How Effective are Carbon Prices for Reducing Emissions? Empirical Evidence From Australia And Slovenia

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Introduction (1/3)

- Economic theory (as well as ex-ante modeling studies) suggests that carbon pricing is an economically efficient policy instrument to mitigate climate change (Nordhaus, 1977; Aldy et al., 2010, Timilsina, 2022)
- Existing empirical studies (ex-post), however, report mixed findings about the effectiveness of carbon pricing in reducing CO2 emissions
- Some studies, such as Andersson (2019), Metcalf (2019), Murray and Maniloff (2015) find significant reductions of emissions due to carbon pricing whereas studies such as Shmelev and Speck (2018), Wakabayashi and Kimura (2018), Pretis (2020) do not find much impacts
- Several reasons, such as methodology used, data quality, measurement errors, and real-world issues might have caused the inconclusive literature
- Lack of strong empirical evidence of emission reduction could discourage the implementation of carbon pricing
- This study investigates the emission reduction effect of carbon taxes with different characteristics in Australia and Slovenia

Introduction (2/3)

Australia

- Prime Minister Julia Gillard (Labor minority government) introduced a carbon pricing scheme in 2011 despite the opposition of Liberal Party; It came into effect on 1 July 2012; tax rate was A$23/tCO2
- Emitters with annual GHG emissions below 25,000 tonnes and those under the transport and agriculture sectors were exempted
- Revenues from the carbon tax were used to cut personal income tax of those with A$80,000 annual income or less; increased pensions and welfare payments to cover expected price increases; compensation for some affected industries
- It was repealed just after two years (1 July 2014) by Tony Abbott's Conservative government
- Our study aims to assess the GHG mitigation impacts of that carbon pricing together with the renewable policy introduced in 2009

Introduction (3/3)

Slovenia

- Introduced in 1996 at the rate of €4.17/tCO2, which was increased to €12.52/tCO2, in 1998; the rate was increased to in 2000 and to 2003 and remained unchanged until 2005 when Slovenia joined the EU ETS

- This study aims to understand how effective was that carbon tax to reduce emissions during the 1996-2005 period in Slovenia

Methodology and Data (1/2)

- Synthetic control technique
- It compares the variable of interest (here per capita emission) of a treated country (Australia or Slovenia) with that of countries (donor pool) which have the most possible similarity on the explanatory variables (predictors)
- The variables (predictors) considered are sectoral emissions shares, GDP per capita, population, and fossil fuel mix in primary energy consumption
- Data are compiled from various sources including International Energy Agency, Energy Informational Administration, World Bank and Emissions Database for Global Atmospheric Research maintained by the EU.

Methodology and Data (2/2)

Denoting countries by index j (j = 1 for the treated country), years by index t, emissions per capita with and without treatments by, $Y_{jt}(1)$ and $Y_{jt}(0)$, respectively, the treatment effect for unit j at time t is

$$\tau_{it} = Y_{jt}(1) - Y_{jt}(0)(1)$$

The estimated treatment effect is given by $\widehat{\tau_{1t}} = Y_{1t}(1) - \sum_{j=2}^{J+1} w_j^* Y_{jt}$

Where wj* are weights of countries in the donor pool, which is determined in such a way that wj*≥ 0 ∀j and ∑ (Wj to W j+1) =1. With X1 to represent the kX1 vector of treated country and X0 to represent the kxj matrix of same characteristics of control countries, the kXk matrix of V that represents the relative importance of the k characteristics through the minimization of

$$sqrt\{ (X_1 - X_0 W)' V (X_1 - X_0 W) \}$$

where $(X_1 - X_0 W) = \sum_{h=1}^{k} v_h (X_{h1} - W_2 X_{h2} - \cdots - W_{j+1} X_{h(j+1)})^2$

with h referring the predictor k

Please see Abadie's JEL 2021 paper for more details on the methodology.

