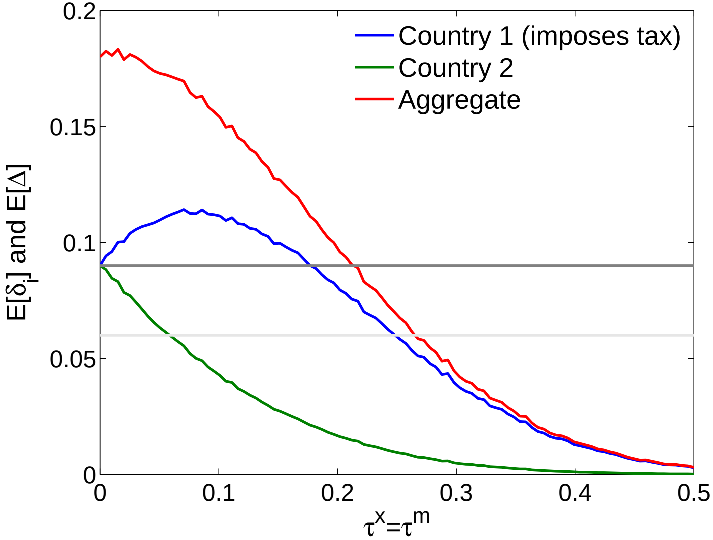
Numerical illustration: Unilateral tax distortions



Conclusions

- You want your partner to be large, volatile and negatively correlated
- Much variation in the data to make the exercise worthwhile
- Sunk costs and unilateral distortions can kill a carbon date
- Linking can be a responsiveness mechanism

Carbon dating: When is it beneficial to link ETSs?

(GRI Working Paper No.208)

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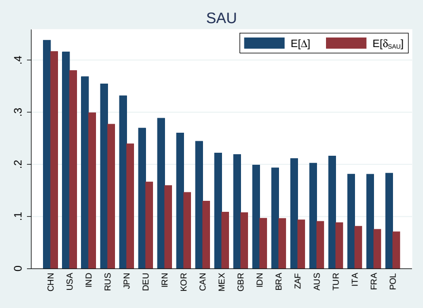
THANK YOU!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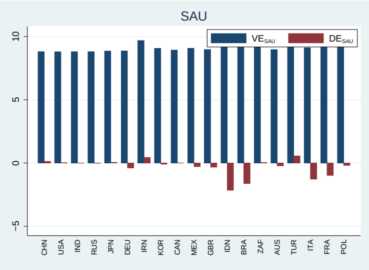
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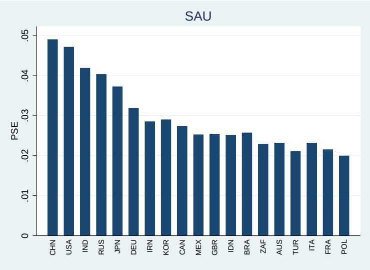
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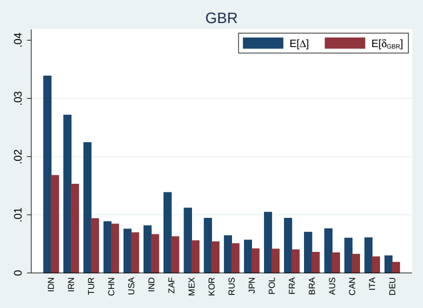
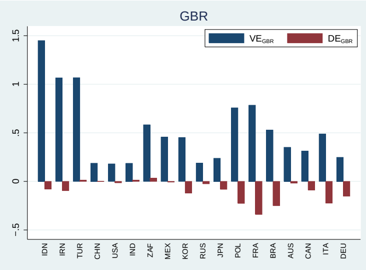
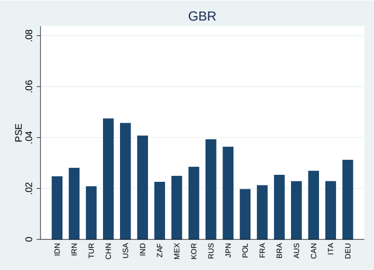
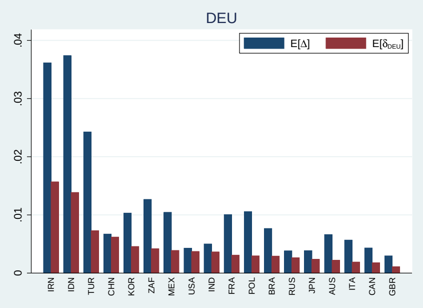
Empirical results: UK

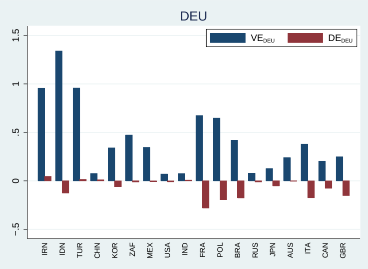


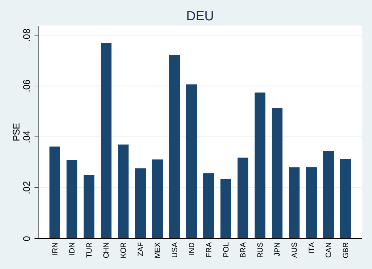




Empirical results: Germany







Empirical results: Observed fluctations in emissions

Table: Summary statistics: $\sigma(e^c_{it})$ and $Corr(e^c_{it}, e^c_{jt})$

	mean	**sdev**	**min**	**max**	**N**
ψ_i	0.142	0.234	0.033 POL	1 CHN	20
$\sigma(e^c_{it})$	0.038	0.032	0.017 AUS	0.153 SAU	20
$Corr(e^c_{it}, e^c_{jt})$	0.122	0.218	-0.459 CHN- ITA	0.688 DEU-FRA	190