Branger, F., P. **Quirion** (2014). Would Border Carbon Adjustments prevent carbon leakage and heavy industry competitiveness losses? Insights from a meta-analysis of recent economic studies, *Ecological Economics* 99: 29-39

CIRED, CNRS

General context

- Scope of the study:

Assess the efficiency of BCAs to reduce carbon leakage with a quantitative meta-analysis of recent ex ante studies on the subject

Descriptive Statistics

- Leakage ratio

$$l = \frac{\triangle E_{NonCOA}}{- \triangle E_{COA}}$$

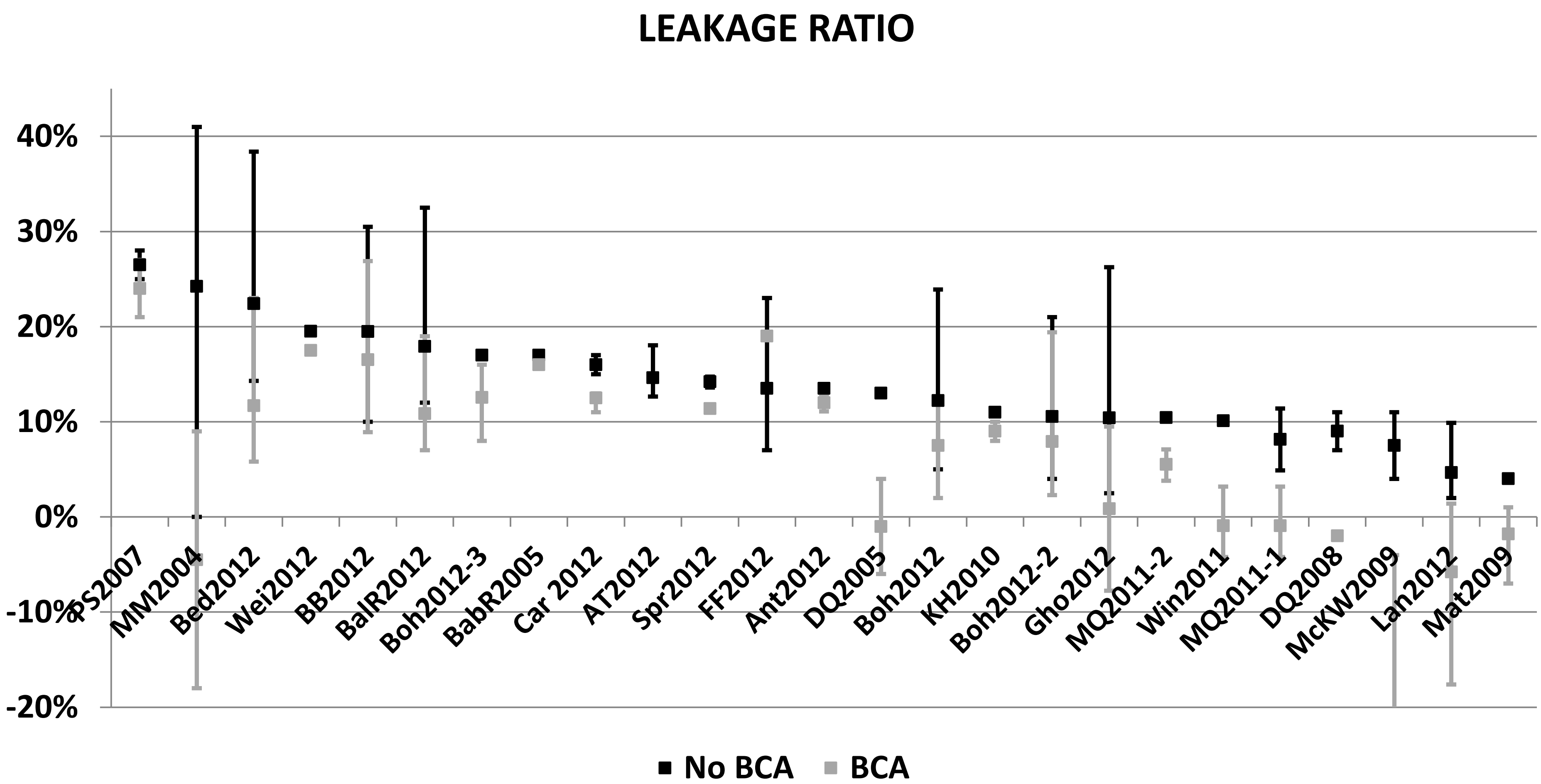
Change in emissions ***in the rest of the world*** compared to the reference scenario

Change in emissions ***in the climate coalition*** compared to the reference scenario

