

# Reviews of ECONJOURNAL-D-23-00149R2

Carbon Taxes and CO2 Emissions: A Replication of Andersson (American Economic Journal: Economic Policy, 2019)

## Round 1

### Reviewer 1

#### Summary

This paper revisits an influential study by Andersson (2019), which assesses the causal effects of carbon taxes on CO2 emissions using synthetic control methods (SCM). The author replicates the analysis using the original and alternative data, and confirms that the qualitative implications remain the same (at least for Sweden). In addition, the author applies the same procedure and analyzes the Norwegian transport sector. The author also evaluates the "overall" impact of the tax reform in Sweden. I find this paper interesting and think it contains important results. A revised version will be an important contribution to the literature. Below I list some comments that I think are important.

#### Main Comments

1. I think the prediction intervals (PI) for SCM should be reported.
  - a. It would be good to show the plot like Figure 1 Panel A with PI using the original Andersson's data in Section 4.1. This additional figure with PI will be informative for interpreting the original results of Andersson (2019).
  - b. It is also important to show the PI for Figure 3 Panel B to interpret the author's SCM result. I suspect that the PI covers (non-synthetic) Norway. The PI may help to provide more evident implications about the representativeness of Andersson's result, strengthening the author's present discussion about it (in Introduction, Section 5.2, and Conclusion).
  - c. For example, the following paper develops a feasible (though perhaps not perfect) method for drawing the PI: Cattaneo, Feng, & Titiunik (2021, Prediction Intervals for Synthetic Control Methods, Journal of the American Statistical Association). They also provide software packages (available in R, Stata, and Python); these can be found at <https://nppackages.github.io/scpi/>.

#### Minor Comments

1. It would be good to include some discussion of the validity or limitations of SCM for the following reasons:
  - a. The manuscript (and perhaps Andersson (2019) as well) emphasizes the merits of using SCM by comparing DID (E.g., page 7 and page 14).
  - b. However, the failure of the parallel trend assumption does not support the use of SCM. The validity of using SCM also rests on several assumptions, including structural ones.
  - c. Moreover, even when the model is correct, it can be biased (when pretreatment periods,  $T_0$ , is small; see Abadie et al. (2010, Appendix B)). If the

SCM estimate (or prediction) is biased, we may not be able to say that SCM should be preferred to DID (at least in terms of bias).

d. Therefore, a discussion of the validity or limitations of the analysis based on the SCM will be helpful in assessing the policy implication of this paper.

2. The image quality of some figures does not look good. I recommend replacing them with similarly formatted versions of Figure 6 to maintain the quality of the paper

## Reviewer 2

This study replicates Andersson (2019), who originally investigated the impact of carbon taxes on CO<sub>2</sub> emissions in the Swedish transport sector using the synthetic control method (SCM). With some minor modifications to the data and approach, the study almost successfully reproduces the findings of Andersson (2019). The study then extends the approach to Norway and found that the estimated impact is much smaller than in Sweden. The study also extends the analysis to the national-level CO<sub>2</sub> emissions in Sweden and found that the results are uninformative due to the failure to construct a satisfactory synthetic counterfactual.

The study provides a very detailed replication of Andersson's work, though further discussion and refinement in writing are necessary.

### Major Comments:

(1) First of all, it is not clear why replicating Andersson (2019) is important. The author should provide more persuasive motivation for the replication.

1. In the replication procedure of the SCM, the author drops Denmark from the sample and uses originally compiled (but almost identical according to Table 1) data. These modifications seem minor to me, and indeed, the effect is not so large as to negate Andersson's results.

2. As for the regression analysis, the author estimates the model via the Prais-Winsten approach because the OLS is not efficient. However, the preferred model is the IV, which handles the endogeneity problem, not the OLS. (Note that the Hausman test is based on OLS vs IV.) Thus, this additional exercise may not be informative. Furthermore, the author states "This is somewhat strange, since the primary interest in estimating the demand curve concerns the coefficient estimates, not the standard errors. As is well-known, OLS is not efficient in the presence of serial correlation." But this is the reason why Andersson used heteroscedasticity robust standard errors, and it is not "strange."

