Water abstraction and its determinants

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Abstract

Water resource allocation has always been of great importance. Nevertheless, water resource supply has largely remained the same while the demand increases radically. It, therefore, put a great pressure on finding optimal ways to manage water resource. Groundwater makes up a great portion of overall water supply. Although there has been a variety of literature on groundwater resource management, the subject still seems to lack its deserved attention. This paper aims at not only looking at the current literature on the topic but also trying to find ways that water resource management can be further optimized.

1 Introduction

The field of sustainable development/environmental economics has always been engaging to me, especially about the allocation of common pool resources. Indeed, such allocation has always been of great essential, especially in the case of water resource. Despite the importance of water for the economy and the well-being of individuals, water may often be over-exploited without proper monitor and regulation.

Often, there always two side of the allocating water resource, the demand side and the supply side. For this project, my focus is what might determine water demand.

Determining and building up proper allocation of water resource should involve both studying about the past and present water usage but also predicting the upcoming usage.

2 Research statement

Symptoms of water degradation have led to rapidly changing water use policies and management institutions in some regions. There have been many measures proposed to improve the efficiency in water allocation among competing uses. Determining and building up the proper allocation of water resource should involve not only about studying about the past and present water usage but also predicting the upcoming usage.

Environmental Kuznet Curve suggests that there might be a negative relationship between economic growth and environmental quality. In this research project, I want to emphasize on environmental quality through water withdrawal, addressing whether there is issue of over-exploitation together with rapid economic growth. More specifically, the following research questions need to be addressed:

1. Is there a relationship between water withdrawal and economic growth?
2. Would economic growth necessarily leads to over-withdrawal?
3. Would there be any other determinants being left out?

3 Preliminary literature review

Katz 2015 sheds light on how taking into account of economic growth would be able to increase the accuracy of predicting water use through panel data analysis. However, the time span of the datasets used in his paper is a little bit short so an extension of the data might be more insightful.

Duarte, Pinilla, and Serrano 2013, on the other hand, analyze the relationship between water use and per capita income with a larger extent of countries and time. Even though there is some evidence following the Kuznet Environmental Curve as the water use income elasticity decrease over time, there is a great variability over the sample. The results can vary considerably across countries and time.

Hemati, Mehrara, and Sayehmiri 2011 look at the relationship between industrial sector water withdrawal and income through the cross sectional data analysis. The paper supports the idea that water resource management policy-maker should account for income level and together with each country's specific socio-economic structure in making decisions.

Cole 2004 also investigate whether there is a systematic relationship between water use and income and also whether the relationship necessarily negative. Cole (2004) shows that despite the increase in water usage as an economy grows, technology can be a solution to the problem of water resource allocation.

Stern 2004 sheds light on how the relationship between economic growth and environmental quality may not follow Kuznet Environmental Curve. Indeed, he shows in his paper that the curve is not supported by robust statistical foundation. Although Stern (2004)'s paper focuses on the quality of the environment as a whole, the paper still lays the foundation for how more thorough and robust data processing and modeling can help us rethink about the proposed theory.

Results vary across countries and time

Some papers point out that the relationship is not statistically significant

Account for country-specific socio-economic factor

4 Dataset and empirical methods

In order to work on the data collection process, I need to look at similar papers and see how related existing datasets can be used.

The dataset I obtain is more like document data. The water withdrawal data is obtained from the OECD database while the GDP per capita indicating economic growth is collected from World Bank database.

Starting with less complicated method of linear regression. Later on I may move on to generalized additive model, but I need to get more insights into the data through the exploratory data analysis before being to decide. Also, before really working on regression, I need to fix the problem of missing variables.

Water abstraction data from OECD of 22 countries

Looking at both total water abstraction data and water abstraction per capita with total water abstraction in terms of billion M3 and water abstraction per capita (M3)

Total water abstractions including withdrawals for public water supply, irrigation, industrial processes and cooling off electric power plants. Mine water and drainage water are also included.