Estimation Technique for Australia (1/2)

The donor pool for Australia is constructed as follows:

- Used a global panel dataset (1980-2018) with all variables
- Economies with any missing data in any year excluded
- Economies with carbon tax or ETS during 1980-2018 excluded
- Small economies with population below 1 million excluded

Estimation Technique for Australia (2/2)

- Total number of economies on donor pools dropped to 33

Kuwait	Canada	Algeria
Russia	Saudi Arabia	Trinidad and Tobago
Turkmenistan	Oman	Singapore
Belarus	Libya	South Africa
Israel and Palestine, State of	Azerbaijan	South Korea
Taiwan	Hong Kong	Venezuela
Mongolia	North Macedonia	Uzbekistan
Moldova	Georgia	Armenia
Bosnia and Herzegovina	Iraq	Iran
Kyrgyzstan	Malaysia	Jordan
Argentina	Cuba	Jamaica

- Only four out of 35 donors has significant weights

Weight	Economy
0.39	Taiwan
0.30	Israel and Palestine, State of
0.26	Canada
0.05	Hong Kong

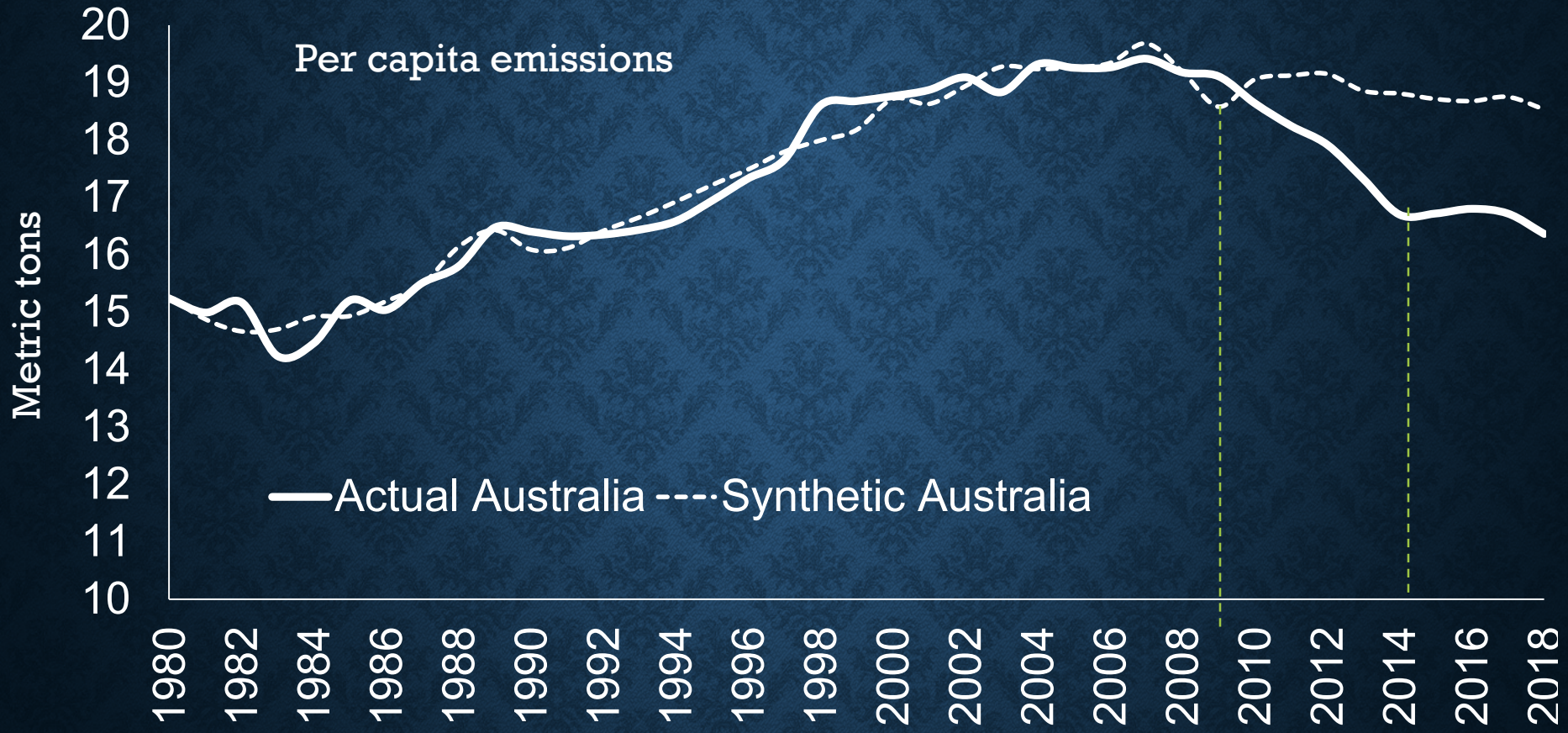
Estimation Technique for Slovenia

- Unlike Australia we faced problem in Slovenia due to too short pre-treatment period (1992-1996)

