Estimating the effect of an EU-ETS type scheme in Australia using a synthetic treatment approach

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Motivating Background

The global effects of climate change are clear, and for Australia

- 2019 was Australia's hottest year on record, and the seven years from 2013 to 2019 all ranked in the nine warmest years on record.
- April-Oct rainfall in South East Australia has declined by 16% since 1970, while monsoonal rainfall has increased across the north. Droughts and floods are now more common.
- Annual fire seasons are now longer, and the 2019 - 2020 bushfire season was the worst on record (the area burnt was bigger than Indiana or Iceland).
- Average sea surface temperature in the Australasian region has risen each decade since 1900. Coral is bleaching, sea levels are rising and sea water is becoming more acidic.

Climate events are having devastating effects on the Australian environment and people.

Motivating Background

.. and wildlife as well ..

Motivating Background

There is overwhelming evidence that green house gas emissions are an important cause and driver of climate change.

Australia had the highest CO_2 per capita in the industrialized world in 2018, and is currently second (to Luxemburg).

81% of emissions in Australia come from the energy sector,

Fossil fuels contributed 79% of total electricity generation in 2019, including coal (56%), gas (21%) and oil (2%). Renewables contributed just 21% of total electricity generation; specifically hydro (5%), wind (7%), and solar (7%).

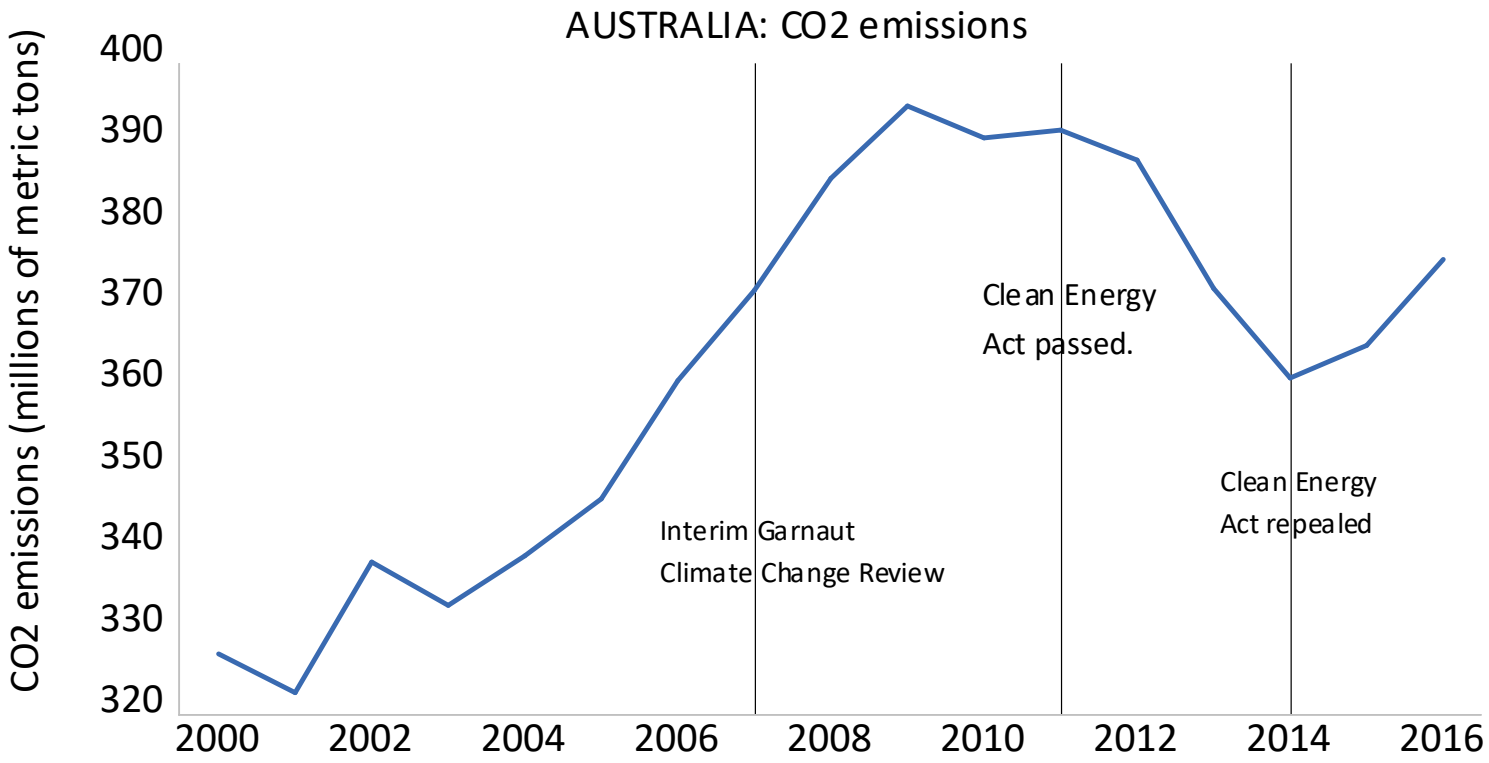
Australia is the fifth biggest coal producer in the world, and second biggest exporter - raising concern about exporting climate change.

