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A REPLY TO LISTO, SABERIAN AND THIVIERGE (2023)*

Ralph De Haas and Alexander Popov

We thank Ariel Listo, Soodeh Saberian and Vincent Thivierge for their careful replication of De Haas and Popov (2023)–using the replication data, code and instructions that we made available at the time of publication and after the usual checks by the Journal's data editor. Here we provide our response to the issues that Listo *et al.* (2023) bring up.

1. SEs

CLAIM. *'For their country panel, the authors mention in the text that they cluster their standard errors at the country level. However, in their script they either only adjusted their standard errors to account for heteroskedasticity or did not make standard error adjustments.*'

RESPONSE. This refers to page 642 of the published article where, when introducing the exploratory country-level regression framework, we wrote 'We cluster the standard errors by country'. At the same time, we wrote in the notes to Table 2 (page 648 of the published article) that the reported SEs in this table are heteroscedasticity robust (as far as the non-generalized method of moments (GMM) results are concerned). While the latter is accurate, the text on page 642 is not. This is an unfortunate and inadvertent oversight, which results from tables being updated during the review process without us fully bringing the related text in line. We should have checked the consistency between the text and the table notes more carefully.

Having said that, while definitely regrettable, we believe that the implications of this inconsistency are limited for two reasons. First, the main takeaway from Table 2 is robust to clustering the SEs at the country level. Also, when we include China (see Section 5 below), the point estimate on *'Equity Share'* has a *p*-value of .10 in the OLS specification and of .06 in the IV specification. When correctly specifying the GMM model (see Section 2 below), the *p*-value in this GMM specification is .11.[1] Second, we always presented the evidence in Table 2 as suggestive and as a first exploratory step in the data analysis. As we wrote on page 650, '[...] we consider these country-level regressions mainly as a first exploratory step in our analysis [...]'.

Regarding the GMM case, the answer lies in the claim in the next paragraph of Listo *et al.* (2023):

> [...] in the case of the GMM first stage estimation, the author (sic) did not adjust their standard errors, and therefore are assuming homoskedasticity. [...] we adjust the GMM standard errors to account for heteroskedasticity. As shown Stata is not able to produce robust standard errors.

Because Stata is indeed unable to produce robust SEs in the tests using the country-industry-year panel, we opted for homoscedastic errors (that is, `vce(gmm)` instead of `vce(robust)`).

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[1] These values are very similar when we drop China: 0.09 in the OLS, 0.08 in the IV and 0.09 in the GMM.

To be consistent across specifications, we did the same in the country panel (Table 2, column 3). The text in the notes to, e.g., Table 3 should have read '*Standard errors clustered at the country-sector level [in the OLS and 2SLS cases] are included in parentheses'* [underlining added].

2. GMM

CLAIM. *'When reproducing their GMM estimators for their country and the country-industry panels, we uncovered that the authors improperly specified the GMM program in Stata. Indeed, they failed to recognize the endogenous variables.'*

RESPONSE. We believed that the way we had coded these regressions, namely,

```
xi: xtabond cotwo_total_per_gdp l(0/0).(fin_dev1_l1 fin_str2_l1
log_gdp_per_cap_l1 log_gdp_per_cap_sq_l1 pop_mil_l1 recession_l1
dom_st_lawpol_l1) i.year, lags(1) vce(gmm)
```

and

```
xi: xtabond_cotwo_per_cap l(0/0).(dirty_fin_dev1_l1
dirty_fin_str2_l1 share_l1) i.ci i.it i.ct, lags(1) vce(gmm),
```

was the correct way to code an Arellano–Bond panel estimation accounting for endogeneity, because of the inclusion of '`lags(1)`' at the end, in both our country-year and country-industry-year panel specifications:

$$\begin{aligned}\text{CO}_2\text{emissions}_{c,t} = \theta\text{CO}_2\text{emissions}_{c,t-1} + \beta_1\text{FD}_{c,t-1} + \beta_2\text{ES}_{c,t-1} \\ + \beta_3 X_{c,t-1} + \psi_c + \phi_t + \epsilon_{c,t}\end{aligned}$$

and

$$\begin{aligned}\text{CO}_2\text{emissions}_{c,s,t} = \theta\text{CO}_2\text{emissions}_{c,s,t-1} + \beta_1\text{FD}_{c,t-1} \times \text{CO}_2\text{intensity}_s \\ + \beta_2\text{ES}_{c,t-1} \times \text{CO}_2\text{intensity}_s + \psi_{c,s} + \gamma_{s,t} + \phi_{c,t} + \epsilon_{c,s,t}.\end{aligned}$$

Instead, we should have included '`endogenous (fin_dev_l1 fin_str2_l1)`' in the country-year panel regressions, and '`endogenous (cotwo_fin_dev1_l1 cotwo_fin_str2_l1)`' in the country-sector-year panel regressions. In this fashion, the variables *'Financial development'* and *'Equity share'* are treated as endogenous and their lags are included as instruments.