- European countries without carbon tax served for the donor pool, the weights are as follows:

Weight	Country (Unit)
0.44	Iceland
0.27	Bulgaria
0.14	Greece
0.12	Portugal
0.02	Poland

Results – Australia (1/2)



- The annual average per capita emission (AAPCE) of Australia for the post treatment period (2009-2018) is 7.9% smaller than the corresponding value of synthetic Australia
- Compared to 2008 per capita emissions, the AAPCE for the post-treatment period is 7.15% smaller

Fossil fuel factors do not get tax benefits

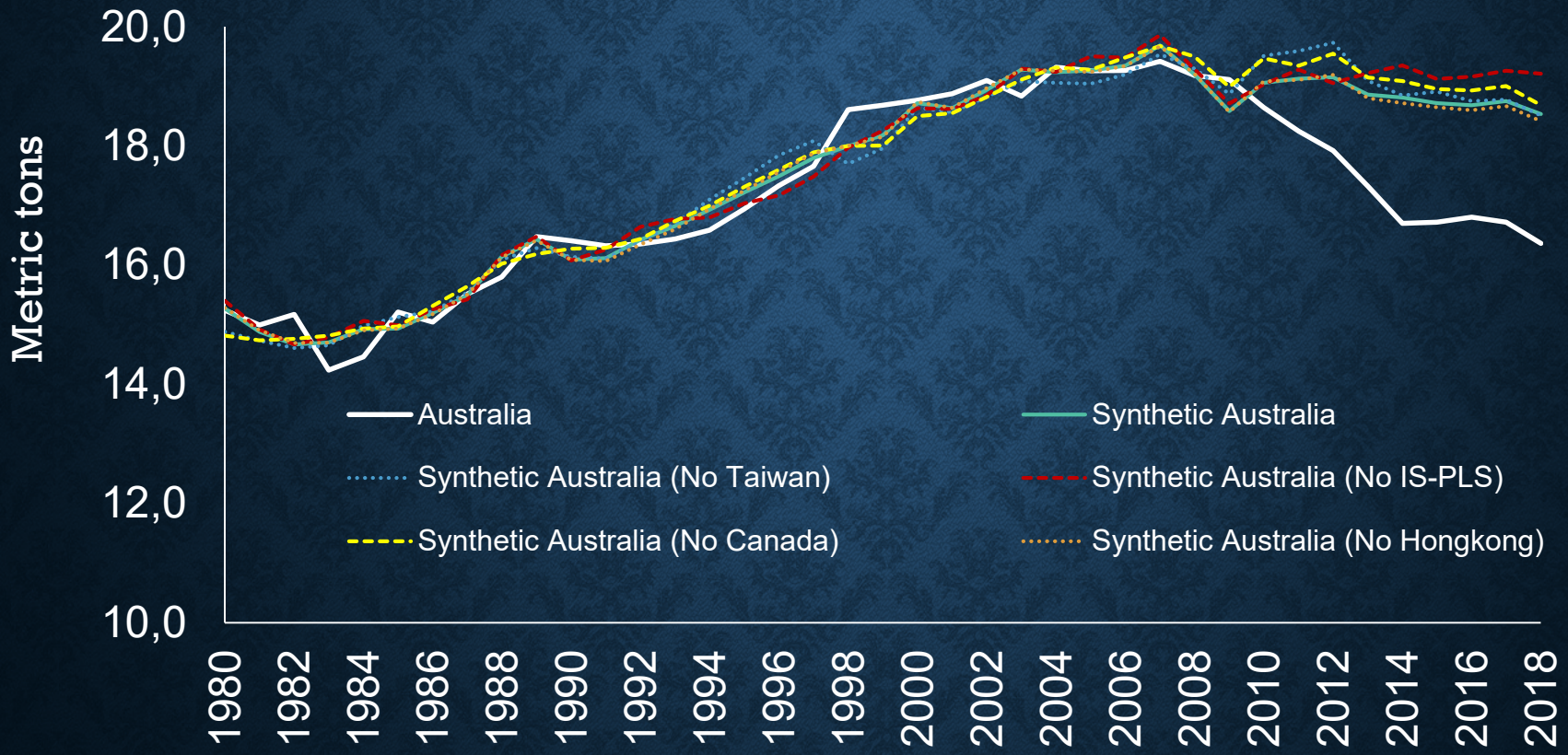
Results – Australia (2/2)