Emission abatement is essential, but has met with economic/political barriers ever since Emissions Trading Schemes (ETS) were first considered.

Some History

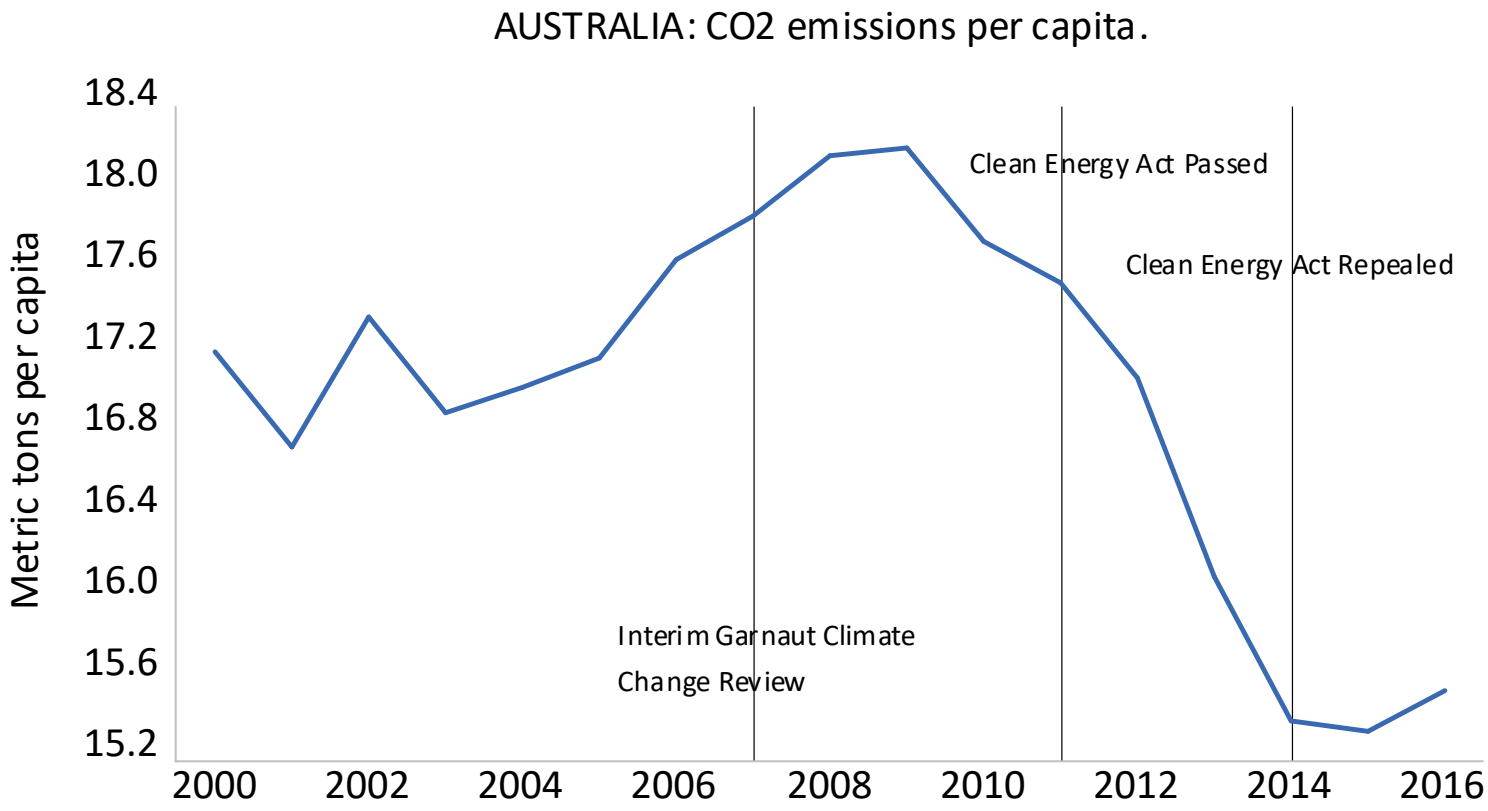
- Australia signed the UNFCCC in 1992, and the Kyoto Protocol in 1998, but did not ratify the Protocol until 2007.
- The 2011 Clean Energy Act sought to align Australia's carbon pricing to the 2005 European Union Emission Trading Scheme (EU ETS) by 2015, but this act was repealed in 2014.
- The Clean Energy Act was replaced by the Emissions Reduction Fund, which essentially pays subsidies on projects that reduce carbon emissions but has not had much effect to date.
- Australia ratified the Paris agreement in November 2016, and its first NDC committed to reduce green house gas emissions by 26 to 28% below 2005 levels by 2030.
- Overall, Australia is lagging behind other countries in implementing renewable energy policy, raising questions regarding whether we can meet international targets, and whether we would have, had we taken stronger action sooner.