(2) Related to the above, one clear difference between the original study and the replication is the drastic increase in CO<sub>2</sub> emission in synthetic Sweden after 2000 (Panel B of Figure 1). If it is reasonable, it would be informative to discuss what drives this difference.

(3) A detailed explanation on the simulation procedure using regression results is necessary in Figures 2 and 7.

(4) More detailed discussion on why the estimated impact of carbon taxes is much smaller in Norway than in Sweden. The author discusses the effect of Norwegian economic performance as a possible confounder. However, the GDP per capita is included as the predictor of the SCM, and thus, the effect is already controlled. Therefore, this discussion is not informative unless there is a structural change that affects the prediction weight of the GDP. Furthermore, the difference between the actual and the synthetic GDP is not shown in Figure 6.

(5) There is a large room for improvement in the writing style. For example, on page 4, "My first approach was to contact Andersson. ... Serendipitously, Anderson also had downloaded data on CO2 emissions..." may not be appropriate in academic writing style. Such issues can be found throughout the text. The author may want to use a professional proofreading service.

#### Minor Comments:

(1) On page 2, the exact date is necessary instead of "At the timing of this writing..."

(2) On page 2, the author should elaborate more on "I use an alternative approach..." and "I use a different methodology..."

(3) On page 9, "Columns (5)-(7) of Table 2 show that...", but the column numbers are missing in the table.

(4) On page 18, "This substitution from gasoline to diesel is not captured in the regression analysis, which focuses solely on the carbon tax effect on gasoline consumption. In contrast, SCM has the advantage of capturing the impact on emissions for the whole transport sector, not just the portion due to gasoline consumption and its attendant CO2 emissions." might be misleading because the substitution effect cannot be captured in the SCM because it is not a structural model.

## Round 2

### Editor

Thank you for the revised manuscript. After checking the manuscript by myself, I found your excellent revision efforts and all reasonable responses to the reviewers' comments. I now feel it has greatly improved, and thus give conditional acceptance without checking with the reviewers again.

However, you can make more improvements, and should put further efforts for completing this paper as a journal article. The following is a list of points you have to address, most of which are minor.

The condition for the final acceptance is that you should address all the points below as well as check the manuscript again carefully. The list below may not be a full, exhaustive list of remaining issues, and you should again do your best efforts to remove awkward expressions and grammatical errors.

Please provide your responses to the comments below that require non-minor changes, if you resubmit a revised manuscript.

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Page 2, Sec 1, first paragraph: "(Tirkaso & Gren, 2020)", instead of "Tirkaso and Gren (2020)".

Page 3, line 7: (Green, 2021), instead of (Green 2021).

Page 4, line 13: "My extension analysis, however," instead of "My extension analysis however,".

Page 3, first line of the last paragraph: "This paper proceeds as follows", instead of "My study proceeds as follows".

Page 4, first sentence of Section 3.1: "The data and code used by Andersson (2019) are posted at:"

Page 5, line 4: "set the time of treatment as 1990".

Page 5, line 10: "I also needed to be certain" instead of "As well, I needed to be certain".

Page 5, lines 11-12: You say ". In doing so, I discovered that data on CO2 emissions from transport are no longer available in the World Bank WDI database (2020)."

But, in Table 1, you indicate that World Bank WDI database (2020) provides CO2 emissions from transport, 1971-2005. You meant, the 2020 database does not provide CO2 emissions from transport for 1960-1970? If so, provide a precise explanation.

And, if so, you provide such a precise explanation here, some descriptions on the latter part of page 5 must be redundant.

In first place, there is no need to write "My initial analysis uses these publicly sourced, CO2 emissions data" as you have not included that initial analysis in the paper, which should be removed.