It is important to note that the GMM specifications estimated by the replication team do not fully align with those outlined in the original paper. Specifically, the replicators include one extra lag for the endogenous variables, deviating from the specification on page 642 of the published article. As a result, the coefficient on the equity share in Table 1 is affected, with the point estimate being four times lower relative to the correct specification. This alteration, not only decreases the coefficient's magnitude, but also reduces its precision.

The code we now use to produce columns (1), (2) and (3) of Table 1 is (using one-period lags)

```
xi: xtabond cotwo_total_per_gdp l(0/0).(log_gdp_per_cap_l1
log_gdp_per_cap_sq_l1 pop_mil_l1 recession_l1 dom_st_lawpol_l1)
i.year, lags(1) endogenous(fin_dev1_l1 fin_str2_l1) vce(gmm),

xi: xtabond cotwo_total_per_gdp l(0/0).(log_gdp_per_cap_l1
log_gdp_per_cap_sq_l1 pop_mil_l1 recession_l1 dom_st_lawpol_l1)
i.year, lags(1) endogenous(fin_dev1_l1 fin_str2_l1) vce(robust)
```

and

```
xi: xtabond cotwo_per_gdp l(0/0).(share_l1) i.it i.ct, lags(1)
endogenous(cotwo_fin_dev1_l1 cotwo_fin_str2_l1) vce(gmm).
```

We note here that the data are '`xtset`' using the panel and time variables as part of the cleaning code. This has two implications for how the '`xtabond`' code is written. First, there is no need to include country or country-industry fixed effects explicitly in the regression code since '`xtabond`' runs the specification on the differenced data, and therefore the group unit fixed effect is removed. Second, unlike in the case of '`reg`' or '`reghdfe`' because the data are '`xtset`', '`vce(robust)`' as part of '`xtabond`' invokes robust SEs that are adjusted for clustering at the level of the panel variable set via '`xtset`', in this case, country.

Table 1 reports GMM regressions of De Haas and Popov (2023), this time properly accounting for the endogeneity of the main explanatory variables (and using conventional instead of robust SEs for the reason described above). In columns (1)–(3) we recover negative and mostly statistically significant point estimates on the main variable of interest, in line with those in the original paper, though smaller in magnitude. Columns (4)–(9) replicate GMM regressions from Tables 4, 5 and 6 of De Haas and Popov (2023), accounting for endogeneity. Again, the GMM results are similar to those in the original paper, though smaller in magnitude.

3. First Stage

CLAIM. *'Since the authors have two first-stages for each model, it is more sensible to report F-statistics for the strength of their instruments for each first stage. Instead, the authors either fail to report their first-stage F-statistics or they only report one F-statistic. In Tables 1 and 2, we report the F-statistics for each of the first stages for the country and country-industry panels. In the case of Table 1, each F-statistics is below* 10*, which is an indication of weak instruments. For Table 2, only the instrument for the financial structure is above* 10*, which also suggests testing for the effects of weak instrument bias on the coefficients.'*

RESPONSE. In our view, there is no clear consensus as to what to report as first-stage statistics. We have seen published papers reporting either separate *F*-statistics from the first stages or the *F*-statistics that Stata reports in the second stage. We opted for the latter. Having said that, we have always acknowledged and been fully transparent about the 'weak instrument' problem. For example, on page 649 in the printed version of the paper, we wrote 'While the

