An Analysis of the Role of Power Inequality in Ground Water Level

Group 5

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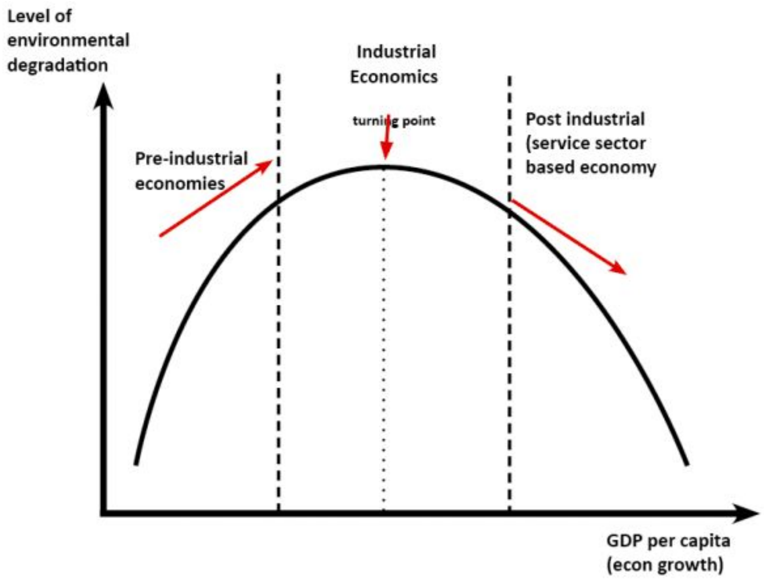
Background

The Environmental Kuznets Curve (EKC) presents a relationship between environmental degradation and per capita income that takes an inverted U-shaped form. It says that the environment quality initially worsens but ultimately improves with income (Grossman & Krueger, 1996).



(Grossman & Krueger, 1996)

Motivation

- Research has shown that a more equitable power distribution also has an impact on pollution. This is because a more equitable power distribution enhances the influence on the policy of those who bear pollution costs compared to those who benefit from pollution generating activities (Torras & Boyce, 1998).

- India has the maximum usage of groundwater among all countries, 90 per cent of the groundwater there is used for irrigation (Siebert et al., 2010). Increased extraction of water and lesser replenishment of aquifers has led to falling levels of groundwater. Groundwater is a critical water resource for India and thus groundwater level depth is a relevant indicator for environmental degradation.

Approach

- This project aims to study the validity of the EKC in the presence of power and income inequality.

- We will analyse this relationship for the states and union territories in India for the years 2009-2012, 2014 and 2016.

- The indicator of environmental degradation will be pre-monsoon groundwater level i.e., the average groundwater level in the months of March, April and May.

- We will see whether the EKC holds for our data. We will investigate for causal linkage between environmental degradation and power and income inequalities.

Model Equation

$$waterdepth_{it} = \beta_o + \beta_1 sdp_{it} + \beta_2 sdp2_{it} + \beta_3 gini_{it} + \beta_4 percentlandless_{it} + \beta_5 mfdiff_{it} + \beta_6 elecmarg_{it} + \beta_7 rainfall_{it} + \beta_8 percentblack_{it} + \beta_9 percentarid_{it} + u_{it}$$

Where *waterdepth* is the dependent variable and the independent variables have been described in the tables below. The β_j , for j from 0 to 9, corresponds to the coefficients of independent variables and u corresponds to the error term of our linear regression model. Each observation is for a state/UT in a particular year. *i* belongs to {1, …, 29} for states and *t* belongs to {2009, 2010, 2011, 2012, 2014, 2016} for years.

