Does the Nonlinearity of the Water Elasticity to Produce Agricultural Goods Influence the Comparative Advantage of Countries?

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Online Appendix

Abstract

This is the online appendix of our article "Climate Change, Comparative Advantage and the Water Capability to Produce Agricultural Goods" published in World Development. In that paper, we show that the technology used to convert water into agricultural goods plays a critical role in addressing climate change by analyzing how the comparative advantages of countries could evolve by 2050. Here we conducted a series of robustness checks to ensure that the results concerning the Relative Comparative Advantages (RCA) of countries remain consistent when considering the nonlinearity of water elasticity in the production of agricultural goods. We found that our approach produces various measures of elasticity depending on fixed effects. However, different estimates of elasticity yielded similar results for RCA.

JEL: F1, Q2

1 Introduction

In Candau, Regnacq and Schlick (2022) we estimate how the crop production varies with water conditions at a very desaggregated level. Then, we use this information of the agricultural technologies that enables to transform water in goods to compute an indicator of the relative comparative advantage of nations. The aim of this appendix is to determine if the water elasticity concept developed in our article can be applied across regions with differing levels of wetness. In the initial phase of our study, we estimate the following equation:

$$\begin{aligned}\ln\left(L_l^k\right) = c_L + \hat{\theta}_T \ln\left(T_l^k\right) + \hat{\theta}_{RW} \ln\left(RW_l^k\right) + 1_{\left\{RW_l^k<1\right\}}\left[\hat{\theta}_{NRW} \ln\left(R_l^{GS}\right) + \hat{\eta}\right] \\ + f_l + f_o^k + \varepsilon_l^k\end{aligned} \tag{1}$$

where L_l^k is our indicator of the production of a given crop k in locality l, and where T_l^k, RW_l^k and R_l^{GS} represent respectively the crop thermal regime suitability, the crop suitability of local renewable hydrologic supplies and the supplemental quantity of non-renewable water respectively. This estimation includes locality fixed effect, f_l, and country-product fixed effect, f_o^k. The indicator variable $1_{\{RW_l^k<1\}}$ takes the value 1 if the quantity of renewable water is insufficient to fulfill the need of the crop k ($RW_l^k < 1$). One drawback is that the elasticities estimated, $\hat{\theta}_T$, $\hat{\theta}_{RW}$ and $\hat{\theta}_{NRW}$, are an average results over the world holding everything else constant thanks to fixed effects. Since these estimates are then used to analyze the comparative advantage of countries, such a simplification may be problematic. We thus propose to study how are results vary when we relax this assumption of linearity, namely when we consider different elasticities according to the different level of renewable water.

2 Nonlinearity in elasticities

We reproduce the estimation (1) presented in the introduction but this time we separate/distinguish locations, namely the geographical cells, in three different groups according to their endowment in renewable water. Cells with a high level of suitable renewable water are clustered in a group called Category 3, cells with intermediate level are in Category 2 while the result for cells with the worst water condition is directly given by the coefficient of the renewable water variable. More precisely, these three groups are defined according to the world cumulative distribution of renewable water suitability indicator (RW) where the Category 1 clusters the first 30 % of the distribution, the Category 2 corresponding to the cells being between the 30% and the 70% of the distribution and finally, the Category 3 clusters the cells corresponding to the 70% and higher of the distribution.

Results are presented in Table (1).[1] In Column 1, without any fixed effects, renewable water has a strong positive effect in cells with few water (Category 1), but the coefficient is surprisingly negative for Category 2 (0.130-0.193) and stronger in cells with high level of water (Category 3). These results may come from the lack of control implying that variables in interaction capture other omitted variables. In Column 2, where only fixed effects at the cell level are set, we observe an increasing effect of water on production in cells that already have a certain level of water. The coefficients of Category 2 and 3 in interaction with renewable water are indeed higher than the one of Category 1. This result is also counter-intuitive because we expect that cells with a lack of water (Category 1) are going to benefit the most of additional water. The reason of this result may come from fixed effects at the local level that capture the difference in production that are specific to locations and then partly control for differences in

[1] Not reported here because results were similar, we have also tried different classifications, such as by dispatching cells in four groups, and also in five groups and finally in ten groups. We have also used different indicators of water to separate cells in different groups.

water. This is somewhat verified in Column 3 where we drop these fixed effects (and add product-country fixed effects) and get a totally different conclusion. In this specification, cells with less water, gain more. In Column 4, we re-introduce local fixed effects (this time with product-country fixed effects) and get again result similar to Column 2, additional renewable water in cells that are richly endowed seems to have more effect (we indeed find a coefficient of 0.153 (=0.132+0.021) for Category 3). To conclude, we face here a significant difficulty. On the one hand, the fact to use fixed effects to control for omitted variables in order to obtain a consistent "mean" coefficient of the renewable water suitability, lead us to neglect the non-linear effect of this variable. On the other hand, the fact to remove fixed effects provides weird results concerning these non-linearities. Indeed, an expected result was to find a decreasing coefficient as we go from Category 1 to 3, increasing water is likely to increase crop suitability in water-scarce parts of the world, but not water-rich parts of the world, or putting differently wet regions might expect to see a decline in crop yield with increasing precipitations due to water logging and flooding. Since none of these columns provide unequivocally these results, we conclude that we are certainly not using the right method to capture these non-linearities. Maybe nonparametric econometrics may be a way to tackle these issues but such an analysis is hard to reconciliate with what we do in the paper.