Re-consider and re-write your descriptions on this page, removing redundant parts and keeping ones useful for readers.

Page 5, line 13 from the bottom: "In order to base my analysis as much as possible on publicly available data", instead of "Wanting to base...."

Page 5, line 7 from the bottom: "on average", instead of "in means"?

Page 6, line 3: The data for the predictors cover the years...

Page 6, line 5: "excluding Norway", instead of "excluding Norway here".

Page 6, 2nd paragraph of Section 3.2: "Suppose there are J+1 units", instead of "Suppose there is J+1 units".

Page 7, line 6: "minimizing the objective function (2)", or "minimizing the objective function defined in Equation (2)", instead of "minimizing Equation (2)" [you know, an equation is not something to be minimized].

Page 7, line 8: For notational consistency, you might want to define  $V$  as a column vector with transpose  $'$ .

Page 7, line 5 "While there are", instead of "While there is".

Page 8, what is  $\tau_{\{t, \text{energy}\}}$ ? Explain or provide its definition.

Page 8, equation (5). vectors do not look conformative.  $X_t$  must be a column vector, and you should write  $X_t'$  with transpose

Page 8, "A simulation was conducted after the regression in which the author approximated the amount of CO<sub>2</sub> emissions in three cases: Sweden without carbon taxes and VAT, Sweden with VAT but no carbon taxes, and Sweden with carbon taxes and VAT. "

This simulation was done by you or Andersson? State clearly. Also, rather than by just saying "simulation", you could say, for example, "analyzed counterfactual scenarios, using regression estimates" or conducted counterfactual simulations using regression estimates" or something.

Page 10, middle part: You might want to write

"I check how conclusions might change if Denmark were excluded from the control group" or

"I check how conclusions may change if Denmark is excluded from the control group".

Page 11, line 13: you might want to add Andersson's estimate after "what Andersson report", so that readers can do easier comparison.

Page 11, first line of Section 4.3: "When SCM is used in Andersson (2019), by its nature, two effects could not be distinguished".

Page 11, 3rd line of Section 4.3: "both of which coincided".

Page 11, 3rd line of Section 4.3: "What further complicate this case" or "What make this case entangled further", instead of "Complicating things further".

Page 12. You re-estimated the regression model using the Prais-Winsten method. According to your description, that is a GLS procedure with AR(1) error specification. On the other hand, Andersson's inference is based on the Newey-West long run variance estimation with is nonparametric allowing for flexible serial correlation from.

If you use AR(p) with reasonably large p (instead of AR(1)), the difference in inference results between OLS and Paris-Winstein may become smaller. I conjecture, this may happen if serial correlation in the errors cannot be captured by a simple AR(1) but can be reasonably by AR(p).

However, according to Table 3, your and Andersson's regression analyses are based on only 46 observations. This is not a large number for the reliability of time series regression and associated inference. It's ok for Andersson and you to provide standard error estimates, but I would not see they are indeed reliable. Due to this small number of observations, the standard errors computed based on the Newey-West procedure are not reliable at all or using GLS with AR(p) specification (with reasonably large p) must not be a very meaningful exercise, which requires a greater number of parameters.

You don't need to do re-estimation by GLS with AR(p), and can keep all the results as they are, but the fact that GLS with AR(1) produced somehow different estimates has to be interpreted carefully:

If AR(1) is a good/reasonable specification, I would simply say that Andersson's estimates (and standard errors) are not reliable, while your estimates must be, probably, more reliable. On the other hand, if AR(1) is not good but AR(p) is a good specification, there is probably nothing you (and

Andersson) can do for improved reliability: AR(p) error specification as well as Newey West procedure requires a larger number of observations for its reliability.

Page 12, line 14 from the bottom: "Andersson's estimates", instead of "Anderson's estimates".