Recent carbon emissions in Australia



Tony Abbott's election campaign strategy, 2013.

Recent carbon per capita emissions in Australia



What we do

- We estimate the hypothetical impact of Australia adopting an emissions trading policy in 2005, which corresponds with the establishment of the EU ETS.

- We use counterfactual approaches (similar to those in Abadie et al (2010), Bai et al (2014), Harvey and Thiele (2020) and Hsiao et all (2012)), to construct **synthetic treatments** for Australian emission.

- The construction of the synthetic treatments for Australian emissions, makes use of the time series properties of pre-2005 emissions in European countries (and Australia).

What we find

- We find that Australian emissions would have fallen by approximately 6% per year.

- We find that our results are robust to several variations of our methodology.

Our model

We use a common (unobserved) trend model of per-capita CO_2 emissions with three assumptions:

- A1: The main feature (i.e. trend) of the emissions of a group of EU countries is similar to that of Australian emissions prior to EU-ETS (i.e. prior to 2005).
- A2: EU-ETS is effective if it affects the trend in emissions.
- A3: EU-ETS does not affect the loadings of the common trend.

If $y_{0,t}$ is Australian PC CO_2 emissions and $\mathbf{y}_t$ is an $N \times 1$ vector containing the PC CO_2 emissions of European countries, A1 states:

$$y_{0,t} = \mu_t^{NT} + \varepsilon_{0,t}, \quad \varepsilon_{0,t} \sim (0, \sigma_\varepsilon^2) \tag{1}$$

$$\mathbf{y}_t = \boldsymbol{\theta}\mu_t^{NT} + \boldsymbol{C} + \boldsymbol{\varepsilon}_t, \quad \boldsymbol{\varepsilon}_t \sim (0, \Sigma_{\boldsymbol{\varepsilon}}) \tag{2}$$

$$\mu_t^{NT} = m^{NT} + \mu_{t-1}^{NT} + \eta_t, \quad \eta_t \sim (0, \sigma_\eta^2) \tag{3}$$

for $t = 1, 2, \ldots, T_0$ where T_0 is the last year before EU-ETS. The superscript NT denotes non-treated units, and the non-trending components $(\varepsilon_{0,t}, \boldsymbol{\varepsilon}_t)$ are weakly stationary and possibly correlated.