Data source for the RHS variables: OECD and World Bank

4.1 Possible predictors

GDP per capita

Government Integrity index: transparency, free from corruption

Property rights index: individuals' ability to accumulate property right, secured by laws and enforced by government

Trade freedom index: a composite measure of the absence of tariff and non-tariff barriers that affect imports and exports

Population

Industrial intensity index:

	N	Mean	Std. dev.	Min.	25 %	Median	75 %	Max.
year	240	2,005.500	5.778	1,996.000	2,000.750	2,005.500	2,010.250	2.015000e+03
water	240	8,517.091	11,774.941	168.380	953.875	2,452.185	11,130.800	3.828090e+04
lwater	240	8.350	1.696	5.126	7.027	8.434	9.650	1.137800e+01
waterpcap	240	487.155	344.774	83.306	183.814	461.850	651.910	1.580573e+03
lwaterpcap	240	5.916	0.774	4.423	5.214	6.135	6.480	7.366000e+00
lgdppcap	240	9.748	0.684	8.545	9.238	9.548	10.401	1.102100e+01
governmentint	240	54.486	18.769	21.000	42.000	50.000	68.000	1.000000e+02
propertyright	240	65.417	16.594	20.000	50.000	70.000	76.250	9.500000e+01
tradefree	240	79.555	8.982	44.200	77.750	81.400	86.650	8.800000e+01
population	240	28,209,495.900	40,033,826.001	1,314,545.000	4,847,708.750	10,200,054.500	38,970,073.750	1.481600e+08
lpop	240	16.250	1.375	14.089	15.381	16.138	17.478	1.881400e+01
Industrial	240	0.404	0.091	0.254	0.334	0.402	0.447	6.610000e-01
cropprod	240	104.623	20.705	65.580	94.213	101.915	109.050	2.254200e+02
wwtreatment	240	70.359	14.399	21.800	61.918	71.662	80.000	9.780000e+01
urbanization	240	72.737	10.744	53.889	66.860	71.843	77.291	9.787600e+01
hydroeprod	240	10.414	16.102	0.022	0.498	2.831	14.305	7.445200e+01

Figure 1: Summary statistics

Crop production index: agricultural production for each year relative to the base period 2004-2006, which includes all crops except fodder crops

Wastewater treatment: sewage treatment connection rates, i.e. the percentage of the population connected to a wastewater treatment plant