Page 12, line 8 from the bottom: "significant increase", instead of "dramatic increase".

Page 13, line 6: "it also shows" instead of "it too shows".

Page 13, second paragraph: "I repeat this calculation based on my synthetic control analysis (without Denmark) and the Prais-Winsten estimates and conclude that the Swedish carbon taxes alone reduced CO2 emissions from transport by 7.7% (0.21 metric tons)." instead of "I did the same...."

Page 13, first two sentences in the third paragraph: you have somehow redundant sentences, while not providing sufficient information. You might want to write as follows, for example:

1) "Why is a larger estimated emission effect of the carbon tax obtained, compared to Andersson (2019), despite I calculated the smaller combined VAT + Carbon tax effect using the Prais-Winsten estimation method (cf. Table 3)? This is because the share of the carbon tax is larger."

2) Would you explain the reason you have obtained larger share of the carbon tax? This is due to your SCM estimate that is different from Andersson's and does not include Denmark??

Page 14, line 8: "It is worth", instead of "It's worth". This sort of abbreviation is not typically used in academic writing.

Page 14, line 9: "while it grew more slowly", instead of "yet it grew more".

Page 14, line 10: "This leads to an interesting comparison to Sweden's carbon tax."

Page 14, line 11: "Similarly to Sweden, there are extensive exemptions and..."

Page 14: "Other high-polluting industries", instead of "Yet other high-polluting industries".

Page 14, last line:

"the number of motor vehicles", instead of "number of motor vehicles".

"urbanization" means "Urban population", which you explained in the previous paragraph?

Page 15: To check the credibility of the SCM results for Norway", instead of "To check the credibility of the previous results".

Page 16, Placebo robustness tests: This sounds an interesting exercise, but its procedure follows some other paper's or textbook's? If so, it is instructive to provide some reference or some more detailed explanation .

Page 16, last paragraph: "For constructing a synthetic Norway's real GDP per capita, the same weights used for the synthetic Norway's CO2 emissions per capita are applied."

Page 17, line 7 from the bottom: "Statistics Norway provides monthly data on gasoline prices, motor gasoline consumption, and quarterly data, which are used for the control variables in this regression analysis, resulting in a dataset of 276 observations."

Page 17, line 4 from the bottom: "The data on the carbon tax rate are from IEA (2009)".

Page 18, line 7 from the bottom: Provide complete sentences.

Page 19, at the end of Section 5: remove "I did not."

Page 20, line 4: change to "generally similarly".

Page 20, line 6: Change to "Synthetic Sweden's path does not necessarily match actual Sweden's in the decade before the carbon tax was imposed.

Remove: "Unfortunately" This is probably not scientific wording in this case.

Page 20, line 8: Change to

"This is evident in the mean squared prediction error (MSPE) prior to the treatment of 0.791, which is in contrast to the MSPE of 0.001 associated with the SCM analysis of the Swedish transport sector."

Page 20, line 11: change to "what is particularly worrisome is that per capita total ...."

Page 21, line 10 from the bottom: "does not" instead of "doesn't".

Page 24, line 14 from the bottom: Saying "a more efficient estimator" may not be appropriate for this time series GLS case. If AR(1) assumption holds for error variables, Prais-Winsten's estimator must be efficient but otherwise, you cannot say anything in general. For interpreting the difference between the OLS estimates and Prais-Winsten's estimates, one may need to consider possible misspecification. But, as stated above, you only have a small number of observations.

Page 23, line 8 from the bottom: "This is" instead of "Such was".

## Round 4

### Editor

Thank you for submitting your manuscript. I see that all the points raised in my previous comments are all addressed, and decide the acceptance of this manuscript to Economics. I appreciate all your efforts and serious responses in the revision process. I now feel this must be almost an ideal piece of work as a replication study.

Thank you for your contribution to Economics, the Open-Access, Open-Assessment Journal. I look forward to seeing your article appear in (online) print.