Environmental Kuznets Curve: Stock and Flow Water Pollutants

Mahesh Pandit, Ph.D. Candidate
Department of Agricultural Economics and Agribusiness
101 Martin D. Woodin Hall
Louisiana State University and LSU AgCenter
Baton Rouge, LA 70803
Office: (225) 578-2728
Fax: (225) 578-2716
Email: mpandi2@tigers.lsu.edu

Krishna P. Paudel, Associate Professor
Department of Agricultural Economics and Agribusiness
225 Martin D. Woodin Hall
Louisiana State University and LSU AgCenter
Baton Rouge, LA 70803
Office: (225) 578-7363
Fax: (225) 578-2716
Email: kpaudel1@lsu.edu

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Mahesh Pandit and Krishna P. Paudel
Louisiana State University and LSU AgCenter, Baton Rouge, Louisiana

The relationship between pollution and per capita income generally appears as an inverted U-shaped curve.

Abstract

We used a seemingly unrelated partial linear regression model (SUPLR) to examine the EKC hypothesis for water quality parameters. Monte Carlo simulation indicates that SUPLR performs better in finite samples. We found that EKC exists for Nitrogen, Dissolved Oxygen, and Mercury.

Introduction

The debate on the existence of EKC continues for various pollutants across different geographical regions. Water pollution occurs when the pollutants are discharged directly or indirectly into water sources such as lakes, river, oceans, aquifers and groundwater. Water pollutants commonly emanating from non-point sources are known as flow pollutants (e.g. N, P, and DO) whereas the pollutants that continue to add rather than dissolve are stock pollutants (e.g. Mercury)

Previous literature has examined the EKC hypothesis in many pollutants using separate equations. Water may get polluted from more than one pollutants at the same time i.e. pollutants may be correlated to each other. However, previous researchers have not considered the potential correlation among pollutants thereby ignoring the covariance of the error terms across different pollutants. In such case, a single equation estimation method may not be sufficient to examine true relationship between income and pollutant.

Objective

- Jointly estimate stock and flow pollutants to determine if the EKC exists in both,
- Use a seemingly unrelated partial linear model to determine the shape of pollution-income relationship,
- Utilize a semiparametric model specification and test whether a semiparametric model performs better than a parametric model.

Method

Seemingly unrelated partial linear model to estimate stock and flow pollutants is given as:

$$P_{jit} = G_j(y_{it}) + X_{jit}\alpha_j + \Gamma_{ji} + u_{jit} \quad j = 1, \dots, M, i = 1, \dots N, \quad t = 1, \dots, T$$

where P_{jit} = is stack vector for concentration of pollutant j in parish i in time t. $G(.)$ is unknown smooth function for M system of equation, Y_{jit} is the stack matrix of quadratic or cubic form of per capita income as defined above and X_{jit} is stack matrix of other factors that affect pollutant j in equation, u_{jit} are random vectors with zero mean and $\sum_{\epsilon} \otimes I_{NT}$ variances. We extended the work by You, Zhou, and Chen (2013) for seemingly unrelated semiparametric partial linear model.

Model Specification Test

We used the method suggested by Hsiao, Li, and Racine (2007) to check for the correct model specification. The null and alternative hypotheses are:

H_0= Parametric model

H_1= Nonparametric / Semiparametric model

Simulation study

Data generating process (dgp)

$$p_1 = X_1\beta_{11} + X_3\beta_{13} + g_1(y_1) + \epsilon_1$$
$$p_2 = X_2\beta_{22} + X_3\beta_{23} + g_2(y_2) + \epsilon_2$$

where, $X_1 \sim .3 \times \chi_1^2$, $X_2 \sim \chi_1^2$, $X_3 \sim |N(0,1)|$, $\beta_{11} = 1.5$, $\beta_{13} = 5$, $\beta_{22} = -2$, $\beta_{23} = 2$, $g_1(.) = 2\sin(2\pi.)$, $g_2(.) = \cos(1.5\pi.)$, $y_1 = y_2 = y$, $\epsilon = (\epsilon_1, \epsilon_1)' \sim N(0, \Sigma)$, $\Sigma = \sigma_{ij}$, $\sigma_{11}^2 = \sigma_{22}^2 = 1$, and $\sigma_{12} = .3$ or. 6 or .9.

