Analysis of Relationship between Ground Water Level and Economic & Power Inequalities

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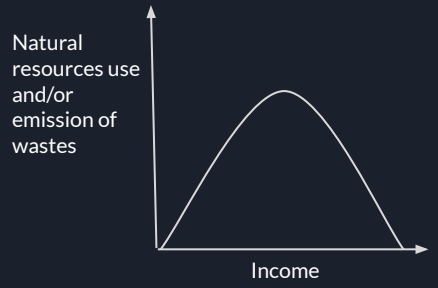
Background and Motivation

The Environmental Kuznets Curve (EKC) :

A relationship between various indicators of environmental degradation and per capita income.

In the early stages of economic growth, pollution emissions increase and environmental quality declines

Beyond some level of per capita income (which will vary for different indicators) the trend reverses, so that at high income levels, economic growth leads to environmental improvement.



With primary focus on economic equality, Kuznet acknowledged that economic equality would lead to power inequalities.
The curve is not simply a function of income but of other factors of power as well.

Variables and their Descriptions

Variable	Description	Mean	Standard Deviation	Remarks
SDP	Net state domestic product in Rupees Crore	517294	372758	Measures the total economic output over an year Source: Database for the Indian Economy(DIBE)
Gini	Ratio that describes income distribution.	0.27	0.06	Dispersion of income across the entire income distribution Source: Mohanty et al. (2016).
Ground Water Level	Measured as vertical distance from ground to water in metres	9.15	11.20	Represents the overall health of the groundwater system Source: National Data Analytics Portal NDAP

Baseline Results and Interpretations

Baseline Model: $GW_{i,t} = \alpha_0 + \alpha_1 SDP_{i,t} + \alpha_2 (SDP_{i,t})^2 + \alpha_3 (SDP_{i,t})^3 + \alpha_4 GINI_i + \gamma_{i,t}$

Intercept	Estimate	Std. Error	t value	Pr(>|t|)
α_0^	-1.92	8.45 x 10^-1	-2.27	0.02 *
α_1^	2.13 x 10^-5	2.88 x 10^-6	7.39	1.74 x 10^-13 ***
α_2^	-1.78 x 10^-11	4.21 x 10^-12	-4.22	2.48 x 10^-5 ***
α_3^	3.50 x 10^-18	1.68 x 10^-18	2.08	0.04 *
α_4^	2.17 x 10^1	2.64	8.23	2.43 x 10^-16 ***
N = 5232, Multiple R-squared: 0.04779, Adjusted R-squared: 0.04706, F-statistic: 65.58 on 4 and 5227 DF, p-value: < 2.2e-16				

EKC Hypothesis:

- $H_0 : \alpha_1 = 0$ and $\alpha_2 = 0$
- $H_a : \alpha_1 \neq 0$ or $\alpha_2 \neq 0$

Since α_1^ and α_2^ are highly statistically significant and α_1^ > 0 & α_2^ < 0, **we reject H_0**, i.e., our model follows inverted U relationship of EKC.

Additional Variables (Power Inequality)

Variable	Description	Mean	Standard Deviation	Remarks
FemWork	It is the percentage of employed female workers in a state	26.00	12.11973	Indicator of gender equality, economic opportunity and overall economic conditions. Source: Ministry of Labour and Employment
crimerate	Defined as incidence rate of crime against Scheduled Caste people in state	21.95	15.73953	Provides insight into the social and political conditions Source: National Crime Records Bureau
margin	Defined as percentage difference of votes between winner and runner up in elections	14.35	11.02236	Indicates the level of political polarisation and effectiveness of political campaigns Source: Election Commission
Rainfall	Rainfall in a state measured in mm.	7.5	157.307	Not a power inequality. Measures climatic difference

Testing Structural Break Across State Groups

$H_0: \beta_9=0 \ \& \ \beta_{10}=0 \ \& \ \beta_{11}=0 \ \& \ \beta_{12}=0$

$H_a: \beta_9 \neq 0 \text{ or } \beta_{10} \neq 0 \text{ or } \beta_{11} \neq 0 \text{ or } \beta_{12} \neq 0$

Method 1: Chow Test

Full Model: $GW_{i,t} = \beta_0 + \beta_1 SDP_{i,t} + \beta_2 (SDP_{i,t})^2 + \beta_3 (SDP_{i,t})^3 + \beta_4 GINI_i + \beta_5 FemWork_{i,t} + \beta_6 margin_{i,t} + \beta_7 crimerate_{i,t} + \beta_8 rainfall_{i,t} + \beta_9 D_{South,i} + \beta_{10} D_{North,i} + \beta_{11} D_{East,i} + \beta_{12} D_{West,i} + \gamma_{i,t}$