Covariate balance

Variables	Treated	Synthetic	Donor Pool Avg.
Emissions share (power)	0.52	0.47	0.40
Emissions share (transportation)	0.21	0.21	0.17
Emissions share (other)	0.28	0.33	0.43
Log of gdp per capita (USD 000s)	3.68	3.42	2.46
Btus of coal per capita (Hundred MMs)	1.04	0.46	0.14
Btus of ng per capita (Hundred MMs)	0.50	0.34	0.50
Btus of petroleum per capita (Hundred MMs)	0.94	0.97	0.65
Emissions per capita in 2001	2.58	2.33	0.23
Emissions per capita in 2007-2008 (avg.)	3.00	3.14	1.49

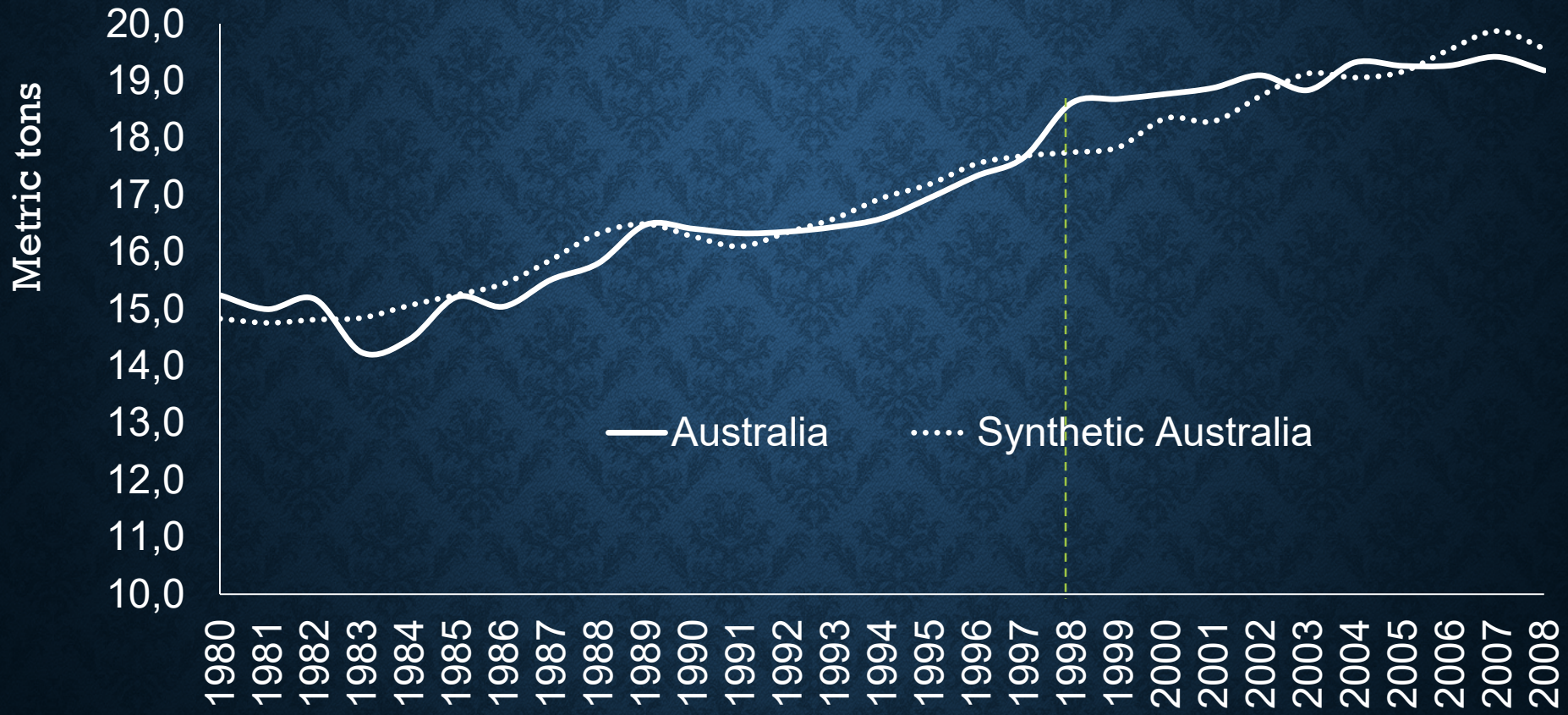
Validation of Results – Australia (1/4)