			Equation 1		Equation 2	
N	Cov.	Statistics	$\beta_{11} = 1.5$	$\beta_{13} = 5$	$\beta_{22} = -2$	$\beta_{23} = 2$
n=100	$\sigma_{12} = .3$	$\hat{\beta}_{ij}$	1.4861	4.9954	-1.9908	1.9965
		SD	0.2712	0.1724	0.0802	0.1726
	$\sigma_{12} = .6$	$\hat{\beta}_{ij}$	1 .4881	4.9994	-1.9899	1.9999
		SD	0.2603	0.1762	0.0781	0.1766
	$\sigma_{12} = .9$	$\hat{\beta}_{ij}$	1.4862	4.9905	-1.9904	1.9926
		SD	0.2697	0.1765	0.0806	0.1743
n=500	$\sigma_{12} = .3$	$\hat{\beta}_{ij}$	1.4988	4.9981	-1.9962	1.9943
		SD	0.1049	0.0752	0.0328	0.0765
	$\sigma_{12} = .6$	$\hat{\beta}_{ij}$	1.5039	4.9973	-2.0001	1.9987
		SD	0.1081	0.0764	0.0328	0.0736
	$\sigma_{12} = .9$	$\hat{\beta}_{ij}$	1.4988	5.0001	-1.9994	1.9998
		SD	0.1014	0.0772	0.0328	0.0743

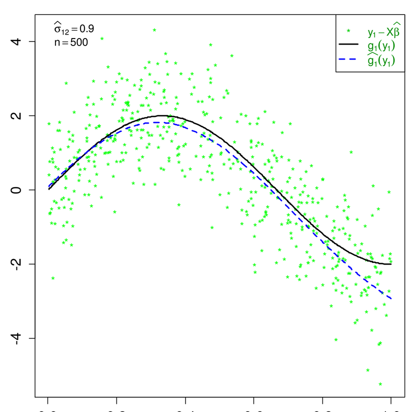

Figure 1. Partial regression plot for $g_1(y_2)$

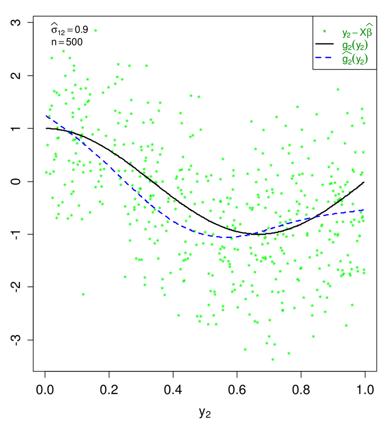

Figure 2. Partial regression plot for $g_2(y_2)$

- Estimated parameters are very close to the true parameters i.e. the parametric components of SUPLR model are asymptotically unbiased.
- The estimated nonparametric estimates are close to the assumed functional form.

Data (1985-2006)

- Water quality parameters (N, P, DO, Hg) : Louisiana Department of Environmental Quality
- Per capita income and population : Bureau of Economic Analysis (BEA).
- Permit: Better Assessment Science Integrating Point Non-point Sources (BASINS)
- Farm land areas: National Agricultural Statistics Service (NASS) quick stats.

Results and Conclusions

Table: Estimated coefficients from a semiparametric model

Variables	N	P	DO
Weighted income	-1.1818	0.0414	2.2100
	(0.000)	(0.435)	(0.004)
Population density	-1.1378	0.0172	7.6416
	(0.000)	(0.445)	(0.000)
Acres	0.0042	0.0025	0.0733
	(0.000)	(0.000)	(0.000)

Table. Estimated coefficients from a parametric model (Mercury)

Income	Income-square	Income-cube	Permit
1.3539	-1.6136	0.4736	0.0029
(0.086)	(0.030)	(0.028)	(0.046)

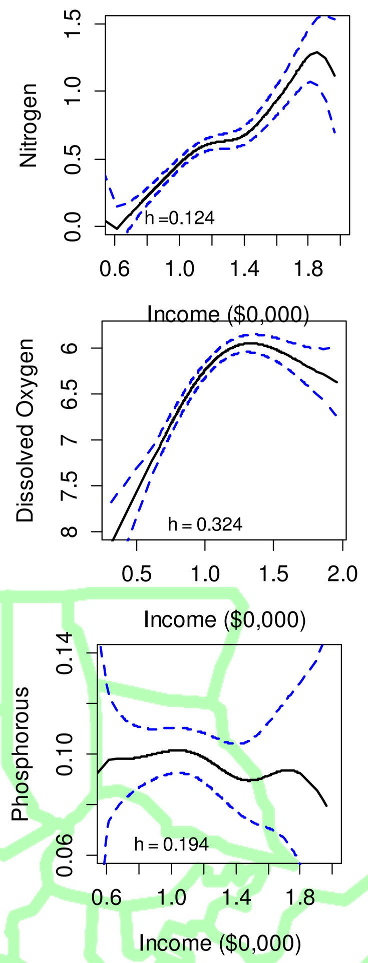

Figure. Partial plot of income for N, P and DO from semiparametric model

- We used a semiparametric seemingly unrelated regression model to examine the EKC hypothesis.
- Results show that the EKC exists for nitrogen, dissolved oxygen and mercury.
- The income spillover effect is found for nitrogen (-).
- Population density has negative effect on nitrogen and positive effect on dissolved oxygen.
- Farm land area has positive effect flow pollutants.
- Model specification test shows that a parametric model is proper specification in case of mercury, and we found that permit has positive and significant effects.

References

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Pollution

Economic growth