Urbanization: urban population (as

Hydroelectric production (

4.2 Exploratory data analysis

Summary statistics

Heterogeneity across countries

Heterogeneity across year

Problems of missing variables

Need to work with small subset of the dataset

There's problem of multicollinearity

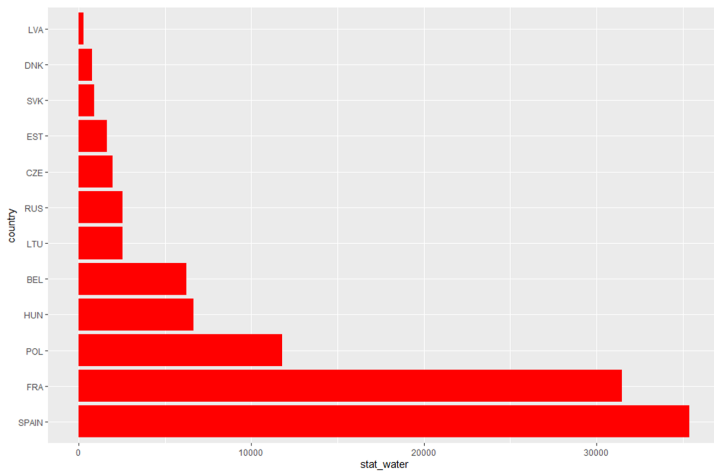

Figure 2: Heterogeneity across country

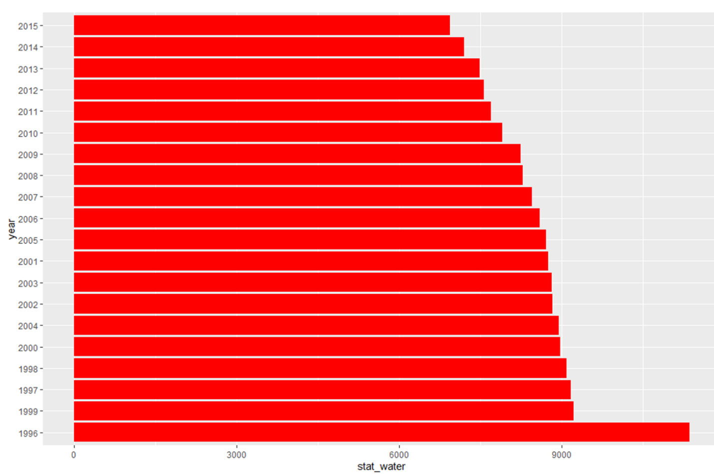

Figure 3: Heterogeneity across year

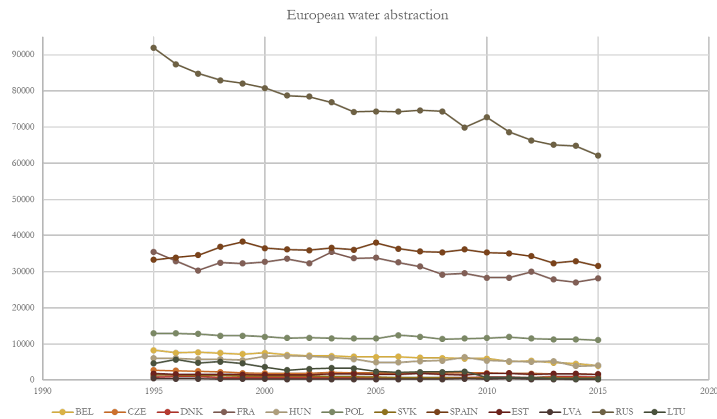

Figure 4: European water abstraction

	lgdppcap	govern~t	proper~t	tradef~e	lpop	Indust~l	cropprod	wwtrea~t	urbani~n	hydroe~d
lgdppcap	1.0000									
government~t	0.8308	1.0000								
propertyri~t	0.7269	0.8435	1.0000							
tradefree	0.4289	0.3872	0.3526	1.0000						
lpop	0.1161	-0.1432	-0.2095	-0.4217	1.0000					
Industrial	0.3867	0.2087	0.3087	0.3164	0.1302	1.0000				
cropprod	-0.0389	0.0270	-0.0340	0.1835	-0.2329	-0.2199	1.0000			
wwtreatment	0.5085	0.4218	0.2055	0.3777	0.1191	0.0265	0.1550	1.0000		
urbanization	0.7299	0.5758	0.5934	0.0904	0.1578	0.1331	-0.0909	0.3270	1.0000	
hydroeprod	-0.3236	-0.3880	-0.4656	-0.1298	-0.1211	-0.4183	-0.0117	0.0400	-0.2209	1.0000

Figure 5: Correlation matrix for predictors

Need to introduce interaction term?

Run different models?

After running mrobust and choosing the most important predictors, the problem of multicollinearity may be decreased