Database Description

- Three criteria to be included:
  - Providing numerical estimates of carbon leakage
  - Include BCAs in a scenario
  - Recent literature (after 2004)
- 25 papers (including 14 of *Energy Economics* Special Issue). Mostly CGE relying on GTAP database
- 310 estimates

Descriptive Statistics



Meta-regression analysis

- Going beyond literature review by combining results from different studies in a statistical manner
- Mostly used in medical studies, the first in economics can be traced back to Stanley and Jarrell (1989)
- In climate policy:
  - Kuik et al. (2009) on mitigation costs
  - Vermont and de Cara (2010) on mitigation costs in agriculture

Meta-regression analysis

- Guidelines on MRAs (Nelson and Kennedy 2009, Stanley et al. 2013) insist on issues with:
  - Research literature searching, compilation and coding; research questions and effect size
  - Meta-regression modelling issues:
    - Publication bias
    - Existence/Treatment of outliers
    - Heteroscedasticity in effect size and non independance of observations of the same primary studies

Meta-regression analysis

- Effect size: common metric in the leakage ratio (all studies measure the same thing)
- Criteria for study inclusion explained earlier
- Standard search engines: Google Scholar, Web of Science

Meta-regression modelling issues

- Publication bias:
  - Studies with statistically weak or unusual results less likely to be published
  - Recognized to exaggerate the effectiveness of pharmaceutical (Doucouliagos and Stanley 2009)
  - Statistical techniques exist but cannot be applied because they need standard errors (and we deal with model studies but not statistical studies)
  - Highly likely that PB exists in modelling studies: authors compare their results to those of the literature
  - We include working papers to mitigate PB

Meta-regression modelling issues

- Heteroscedasticity in effect size and non independance of observations of the same primary studies:
  - Some authors (Stanley 2011) favor the use of a « best set » : a single estimate by study
  - In our case:
    - Random Effect Multi Level (REML) model, with study identifiers as in Doucouliagos and Stanley (2009)
    - Cluster Robust OLS estimator as in Kuik and al. (2009) and Vermont and de Cara (2010) as a sensitivity analysis

Meta-regression: the model

Three variations of the meta-regression based on different samples: one for all the sample, one for No BCAs scenarios and one for BCAs scenarios

$$\begin{aligned} Leakage_{ij} = \quad & Const + \beta_1 GE_{ij} + \beta_2 Coasize_{ij} + \beta_3 Abatement_{ij} + \beta_4 Link_{ij} \\ & + \beta_5 GHG_{ij} + \beta_6 Armington_{ij} + \beta_7 BCAs_{ij} + u_{ij} \end{aligned}$$

$$\begin{aligned} Leakage_{NoBCAs,ij} = \quad & Const + \beta_1 GE_{ij} + \beta_2 Coasize_{ij} + \beta_3 Abatement_{ij} + \beta_4 Link_{ij} \\ & \beta_5 GHG_{ij} + \beta_6 Armington_{ij} + u_{ij} \end{aligned}$$

$$\begin{aligned} Leakage_{BCAs,ij} = \quad & Const + \beta_1 GE_{ij} + \beta_2 Coasize_{ij} + \beta_3 Abatement_{ij} + \beta_4 Link_{ij} \\ & + \beta_5 GHG_{ij} + \beta_6 Armington_{ij} + \beta_8 Exp_{ij} + \beta_9 Foreign_{ij} \\ & \beta_{10} AllSect_{ij} + \beta_{11} Indirect_{ij} + u_{ij}. \end{aligned}$$

Meta-Regression: Results

	All	No BCAs	BCAs
GE	0.091	0.047	0.124
	(2.74)***	(1.60)	(4.27)***
Coasize	-0.214	-0.221	-0.147
	(12.12)***	(10.97)***	(5.94)***
Abatement	0.090	0.163	0.084
	(1.04)	(1.78)*	(0.69)
Link	0.003	-0.005	0.002
	(0.26)	(0.48)	(0.13)
GHG	-0.029	-0.014	-0.062
	(2.24)**	(1.04)	(2.82)***
Armington	0.019	0.033	0.003
	(4.68)***	(7.75)***	(0.51)
BCA	-0.063		
	(14.27)***		
Exp			-0.039
			(2.98)***
Foreign			-0.020
			(1.90)*
Allsect			-0.042
			(2.90)***
Indirect			-0.015
			(0.87)
N	294	134	160
Wald χ^2	$386.13^\dagger$	$192.61^\dagger$	$78.25^\dagger$
LR test	$220.50^\dagger$	$96.95^\dagger$	$42.02^\dagger$
DW test OLS	0.68	0.52	1.08

† $prob = 0.0000$

-BCAs, on average decrease leakage ratio by 6.3 percentage points everything else being constant

-Main result

-High statistical significancy

Meta-Regression: Results

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Leakage higher for CGE models: International fossil fuel leakage?