Leave one out test



Validation of Results – Australia (2/4)

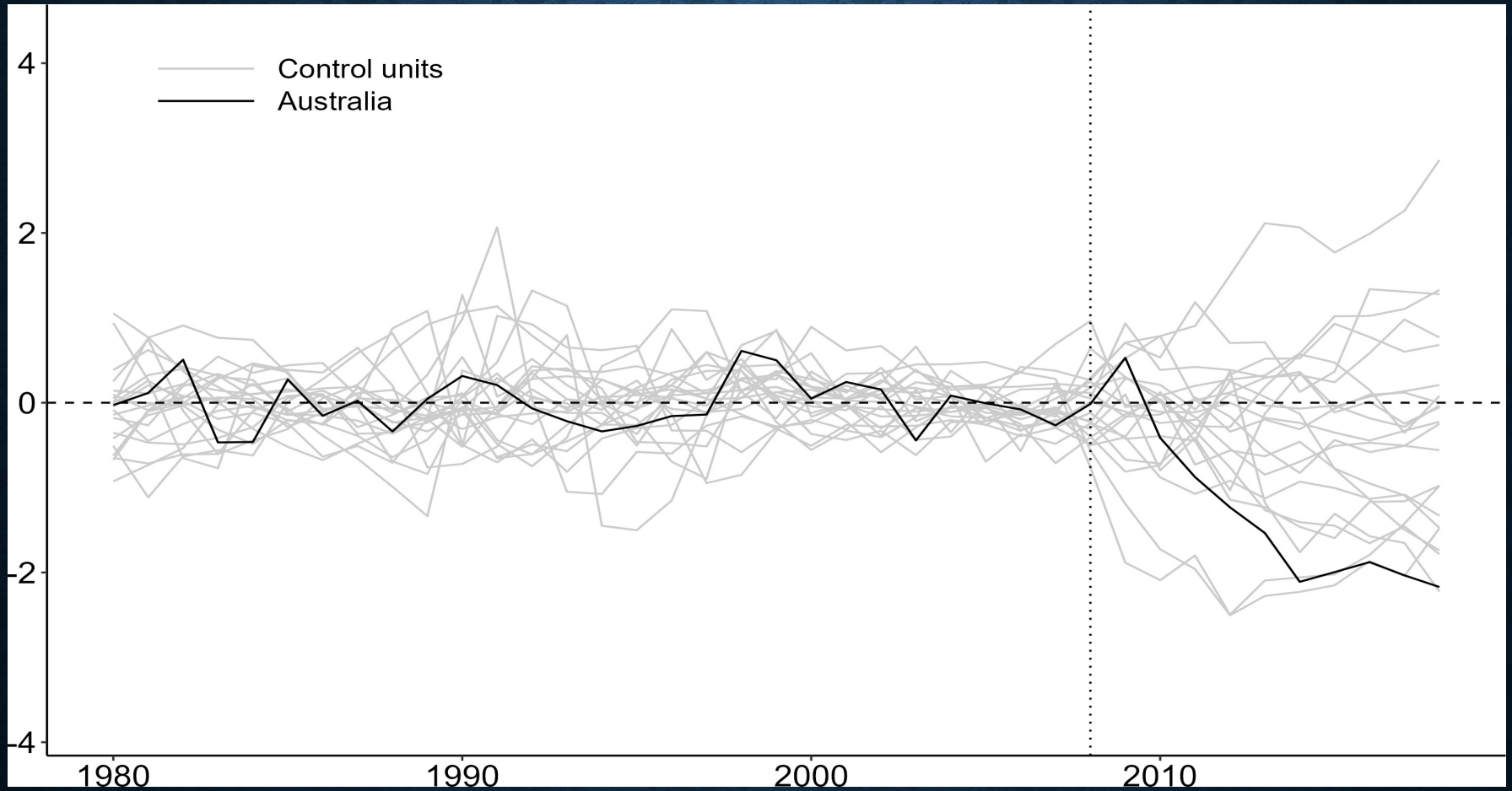
Placebo in-time test



The pre-treatment period is moved back by 10 years to 1998 to examine the effect of a fake policy