Looking at the correlation matrix

5 Preliminary results

mrobust for important predictors

lpop and hydroeprod are the most powerful predictors: both significant

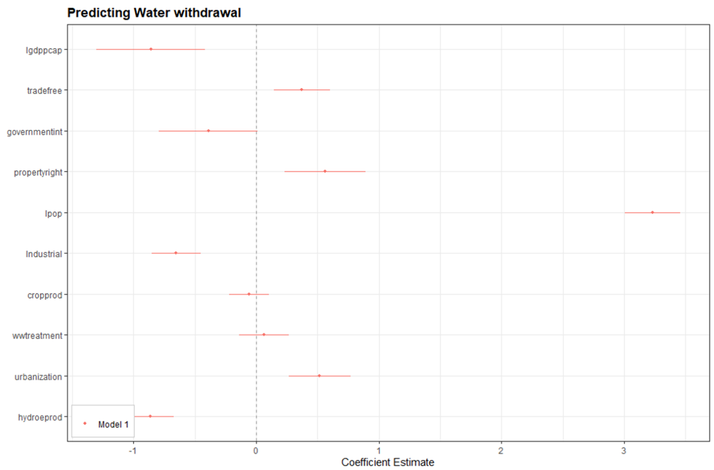

Figure 6: Coefficient plot

and sign stable

Some other variables are significant but are not 100 percent sign stable: lgdppcap, tradefree, urbanization, industrialization index, property right

Variables that both not sign stable and not significant: waste water treatment, government integrity index, and crop production

Looking into coefficient plot

Using reg subset to further examine how many predictors should be included

Linear model: preliminary results

Cross validation

Updated linear model estimation after taking into account the degree of the predictors

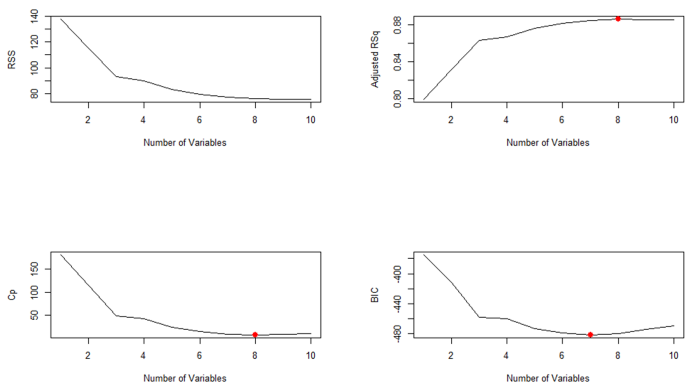

Figure 7: regsubset results

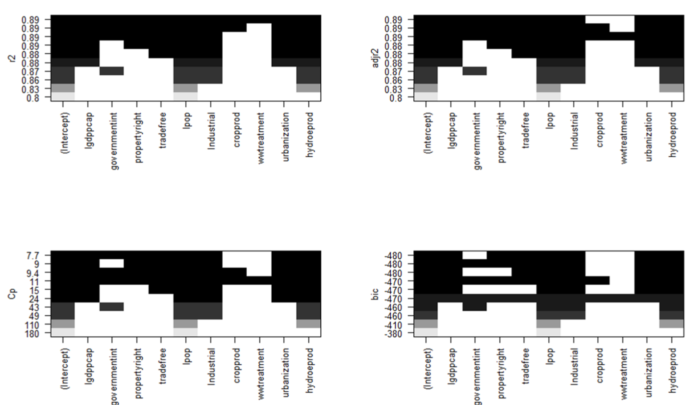

Figure 8: Further look into the importance of predictors

Source	SS	df	MS			
				Number of obs	=	240
				F(7, 232)	=	262.73
Model	610.673692	7	87.2390989	Prob > F	=	0.0000
Residual	77.0348638	232	.332046827	R-squared	=	0.8880
				Adj R-squared	=	0.8846
Total	687.708556	239	2.87744166	Root MSE	=	.57624

lwater	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdppcap	-.8231982	.1215951	-6.77	0.000	-1.06277	-.5836264
tradefree	.0231519	.0060191	3.85	0.000	.0112929	.0350109
propertyright	.0119794	.0042269	2.83	0.005	.0036514	.0203074
lpop	1.202679	.0389395	30.89	0.000	1.125959	1.2794
Industrial	-3.176349	.5009244	-6.34	0.000	-4.163291	-2.189407
urbanization	.0278337	.0056359	4.94	0.000	.0167296	.0389378
hydroeprod	-.0250961	.0028937	-8.67	0.000	-.0307974	-.0193948
_cons	-6.273348	.8142318	-7.70	0.000	-7.877582	-4.669114