Our model (continued)

A2 states that an emissions policy is effective if it changes the trend. This ensures that the policy treatment can be distinguished from other transitory movements in these time series. A2 and A3 then imply that:

$$\mathbf{y}_t^T = \boldsymbol{\theta}\mu_t^T + \boldsymbol{C} + \boldsymbol{\varepsilon}_t, \quad \boldsymbol{\varepsilon}_t \sim (0, \Sigma_{\boldsymbol{\varepsilon}}) \tag{4}$$

$$\mu_t^T = m^T + \mu_{t-1}^T + \eta_t, \quad \eta_t \sim (0, \sigma_\eta^2) \tag{5}$$

for $t > T_0$, where the superscript T denotes treated units, and $m^T \neq m^{NT}$. Had Australia adopted the EU-ETS in 2005, then Australian emissions would have followed

$$y_{0,t}^T = \mu_t^T + \varepsilon_{0,t}, \quad \varepsilon_{0,t} \sim (0, \sigma_\varepsilon^2).$$

The goal is obtain an estimate of the common latent trend and to use this to construct a counterfactual for Australian emissions.

Data

- (100 $\times$ the natural logarithms of) CO_2 emissions per capita from the World Bank database
- Countries: Australia, EU members, Iceland, Norway and UK
- Annual data, 1960 - 2016 (57 observations, with 12 of these after 2004, noting that the EU ETS was established in 2005)
- We exclude countries with missing observations
  - Note this includes France, Italy and Germany
- In total, we consider 17 EU members + Iceland, Norway and UK as possible treatment donors.

Inspection of a plot of $lnCO_2$ together with unit root tests indicate that Australian $lnCO_2$ emissions per capita follow a random walk with (positive) drift.

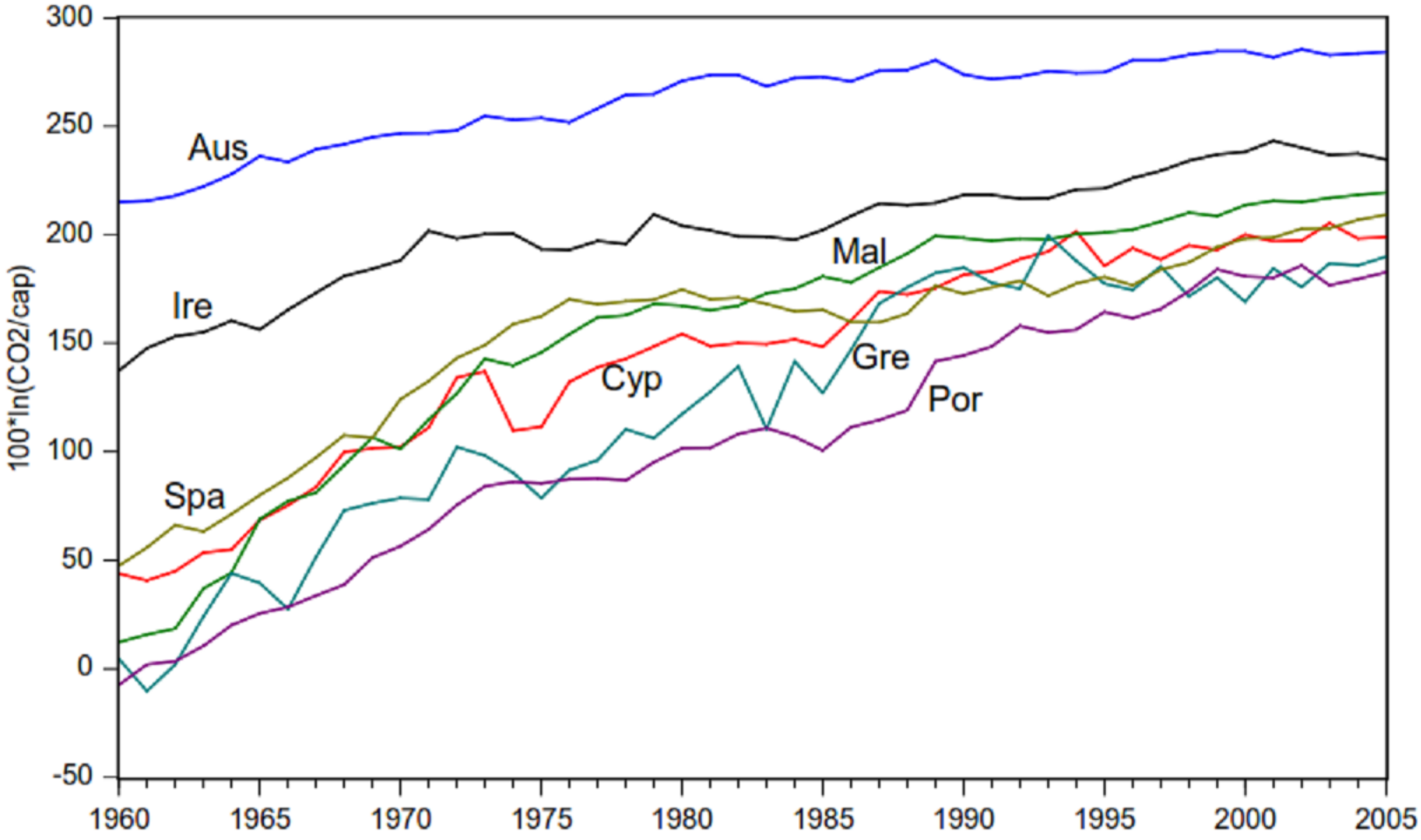
Properties of the European data from 1960 to 2004