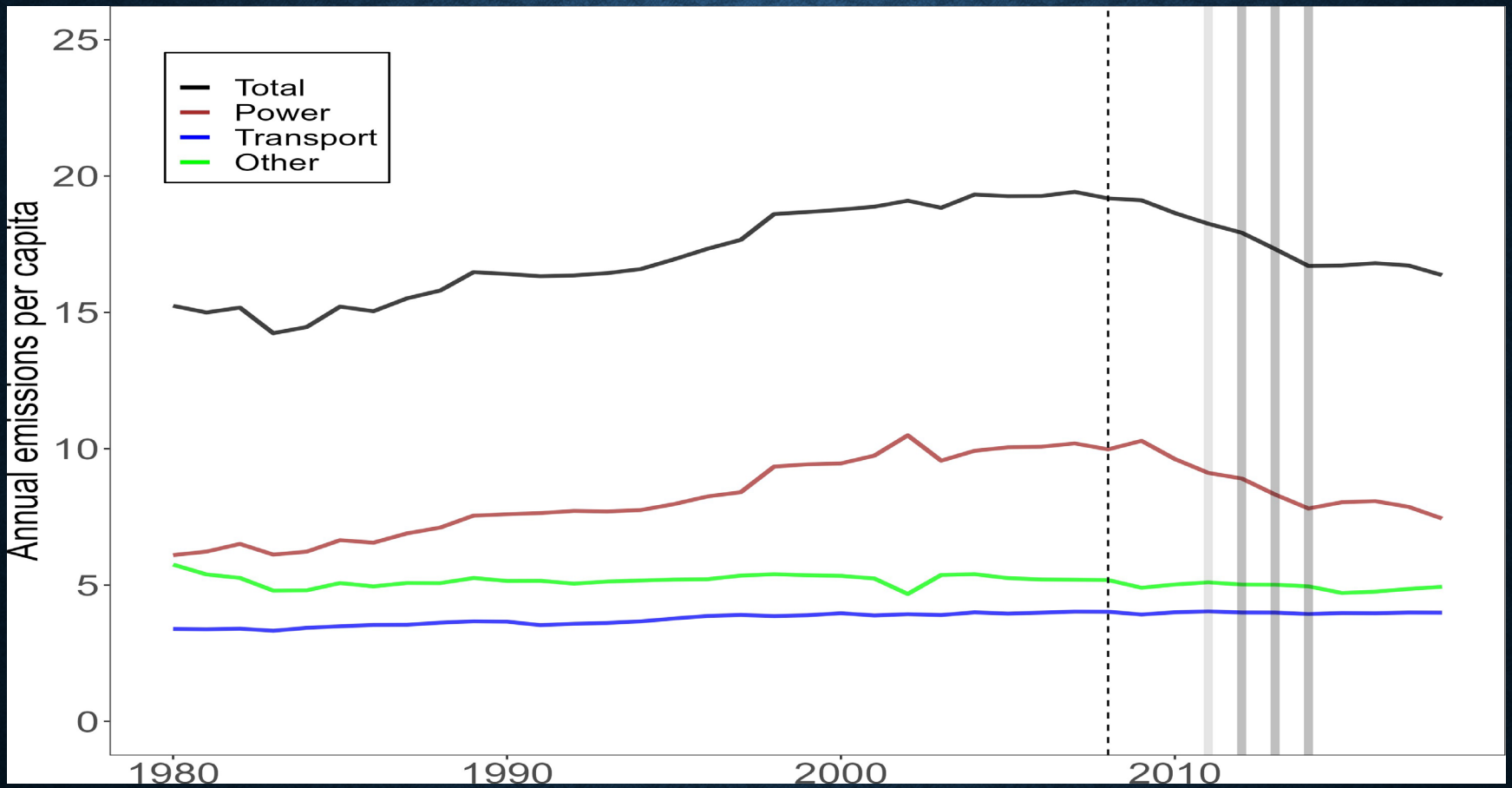
Validation of Results – Australia (3/4)

Placebo in-space test (gaps plot)