Variables

Environment Quality Indicator (dependent variable)

Variable	Description	Acronym
Groundwater level (dependent variable)	It is measured as the vertical distance in meters from the ground to the water.	waterdepth

Income Level Variables

Variable	Description	Acronym
State Domestic Product	Measured as per capita net state domestic product in rupees.	sdp
Income	Measured as the square of per capita net state domestic product in rupees squared.	sdp2

Variables

Income Inequality Variables

Variable	Description	Acronym
Gini Index	It is a ratio that represents the income distribution. It can take values between 0 (complete equality) and 1 (complete inequality).	gini
Percentage of landless farmers	Measured as the percentage of farmers who do not own agricultural land.	percentlandless

Variables

Power Inequality Variables

Variable	**Description**	**Acronym**
Male and female literacy difference	It is the measure of gender disparity in literacy levels of states given by difference between male and female literacy percentages.	mfdiff
Election Margin	It is the metric of "win margin" of the ruling political party in a state defined by the difference in vote percentage of the ruling and runner-up party.	elecmarg

Variables

Control Variables

Variable	Description	Acronym
Rainfall	It is measured as the amount of average precipitation in the pre-monsoon months in mm. Groundwater recharge primarily depends on rainfall as its source.	rainfall
Percentage of black soil	It is measured as the percentage of the total land with black soil (in India) that is present in a state. Black soils have high water retention capacity.	percentblack
Percentage of arid soil	It is measured as the percentage of the total land with arid soil (in India) that is present in a state. Arid soils lack moisture holding property.	percentarid

Data Summary

We use data for twenty-nine states and union territories in India. For every state/UT, we collected data for six years.

Variable Acronym	Mean	Median	SD	Minimum	Maximum
sdp	6.97E+04	5.47E+04	4.86E+04	1.06E+04	3.08E+05
sdp2	7.21E+09	3.001E+09	1.195E+10	1.13E+08	9.54E+10
gini	0.3118	0.3110	0.046	0.2	0.39
mfdiff	15.44	14.85	6.41	3.06	31.85
percentlandless	46.04	51.75	20	7.8	84.96
elecmarg	8.66	5.36	7.12	0.7	31.05
rainfall	60.25	31.20	67.63	0.0	339.13
percentblack	3.448	0.10	6.43	0.0	27.0
percentarid	3.441	0.0	11.72	0.0	62.0
waterdepth	18.44	14.71	11.78	2.6	76.75

Relevant Hypotheses

1. The Environmental Kuznets Curve

We want to test whether our data follows the EKC by seeing the coefficient of the income squared variable (sdp2).

$$H_0 : \beta_2 = 0$$
$$H_a : \beta_2 < 0$$

Relevant Hypotheses

2. Gini Index (gini) and percentage of landless farmers (percentlandless)

These are income inequality variables. We want to test for the association between income distribution and groundwater depth.

$$H_0 : \beta_3 = 0$$
$$H_a : \beta_3 \neq 0$$

$$H_0 : \beta_4 = 0$$
$$H_a : \beta_4 \neq 0$$

Relevant Hypotheses

3. Male & female literacy rate difference (mfdiff) and margin of election victory (elecmarg)

These variables are indicators of power inequality, using them we want to test for the association between power inequality and environmental degradation.

$$H_0 : \beta_5 = 0$$
$$H_a : \beta_5 \neq 0$$

$$H_0 : \beta_6 = 0$$
$$H_a : \beta_6 \neq 0$$

Multicollinearity

Before running an OLS regression model on our selected variables, we needed to ensure that all variables are independent of each other.

For detecting multicollinearity we used the VIF quotient. The larger the value of VIF_j the more “troublesome” or collinear the variable X_j is.

From the results, we observe that our data is not multicollinear. We can infer that the regression model will not give unreliable estimates.

VIF Results

sdp	gini	mfdiff	plandless	elecmarg	rainfall	percentblack	percentarid
1.855	1.431	2.014	1.370	1.271	2.356	1.299	1.287

Results

We see that the estimate for sdp is positive and statistically significant. This implies that water depth increases with income.