Inspection of plots of European $lnCO_2$ emissions per capita series together with unit root tests indicate that 9 of these series follow a random walk with (positive) drift.

KPSS tests based on the residuals of $100lnAus_t = \alpha_0 + \alpha_1 100lnEur_{it}$ find that 6 of the European series are cointegrated with the Australian series. The (asymptotic) 10% CV for KPSS is 0.231.

Country	α_0	α_1	R^2	KPSS
Cyprus	203.95	0.402	0.945	0.116
Greece	210.20	0.336	0.971	0.080
Ireland	113.48	0.723	0.899	0.167
Malta	221.64	0.330	0.919	0.106
Portugal	225.80	0.345	0.907	0.173
Spain	192.73	0.453	0.916	0.197

CO2 trajectories in Australia and donor countries

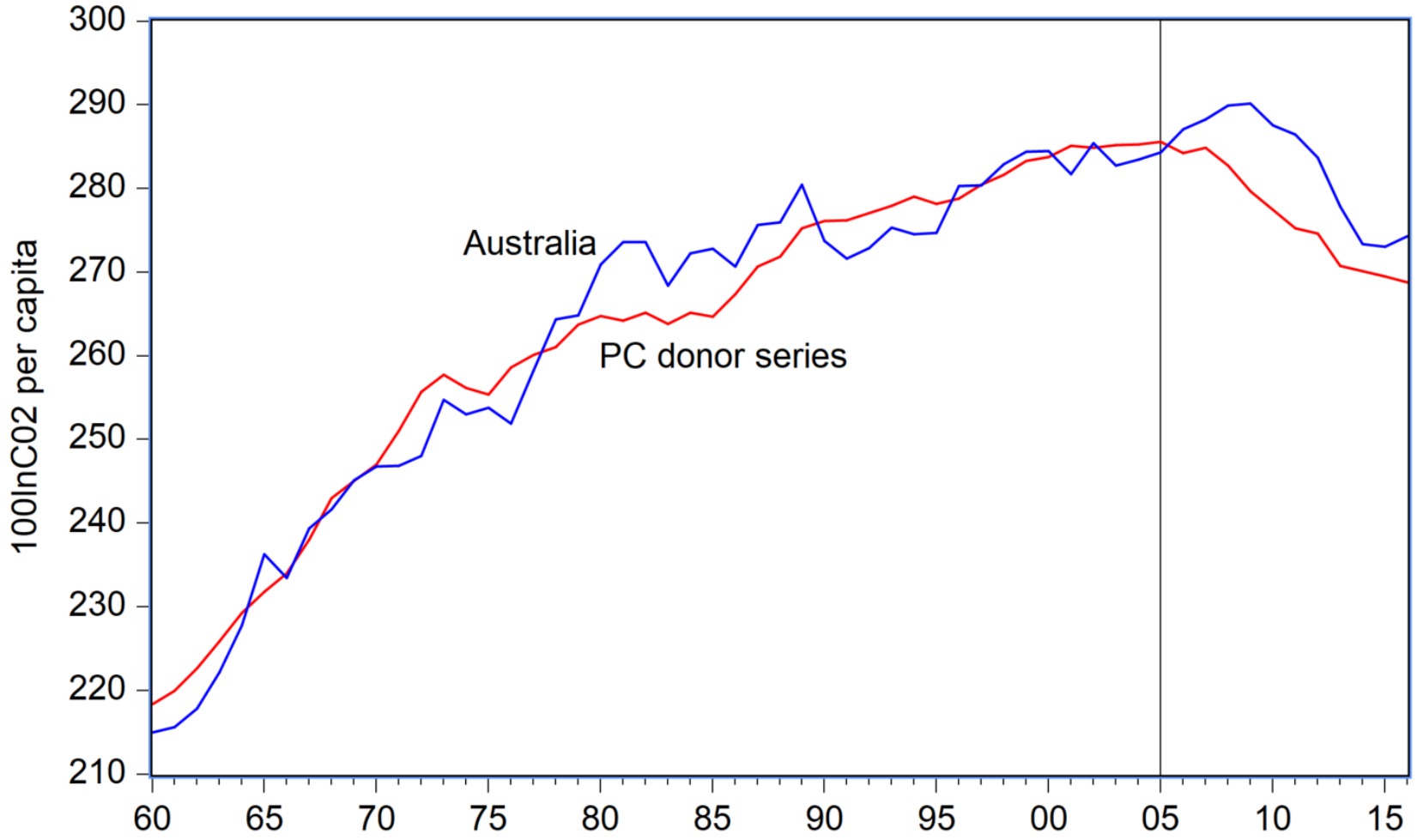


Estimation of the counterfactual observations

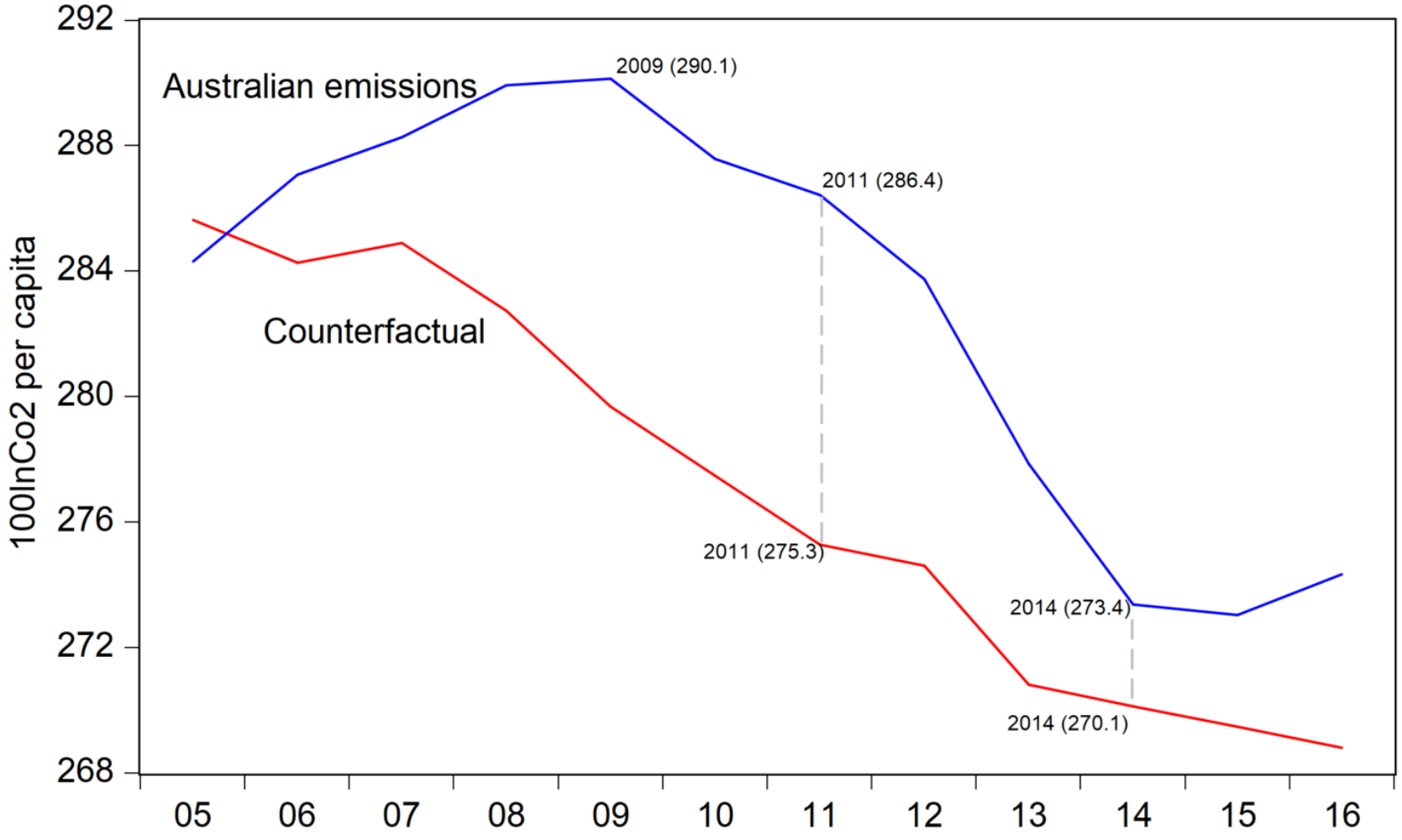
- Each of these six European "donor" series in $\mathbf{y}_t^T$ has pairwise cointegration with the Australian series prior to EU-ETS.
- We scale each by its (pre-EU-ETS) α_1 coefficient to bring them all to the same scale as the Australian series ($y_{0,t}$), and then look for weights w_i such that $0 \leq w_i \leq 1$ and $\sum_{i=1}^{N} w_i = 1$ where $N = 6$.
- A proxy for the trend in $y_{0,t}$ prior to EU-ETS is then given by $y_{0,t}^P = \sum_{i=1}^{N} w_i y_{i,t}$.
- The estimate of the counterfactual $y_{0,t}^{CF}$ then applies the same weights to the European donor data from 2005 onwards.
- There are many sets of weights that satisfy these constraints, and one that is consistent with our common factor interpretation is to take the first principle component of the six (scaled) donor series and weigh them using the associated loadings.