Table 1. *Robustness of the GMM Estimations in De Haas and Popov (2023).*

	CO_2 emissions/GDP			Growth in value added	CO_2 emissions/ value added	Green patents/GDP (all)	Green patents/GDP (excl. trans. and waste)	Green patents/GDP (industrial production)	Green patents/GDP (industrial production), OECD
	T2 (5) (1)	T2 (5) (2)	T3 (3) (3)	T4 (3) (4)	T5 (5) (5)	T6 (1) (6)	T6 (2) (7)	T6 (3) (8)	T6 (4) (9)
Financial development	0.0161*	0.0161*							
	(0.0090)	(0.0092)							
	[0.0728]	[0.0796]							
Equity share	−0.0435**	−0.0435							
	(0.0213)	(0.0276)							
	[0.0416]	[0.1147]							
Financial development × CO_2 intensity			0.0000	−0.0012	−0.0541	−0.0003	0.0002	−0.0006	0.0000
			(0.0001)	(0.0060)	(0.0372)	(0.0013)	(0.0010)	(0.0005)	(0.0002)
			[0.6892]	[0.8465]	[0.1465]	[0.8381]	[0.8386]	[0.2539]	[0.8287]
Equity share × CO_2 intensity			−0.0015***	−0.0093	−0.6829***	0.0011	0.0048	0.0040***	0.0016***
			(0.0003)	(0.0145)	(0.0878)	(0.0040)	(0.0031)	(0.0014)	(0.0005)
			[0.0000]	[0.5191]	[0.0000]	[0.7838]	[0.1254]	[0.0054]	[0.0017]
Sector share			0.0051*	−5.6575***	5.2725***	−0.0020	0.0051	0.0238**	−0.0012
			(0.0028)	(0.1260)	(0.9083)	(0.0265)	(0.0193)	(0.0093)	(0.0047)
			[0.0649]	[0.0000]	[0.0000]	[0.9399]	[0.7902]	[0.0105]	[0.8052]
Country FEs	Yes	Yes							
Year FEs	Yes	Yes							
Country × sector FEs			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country × year FEs			Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector × year FEs			Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. observations	978	978	7,057	7,979	6,945	2,990	2,648	2,188	5,090

Notes: This table reports GMM regressions from De Haas and Popov (2023). Column headings refer to the dependent variable and reference the table and column number in De Haas and Popov (2023) (i.e., T2 (5) is Table 2, column 5 on page 648 of De Haas and Popov, 2023). Conventional SEs are reported in parentheses in columns (1) and (3)–(9), while in column (2) SEs are clustered at the country level. Significance levels: * $p < .1$, ** $p < .05$, *** $p < .01$.

Kleibergen-Paap LM statistic is reasonably high, the *F*-statistics are quite low, pointing to relatively weak instruments'.

4. Weak Instrument Test

CLAIM. *'We view this as evidence that the potential weak instrument problem in this paper is not biasing the 2SLS estimator, especially for the structure of the financial sector coefficient.'*

RESPONSE. We appreciate this additional analysis, which seems to confirm that the main coefficient of interest—that on *'Equity Share'*—is not biased by weak instruments.

5. Consistent Samples

CLAIM. *'Indeed, in their country sample, the authors note in their code that they drop China since there are not sufficient data on "No. environmental laws and policies". However, they do not drop China in their country-industry panel models. The authors do not further discuss these choices in the code or in the main text. Therefore, as a replication exercise, we drop China from the country-industry sample in order to keep a consistent country sample across both panels. Table 4 presents the coefficients of interest for the interacted financial market size and structure when dropping China. Relative to the results presented in Table 2, which corrects for the coding errors, the results are qualitatively similar.'*

RESPONSE. During the early stages of this project, the environmental data for China (which we need in the country-year, but not in the country-sector-year analysis) were only available for two points in time. Our approach was to deliberately run each part of our analysis on the largest country sample possible. Dropping China from the sector-level analysis in order to be consistent with the country-level analysis would (in our view) be too high a price to pay for sample consistency across tables, especially given that we view the country-level regressions mainly as setting the scene for the later sector-level analysis. We thus wrote in the original code: 'Do not have sufficient data on "No. environmental laws and policies" alongside the line that drops China from the country-level sample.'

Whilst preparing the replication package, we re-downloaded all data from scratch and at this point the full time-series data for China had become available. At that stage, we should have deleted the line of code that dropped China from the country-level analysis. When we include China in the country-year analysis, the main results go through, as shown in Table 1. In addition, it is reassuring that the country-sector analysis is robust to including or excluding China, too, and we appreciate you having made that explicit.

6. Conclusion

Thanks to the diligent work of the replicators, we have realised that there was an inconsistency between how we described the SEs in the text and in some of the tables, and that we made a coding mistake in the GMM analysis. In this Reply, we have shown that our results remain economically meaningful and statistically precise (though smaller in magnitude) when we (*i*) cluster SEs by

country in the country panel, (*ii*) correct the GMM code and (*iii*) include or exclude China in the country and industry samples.

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