Restricted Model: $\beta_0 + \beta_1 SDP_{i,t} + \beta_2 (SDP_{i,t})^2 + \beta_3 (SDP_{i,t})^3 + \beta_4 GINI_i + \beta_5 FemWork_{i,t} + \beta_6 margin_{i,t} + \beta_7 crimerate_{i,t} + \beta_8 rainfall_{i,t} + \gamma_{i,t}$

Critical Value: $F_{Q=4'N-k=3232}$ = 2.374682, F-value calculated = 153.633, F-value obtained from function=153.4

Method 2: t-test

F-Value calculated = 153.4, Pr(>F) = < 2.2e-16 ***

Conclusion: We reject the null hypothesis (H_0). Therefore,

Verification of Consistency of OLS Estimators

Monte Carlo Simulation: Verifying consistency

$GWi,t = \alpha_0 + \alpha 1 SDP_{i,t} + u_{i,t}$

$\alpha_0 = 8.2, \quad \alpha_1 = 2.423e\text{-}06$

M (no of simulations)	α_0	α_1
10	Mean = 8.234, St. Dev = 0.453	Mean = 0.000, St. Dev = 0.000
100	Mean = 8.239, St. Dev = 0.283	Mean = 0.000, St. Dev = 0.000
1000	Mean = 8.202, St. Dev = 0.266	Mean = 0.000, St. Dev = 0.000

Difference of Variance Across State Groups

- Var(overall) = 133.38
- Var(south) = 13.07
- Var(north) = 392.77
- Var(east) = 3.029
- Var(west) = 101.67
- Var(Centre) = 64.58

- OLS is no longer BLUE
- Inference based on OLS will be incorrect which assume homoskedasticity
- Hence the need for GLS

Generalized Least Squares

Model: $\beta_0 + \beta_1 SDP_{i,t} + \beta_2 (SDP_{i,t})^2 + \beta_3 (SDP_{i,t})^3 + \beta_4 GINI_i + \beta_5 FemWork_{i,t} + \beta_6 margin_{i,t} + \beta_7 crimerate_{i,t} + \beta_8 rainfall_{i,t} + \gamma_{i,t}$

Coefficients	Value	Std.Error	t-value	p-value
Intercept	-0.968398	2.1184	-0.457126	0.6476
SDP	0.000026	0.0000089	2.947651	0.0032
SDP^2	0.0000	0.00	-1.899	0.0576
Gini	10.756	2.981	3.6082	0.0003
FemWork	0.013086	0.0296	0.44111	0.6592
margin	-0.00536	0.01449	-0.3698	0.7115
crimerate	0.0377	0.024228	1.556215	0.1198
rainfall	-0.0039	0.00191	-2.0386	0.0416
N = 3240, Residual Standard Error = 11.27332, Degrees of freedom: 3240 total; 3231 residual				

Impact of Variables on the environmental quality indicator

SDP: The coefficient of SDP is positive and its p value is also less than 0.05 which means it is statistically significant and it means that increase in SDP increases groundwater level and thus increases environmental degradation.

GINI: The coefficient of Gini is positive and its p value is also less than 0.05 which means it is statistically significant and it means that increase in GINI (increase in income inequality) increases groundwater level and thus increases environmental degradation.

FemWork: The coefficient of FemWork is positive and its p value is greater than 0.05 which means it is not statistically significant. Basically it is saying that greater the Female Worker percentage in a state greater will be environmental degradation. But its p-value is larger than 0.05. It is not significant

Margin : The coefficient of Margin is negative and its p value is greater than 0.05 which means it is not statistically significant. Basically it is saying if election win margin increases the environmental degradation decreases. But its p-value is larger than 0.05 so it is not significant.

Crimerate : The coefficient of crimerate is positive and its p value is greater than 0.05 which means it is not statistically significant. Basically it is saying if crime rate against SC people increases the environmental degradation increases.

Rainfall: The coefficient of rainfall is negative and its p value is less than 0.05 which means it is statistically significant. Basically it is saying if rainfall in a state increases the environmental degradation increases which is expected as well.

Conclusion

A significant relationship between groundwater pollution and power inequality could not be established.

The coefficient for income inequality and the total economic output suggests a positive relationship with pollution.

Crime against SCs has a direct relationship with environmental degradation though insignificant.

The Election win margin has an inverse relationship, though insignificant.

Rainfall has a result as expected.