Counterfactual based on principle components

After 2004 the (average) counterfactual is 6.029% lower than the observed Australian series (with a HAC se of 1.340%).



Details of the counterfactual series

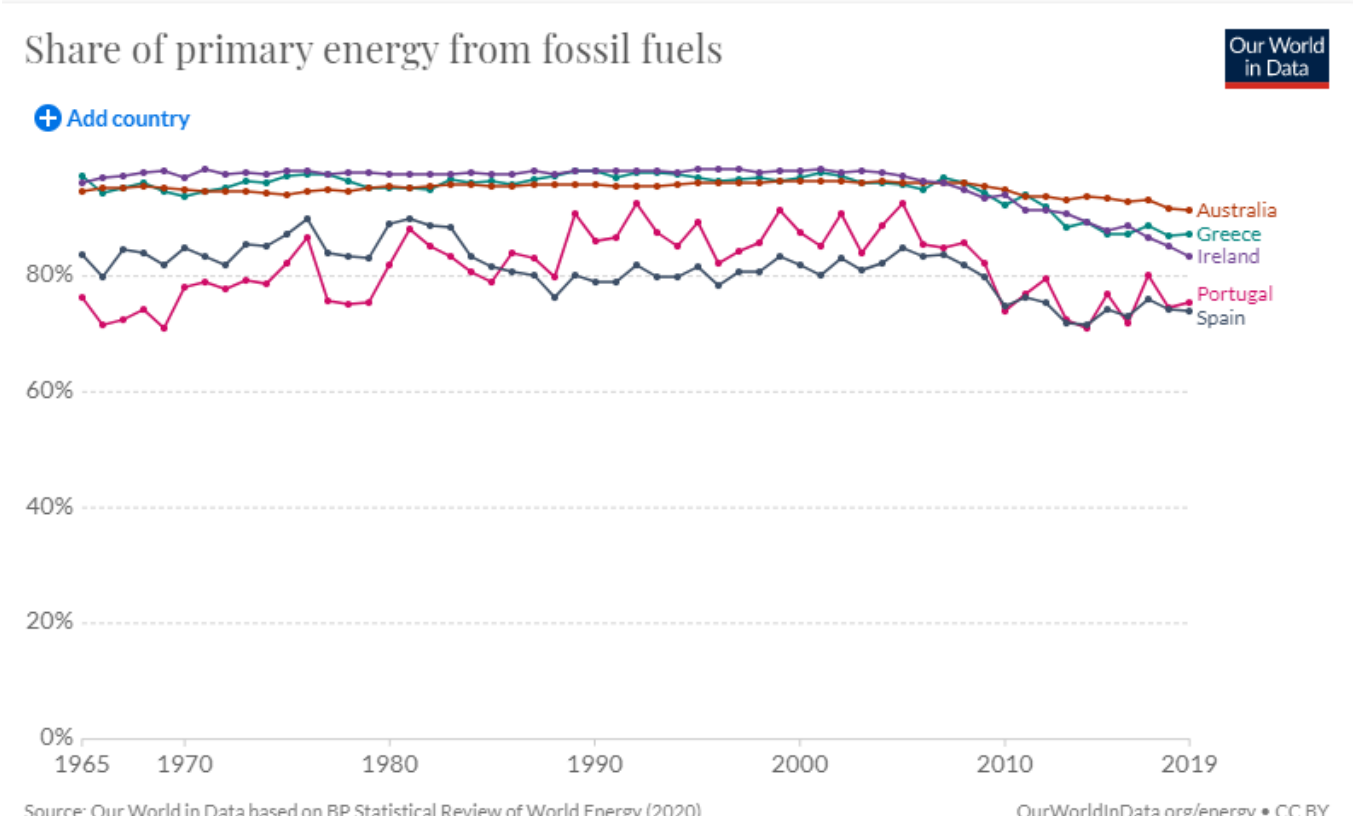


Discussion: EU-ETS or the GFC?

After the EU-ETS started, the (average) counterfactual was 3.017% lower than the observed Australian series (with a se of 1.697%) until 2008 and then, (on average), it was another 4.518% lower (with a se of 1.762).

Several countries in the donor set went bankrupt in the wake of the GFC, so was the decline in the counterfactual due to this?

The following plot suggests otherwise.



Robustness

In addition to using principle components (PC) to determine our donor weight we also calculate our weights in other ways, including equal weights (EQ), restricted least squares (RW), shrinkage of weights from equal weights (SH) and direct OLS estimation of donor coefficients as in Bai (2014).

The following table shows that the counterfactual predictions change only slightly.

Country	PC	EW	RW	SH	BW
Cyprus	0.169	$0.16\overline{6}$	0.000	0.152	-0.137
Greece	0.169	$0.16\overline{6}$	0.833	0.275	0.895
Ireland	0.165	$0.16\overline{6}$	0.000	0.080	0.015
Malta	0.165	$0.16\overline{6}$	0.167	0.203	0.226
Portugal	0.167	$0.16\overline{6}$	0.000	0.087	0.020
Spain	0.165	$0.16\overline{6}$	0.000	0.202	-0.006
Ave annual % $\downarrow$	6.029	6.044	5.471	5.150	5.485
(HAC se)	(1.340)	(1.181)	(0.952)	(1.210)	(1.093)

Would an EU-ETS type scheme have allowed Australia to meet its NDC?