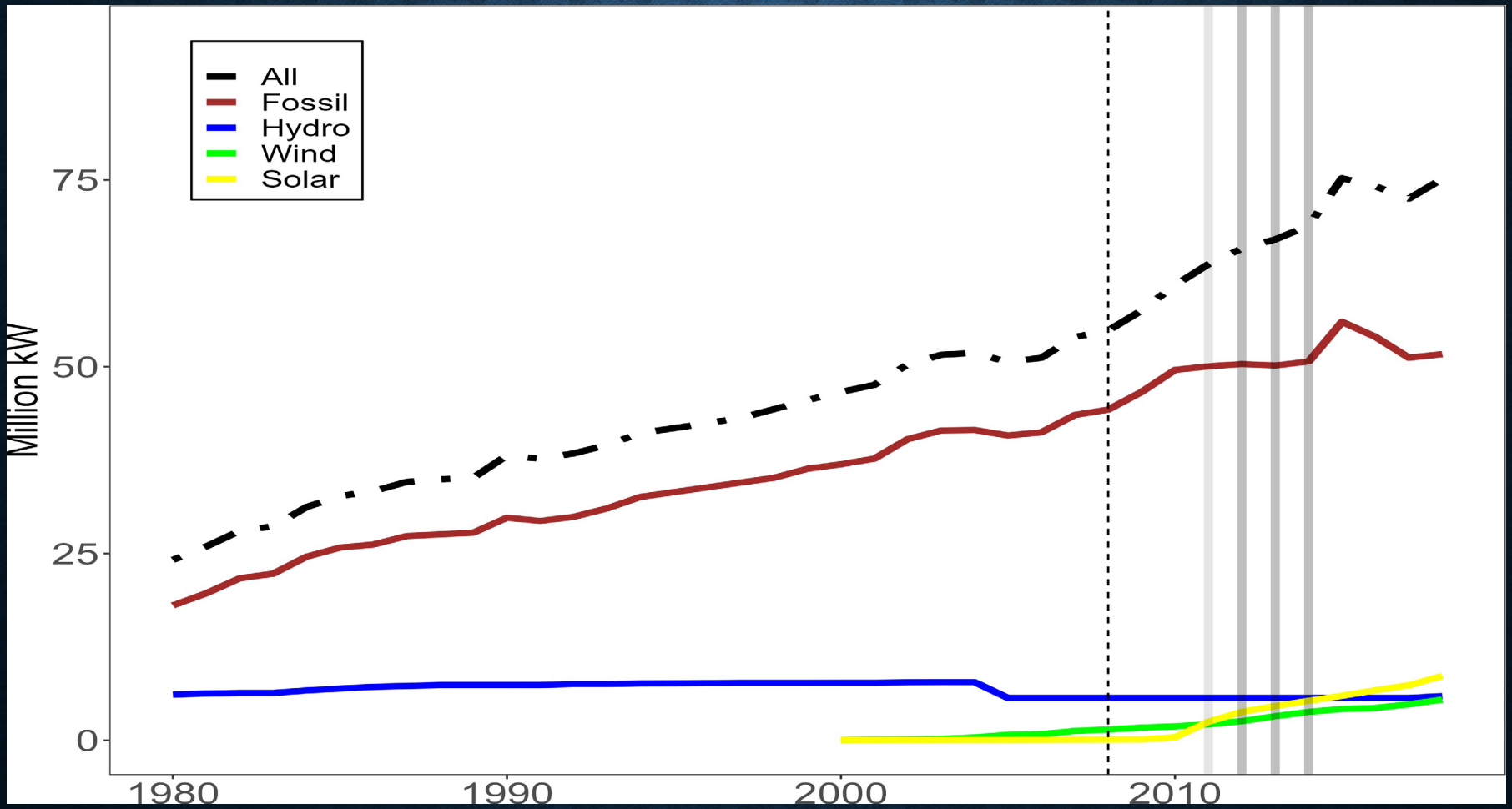
Explanation of Australia Results (1/2)