Table 1: Nonlinear elasticity

	(1)	(2)	(3)	(4)
Thermal Regimes Suit.	0.775^a	1.132^a	1.799^a	0.859^a
- $\log(T_l^k)$	(0.0251)	(0.0208)	(0.0438)	(0.0358)
Renewable Water Suit.	0.130^a	0.104^a	0.120^a	0.0210^c
- $\log(RW_l^k)$	(0.0109)	(0.0200)	(0.0088)	(0.0126)
Groundwater	-0.0520^a		-0.0139^b	
- $\log(R_l^{GS})$	(0.0057)		(0.00595)	
Insufficient Renew Water Res.	-0.544^a	0.0753^c	-0.628^a	-0.0688^a
- $1_{\{RW_l^k<1\}}$	(0.0400)	(0.0405)	(0.0303)	(0.0263)
Insuf Renew Water*Groundwater	0.304^a	0.0027	0.280^a	0.0287^a
- $1_{\{RW_l^k<1\}} log(R_l^{GS})$	(0.0092)	(0.0122)	(0.0075)	(0.0078)
Categorie= 2	-0.313^a	-0.0285	-0.367^a	-0.0762^a
-	(0.0316)	(0.0344)	(0.0231)	(0.0220)
Categorie= 3	-0.688^a	0.0402	-0.662^a	-0.301^a
-	(0.0545)	(0.0561)	(0.0455)	(0.0399)
Categorie= 2 ×	-0.193^a	0.284^a	-0.240^a	0.0284
Renewable Water Suit.	(0.0381)	(0.0401)	(0.0283)	(0.0257)
Categorie= 2 ×	0.242^a	0.283^a	-0.0675^a	0.132^a
Renewable Water Suit.	(0.0211)	(0.0270)	(0.022)	(0.0209)
Constant	0.386^a	-0.153^a	0.638^a	0.0924^a
	(0.0441)	(0.0440)	(0.0338)	(0.0286)
Localities FE	No	Yes	No	Yes
Exporter-Product FE	No	No	Yes	Yes
Observations	256378	255446	256269	255336
R-squared ajusted	0.0134	0.367	0.493	0.748

Notes: Standard errors in parenthese. a: p<0.01, b: p<0.05, c: p<0.1.

3 Impact on Water Capacity and on Comparative Advantage

To be sure that our analysis of RCA is not too much driven by our simplifying assumptions, we re-run all analysis for fourth scenarios:

1. Coefficient of each category obtained in the last column of the previous table: category 1=0.021, category 2=0.021, category 3= 0.153.
2. We set a coefficient of 0.03 for Category 1, 0.02 for Category 2 and 0.01 for Category 3.
3. We use a coefficient of 0.04 for Category 1, 0.015 for Category 2 and 0.005 for Category 3.
4. We set a coefficient of 0.12 for Category 1, 0.06 for Category 2 and 0.01 for Category 3.

Then, we re-run all our analysis (computation of variables that enters in our gravity equation, estimation of this equation, computation of water capability and of comparative advantages) with these elasticities and we show the results in comparison with the main simulation results in the paper for the Local Water Capabilities and for RCA. More precisely, we regress our simulation of local water capabilities presented in the paper on the Local Water Capabilities get with the four sets of coefficients (previously explained). Results are presented in Table (2). We can see that for each set of coefficients, we have a coefficient close to 1 indicating a high level of correlation between our main results and the robustness checks.

Table 2: Robustness Checks of Local Water Capability

dep: Local Water Capability	(1)	(2)	(3)	(4)
Robustness 1	0.988^{a}			
New Local Water Capabilities	(0.000583)			
Robustness 2		0.999^{a}		
New Local Water Capabilities		(0.000456)		
Robustness 3			0.999^{a}	
New Local Water Capabilities			(0.000459)	
Robustness 4				0.996^{a}
New Local Water Capabilities				(0.000507)
Constant	0.0534^{a}	0.00415^{a}	0.00505^{a}	0.0175^{a}
	(0.00184)	(0.00156)	(0.00157)	(0.00177)
Observations	256378	255446	256269	255336
Log-likelihood	-4341429.0	-35355644.4	-3557094.9	-3787163.3
R-squared ajusted	0.0134	0.367	0.493	0.989

Notes: Standard errors in parenthese. a: p<0.01, b: p<0.05, c: p<0.1.