- The target is for Australian carbon emissions in 2030 be 26 - 28 percent lower than in 2005.
- We follow Hsiao et al (2012) and use a simple AR(1) model of the differences of the twelve counterfactual observations to forecast emissions out to 2030.
- The model is estimated imprecisely, but it predicts that $lnAusCO_2$ in 2030 will be 2.49, relative to $lnAusCO_2$ in 2005 which was 2.84.
- Translating this back to levels (accounting for translation bias) leads to a forecast of 12.047 (10.178, 14.299) metric tons per capita (vs 17.398 metric tons in 2005), i.e. a 31% drop.
- If we use our last 12 $lnAusCO_2$ observations to forecast Australian $lnAusCO_2$ in 2030, then we obtain a forecast of 14.711 (8.004, 27.133) metric tons per capita (vs 17.398 metric tons in 2005), i.e. a 14% drop.

Conclusion

- We estimate the hypothetical impact of Australia adopting an emissions trading policy in 2005 that was similar to the EU ETS.
- We use a counterfactual approach that is based on the principle components of several European emission series to construct a **synthetic treatment** for Australian emission.
- We find that had Australia adopted the policy, carbon per capita emissions would have fallen by 31% by 2030. In comparison, we find that Australian carbon emissions will fall by about 17%.
- Whether either projection will meet the NDC depends on population growth (which is projected to be strong), but it is clear that early adoption of an EU-ETS type policy would have led to greater reductions than are going to be observed.

Sydney was blanketed by bushfire smoke this time last year. *(ABC News)*