Since sdp2 has a negative estimate, we can see that the EKC would hold for our data. However, the estimate is not statistically significant. Therefore, we can't be confident that water depth will start decreasing with income beyond a threshold and the EKC will hold.

	term	estimate	std.error
1	(Intercept)	-3.57	6.36
2	sdp	8.50E-05 *	4.85E-05
3	sdp2	-2.27E-10	1.72E-10
4	gini	5.84E+01 ***	1.74E+01
5	percentlandless	-7.42E-01 *	3.81E-02
6	mfdiff	8.42E-02	1.57E-01
7	elecmarg	1.49E-01	1.02E-01
8	rainfall	-5.33E-02 ****	1.47E-02
9	percentblack	4.09E-01 ****	1.15E-01
10	percentarid	6.16E-01 ****	6.34E-02

* Statistically significant at 10% level.
** Statistically significant at 5% level.
*** Statistically significant at 1% level.
**** Statistically significant at 0.1% level.

	R-squared	0.63
	Adjusted R-squared	0.61

Conclusions

- We fail to reject the null that our data doesn’t follow the EKC.
- Gini Index appears as a significant variable.
- Greater income inequality is associated with greater groundwater depth and hence implies more environmental degradation.
- A unit increase in gini index leads to increase in groundwater depth by 58.4 meters.
- We reject the null for gini.

Conclusions

- Percentage of landless farmers (percentlandless) shows a significant relationship with groundwater depth.

- However, the result is contrary to our expectation of a positive estimate. But a one percent increase in percentlandless reduces the groundwater depth by 0.74 meters.

- A possible explanation for the result could be that landless farmers generally rent land. They do not have to worry about any long term impacts on the land which could lead to more exploitative practices.

- We reject the null for percentlandless.

Conclusions

- A greater difference in male and female literacy (mfdiff) is associated with greater groundwater depth.

- A one percent increase in mfdiff leads to increases the groundwater depth by 0.0842 meters.

- However, mfdiff does not show a statistically significant relationship with groundwater depth. We fail to reject the null for mfdiff.

Conclusions

- A one percent increase in election margin (elecmarg) causes an increase in groundwater depth of 0.149 meters.

- However, elecmarg estimate doesn't show a statistically significant relation with groundwater depth in our model results. We fail to reject the null for elecmarg.

- We observe that income inequality has a more significant effect on water depth compared to power inequality.

Conclusions

- Higher rainfall is associated with significant improvements in the groundwater level.

- A higher percentage of black and arid soils is associated with more water depth. The result for percentarid is not surprising because it has a very low water holding capacity and lacks moisture.

- The result for percentblack is contrary to our expectation of a negative estimate. A possible explanation for the result could be that crops like cotton and sugarcane are grown in black soil. These require a lot of water which could lead to more exploitation of groundwater by the farmers.

Robustness

- Robust Linear Regression (RLM)
    - OLS estimators are very sensitive to outliers
    - We compared the estimator and the standard errors of our OLS model with the RLM to check for model robustness.
    - It was found that our model is not affected by outliers as the value of estimators and standard errors of our model were very similar to that of RLM
    - This indicates our model is robust to outliers.

Robustness by Eliminating Variables

- We excluded each variable one by one from our model and observed its effect by analyzing the coefficients and t-values returned by the linear regressor.

- It was found out that the model is robust and all coefficients and t-values were similar except for rainfall which when omitted had a significant effect on the estimators.

References

Grossman, G. M., & Krueger, A. (1995). Economic Growth and the Environment. *The Quarterly Journal of Economics*, *110*(2), 353–377.

Grossman, G. M., & Krueger, A. B. (1996). The inverted-U: What does it mean? *Environment and Development Economics*, *1*(1), 119–122. https://doi.org/10.1017/S1355770X00000450

Siebert, S., Burke, J., Faures, J. M., Frenken, K., Hoogeveen, J., Döll, P., & Portmann, F. T. (2010). Groundwater use for irrigation – a global inventory. *Hydrology and Earth System Sciences*, *14*(10), 1863–1880. https://doi.org/10.5194/hess-14-1863-2010

Torras, M., & Boyce, J. K. (1998). Income, inequality, and pollution: A reassessment of the environmental Kuznets Curve. *Ecological Economics*, *25*(2), 147–160.