We also do below the same exercise for RCA, namely we regress our simulation of RCA presented in the paper on the RCA get with the four sets of coefficients (previously explained). Results are presented in Table (3) where we also verify a high level of similarity.

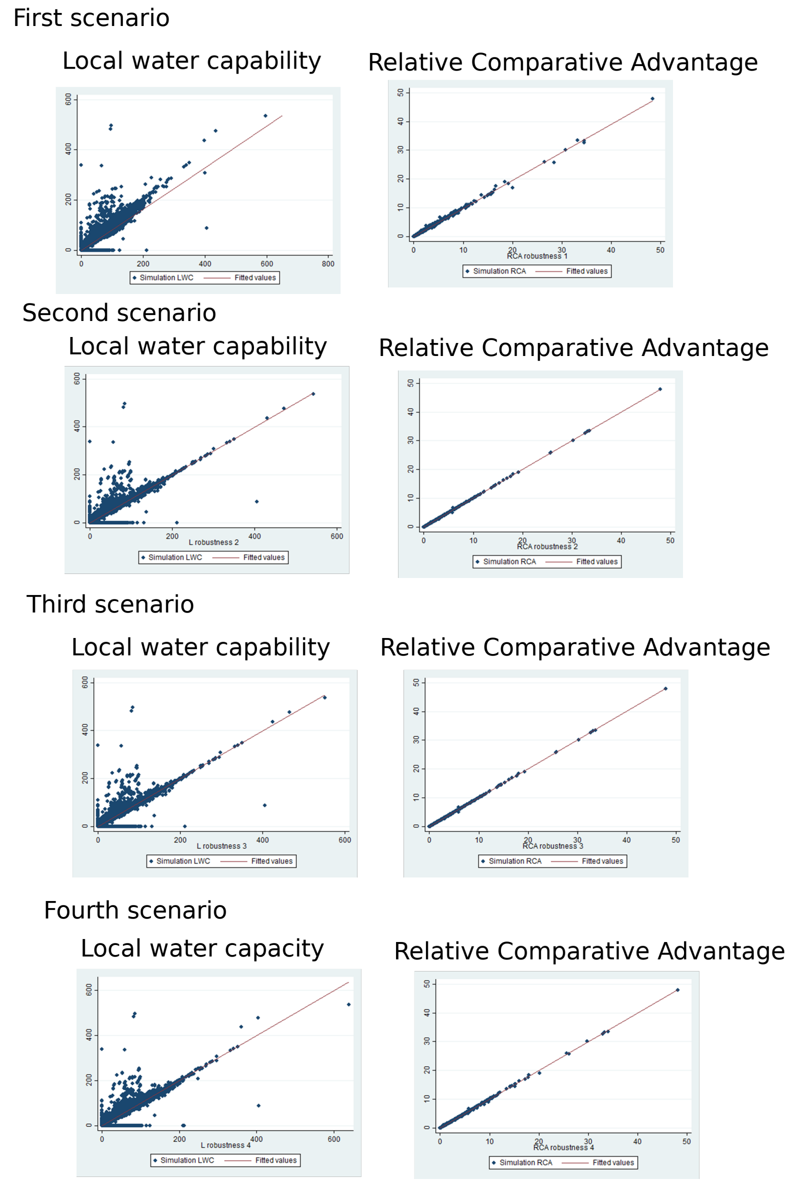
Table 3: Robustness Checks of Relative Comparative Advantage (RCA)

dep: RCA	(1)	(2)	(3)	(4)
Robustness 1	0.977^{a}			
New RCA	(0.000551)			
Robustness 2		1.001^{a}		
New RCA		(0.000661)		
Robustness 3			1.000^{a}	
New RCA			(0.000843)	
Robustness 4				0.997^{a}
New RCA				(0.00208)
Constant	0.0203^{a}	0.0013^{b}	-0.000784	0.00354^{c}
	(0.00592)	(0.000609)	(0.000813)	(0.00208)
Observations	3420	3420	3420	3420
Log-likelihood	2308.3	7494.8	7154.7	4927.3
R-squared ajusted	0.997	1.000	1.000	0.999

Notes: Standard errors in parenthese. a: p<0.01, b: p<0.05, c: p<0.1.

To make this clearer, we propose in Figure (3.1) to represent all these results by different plots where we fit our main results with robustness checks results for Local Water Capability and for RCA.

Figure 3.1: Correlation between the baseline and robustness checks



We can observe that while our indicator at the local level is marginally affected (there is clearly some dispersion around the 45° line), the result at the aggregate level concerning RCA is almost not affected, which is reassuring concerning our results.

4 Reference

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