Figure 9: Linear model estimation

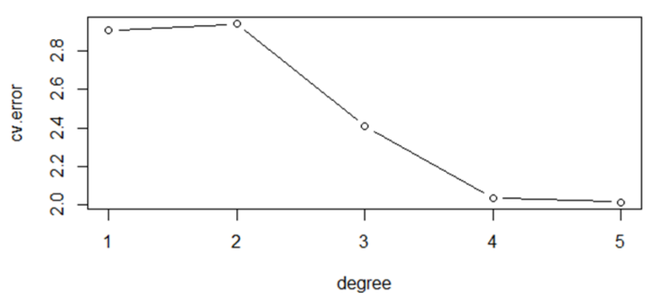

Figure 10: Degree of lgdppcap

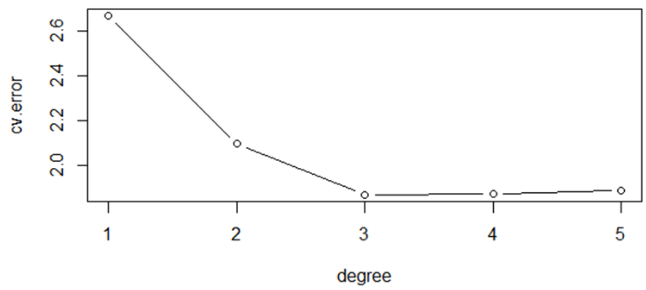

Figure 11: Degree of hydro electricity production variable

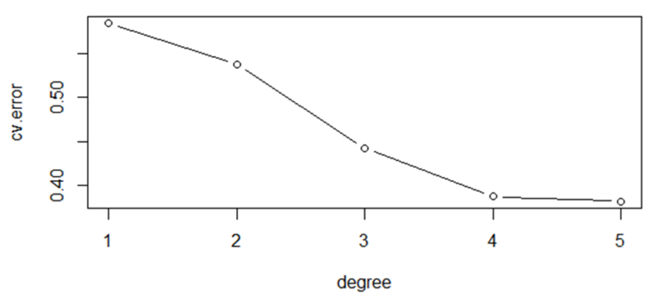

Figure 12: degree of log population

Source	SS	df	MS			
				Number of obs	=	240
				F(10, 229)	=	238.53
Model	627.467697	10	62.7467697	Prob > F	=	0.0000
Residual	60.240859	229	.26306052	R-squared	=	0.9124
				Adj R-squared	=	0.9086
Total	687.708556	239	2.87744166	Root MSE	=	.51289

lwater	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
lgdppcap	7.934999	2.036558	3.90	0.000	3.922211	11.94779
lgdppcap2	-.4498429	.1026682	-4.38	0.000	-.652138	-.2475479
lpop	-2.877893	.8291126	-3.47	0.001	-4.511557	-1.244228
lpop2	.1230335	.0252393	4.87	0.000	.0733025	.1727645
hydroeprod	-.0075513	.0105636	-0.71	0.475	-.0283656	.013263
hydro2	-.0002652	.0001645	-1.61	0.108	-.0005893	.0000589
propertyright	.0204152	.0042859	4.76	0.000	.0119704	.02886
tradefree	.0162631	.0059764	2.72	0.007	.0044873	.0280389
Industrial	-2.177075	.5368696	-4.06	0.000	-3.23491	-1.119239
urbanization	.0367368	.005679	6.47	0.000	.025547	.0479267
_cons	-16.24435	12.14422	-1.34	0.182	-40.17304	7.684338

Figure 13: Linear model estimation accounting for the degree of predictors

6 Concluding remarks

GDP per capita, population and hydro-electricity production play the most important role in predicting water withdrawal.

Some others also matter include: trade freedom, property right, Industrial intensity index, urbanization

The relationship between the predictors and water withdrawal is more complicated than just simple linear model (different degree for most important predictors).

7 Limitation and further research

More recent data

Data on other possible predictors: agricultural water use, industrial water use, temperature

Predict within those European countries

Extend to other countries within OECD

Using Levene test to check the for heteroskedasticity

References

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