Meta-Regression: Results

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Switch of coalition from Europe (15% of world's emissions) to A1+China-Russia (71%):

-Decrease of 12 percentage points without BCAs

-Decrease of 8 percentage points with BCAs

Meta-Regression: Results

	All	No BCAs	BCAs
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† $prob = 0.0000$

$$l = \frac{\triangle E_{NonCOA}}{-\triangle E_{COA}}$$

-Theoretical indeterminacy of leakage and abatement

-Here positive relation (but statistically weak)

-Positive relation in Alexeeva-Talebi et al. (2012) but negative in Böhringer et al. (2012)

Meta-Regression: Results

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-No statistical significance of Link (but when included in scenarios reduce leakage to a smaller extent)

-Statistical significance for including all GHGs gases (reduces leakage)

Meta-Regression: Results

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† $prob = 0.0000$

-Higher values of Armington elasticities (international trade more price-sensitive) increase leakage

-Switching from low to high values increases by 2x1.9=3.8 percentage points

Meta-Regression: Results

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DW test OLS	0.68	0.52	1.08

† $prob = 0.0000$

Among BCAs features,
-Inclusion of exports and
-Inclusion of all sectors (not only EITE)
have the highest impact

Conclusion

- Meta-analysis on 25 articles (310 estimates)
- Leakage ratio ranges from 5% to 25% without BCAs to -5% to 15% with BCAs
- On average BCAs led to 6.3 percentage points decrease of leakage ratio (meta-regression), some leakage remain (<- international fossil fuel channel)

Conclusion

- A bigger coalition decreases leakage
- Among BCAs features, in the meta-regression, the inclusion of all sectors and the presence of export rebates are the two most efficient to reduce leakage
- However political and administrative costs left aside in these models. A realistic BCAs implementation would be a “light” version (BAT carbon level, selected products like clinker)

Border carbon adjustments: a way forward

Philippe Quirion

CIRED, CNRS

Anti-leakage policies in the EU-ETS

- Phases 1 & 2: historic allocation + ‘new entrants’ reserve
- Phases 3 & 4: partial move toward output-based allocation (with thresholds)
- Plus subsidies for electro-intensive industries
- Problems with historic allocation (Quirion, *Climate Policy*, 2009)
  - Windfall profits
  - Overallocation profits (cement: 3.5 bn. € during phases 1&2; Branger & Quirion, *Energy Economics*, 2015)
  - Ineffective against leakage
- Problem with output-based allocation
  - Reduced incentive to replace GHG-intensive products
  - Transfer of the non-compliance risk onto Member States and the EU
- Problem with activity thresholds
  - Incentive to ‘game’ output levels (Branger et al., *JAERE*, 2015)

‘Pour vivre heureux, vivons cachés’

- Full auctioning & BCA
  - Economic first-best
  - Politically difficult
- Equivalent solution: OBA + taxation of consumption
  - Holland, *JEEM*, 2012; Böhringer et al., 2019
  - Exports: OBA = BCA based on a fixed benchmark
  - Imports:
    - OBA → right incentive for choices of inputs
    - Consumption tax → right incentive for choices of outputs

Proposed way forward

(Neuhoff et al., 2016)

1. Output-based allocation in sectors 'at risk of carbon leakage': allocation based on benchmarks multiplied with the *current* production volume
2. Climate Contribution charged for the use of basic materials
   - Rate = EUA price x EU-ETS benchmark
   - Charged on consumption, not exports, e.g. :
     - Cement : clinker rate x clinker benchmark
     - Steel products : % of steel x crude steel benchmark, throughout the value chain
   - CO_2 price of €30/t increases the price of steel by 11%, of aluminium by 20% and of cement by 28% (Pauliuk et al., 2016) if 100% pass-through
   - Implied increase in the cost of a car: around €90

at €30 /t CO2.

Material	Total production, EU28 2012, (Mt)	EU-ETS benchmarks tons of CO_2-eq/ ton of material)	Liability per ton (EUR)	Total liability created within EU28 (MEUR)
Steel	160	1.780	53	8500
Aluminum	3.6	12.82	385	1400
Plastics	57	1.5	45	2500
Paper	100	0.4	12	1200
Cement	170	0.69	21	3600
Sum				**17200**

Source: Pauliuk et al. (2016), assuming carbon intensity of continental European power generation for indirect emissions.

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