Sectoral emission trends

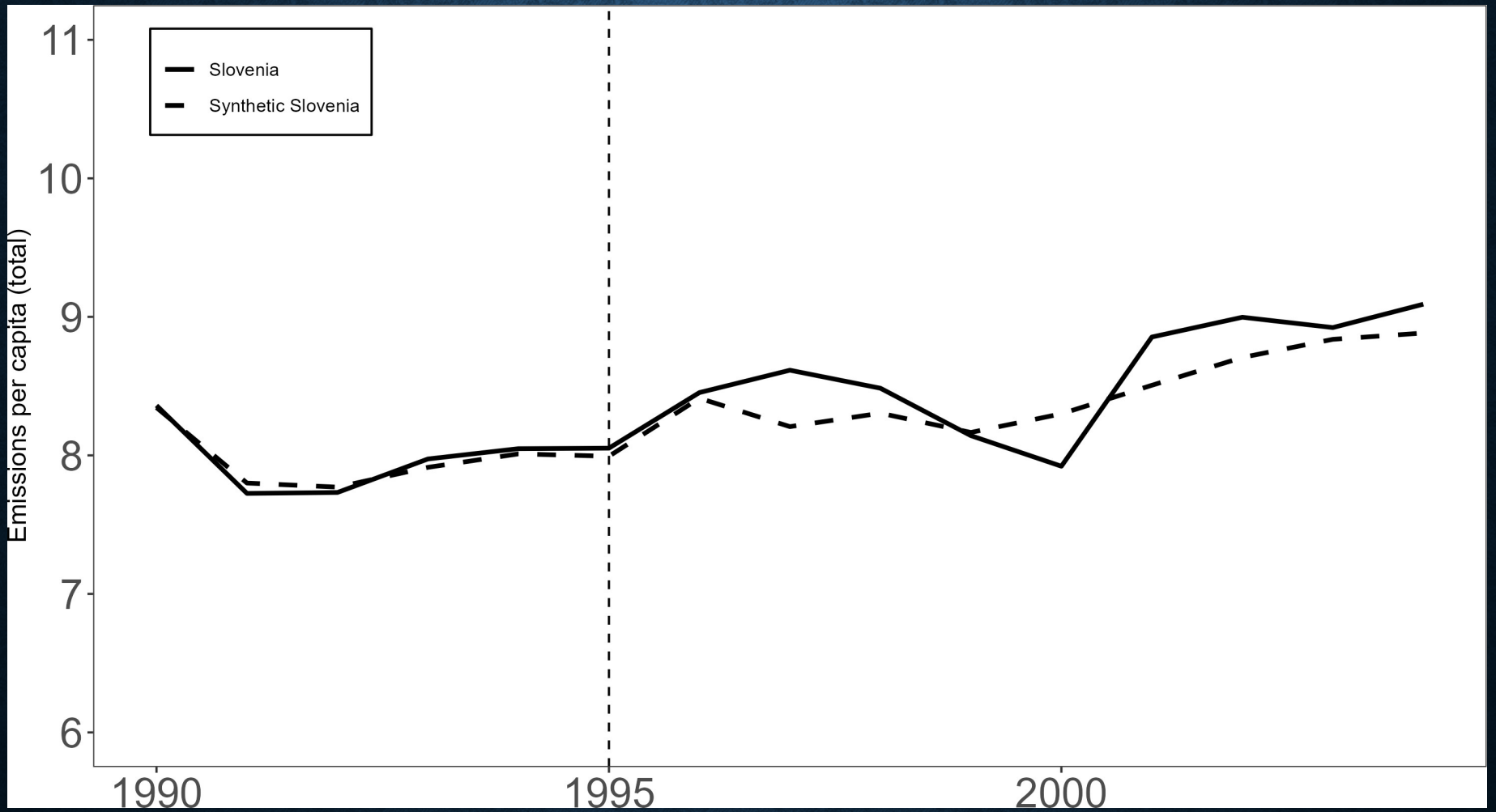


Explanation of Australia Results (2/2)

Electricity generation trends



Results – Slovenia



Conclusions

- The renewable energy policy introduced in 2009 and carbon tax policy introduced in 2012 (but withdrawn in 2014) were found to reduce, on average, 8% of CO2 emissions annually during the 2009-2018 period in Australia
- The findings are validated for all possible tests for robustness
- The reductions in CO2 emissions occurred mainly in the power sector where renewables caused reduction of coal-based power generation, which was further reduced due to the carbon tax
- We could not find a concrete evidence of CO2 emission reduction in Slovenia, however, the result might be caused due to lack of data as we did not have necessary data for the pre-treatment analysis.

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THANK YOU

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Validation of Results – Australia (4/4)

Placebo-in-space (MSPE ratios)