

Economic Development, Trade and Environmental Quality:
Environmental Kuznets Curve Hypothesis in a Threshold Model

- What is EKC?
- Earlier Studies :
 - Grossmann and Krueger 1992, 1995
 - Shafik and Bandyopadhyay 1992
 - Selden and Song 1994
 - Holtz-Eakin and Selden 1995
 - Stern et al. 1996
 - Ekins 1997
 - Suri and Chapman 1998,
 - Kaufmann et al. 1998
 - Agras and Chapman 1999
 - Rothman 1998
- Mixed Empirical Evidence, mostly supportive of EKC
- Structural Linkages between income and environmental quality are not usually shown
- Reduced form equation where pollution is expressed as a quadratic function of income

What is new in our paper ?

- Introduction of a new econometric technique to test and identify the threshold
 - New Econometric Model

Hansen (1996, 2000) Econometrica Papers
 - Advantages
- Searching for EKC in openness index
 - Production versus consumption and shifting of pollution between developed and developing countries

ECONOMETRIC MODEL

We consider the following threshold regression model by Hansen (2000):

$$Y_i = \beta_1 + \beta_{21} X_i 1_{(X_i < \lambda)} + \beta_{22} X_i 1_{(X_i > \lambda)} + \beta_3 Z_i + \epsilon_{it}$$

where X_i is the threshold variable, the variable that causes the regime shift
 Z_i represents the rest of the independent variables, λ is the threshold level,
and $1_{(.)}$ is the indicator function ($1_{(.)}$ is 1 if the condition in $(.)$ is satisfied,
otherwise it is zero).

We test

$$H_0 : \beta_{21} = \beta_{22}$$

against a regime shift, i.e. $\beta_{21} \neq \beta_{22}$. We use a supLm test for threshold
models introduced in Hansen (1996).

The next step is the estimation if a threshold is found to be present in data.
Estimation is done by simple least squares (LS) regression. Firstly, we
transform the model into a matrix form:

$$Y = X \beta_{22} + X_\lambda \Delta + Z \Phi + \epsilon$$

where $\Delta = \beta_{21} - \beta_{22}$ and $\Phi = (\beta_1, \beta_3)'$.

X_λ is a $n \times 1$ vector where the i th element is $X_i 1_{(X_i = \lambda)}$. X is n dimensional vector. Z is $n \times (k-1)$ matrix.

We use Hansen's LS methodology of estimating thresholds. First set

$$S_n(\Phi, \Delta, \beta_{22}, \lambda) = (Y - X\beta_{22} - X_\lambda\Delta - Z\Phi)'(Y - X\beta_{22} - X_\lambda\Delta - Z\Phi)$$

Then given λ , the above equation is linear in Φ , Δ , and β_{22} . We first find conditional LS estimates for these parameters given the threshold parameter λ . Then we set

$$S_n(\lambda) = S_n(\hat{\Phi}(\lambda), \hat{\Delta}(\lambda), \hat{\beta}_{22}(\lambda), \lambda)$$

Unique estimate of λ is determined by minimizing above expression

$$\hat{\lambda} = \arg \min_{\lambda \in \Lambda} S_n(\lambda)$$

where Λ is a compact space. Given the solution to above minimization problem, the slope estimates are computed by plugging $\hat{\lambda}$ into the values for conditional slope estimates found above, namely $\hat{\Phi}(\hat{\lambda})$, $\hat{\Delta}(\hat{\lambda})$, and $\hat{\beta}_{22}(\hat{\lambda})$. For the details of the limit law of the threshold, the slope parameters and also for the corresponding confidence intervals, see Hansen (2000). Note that we use heteroskedasticity robust confidence regions for our parameters.

Environmental Model:

- **Commonly Used Model**

Grosmann and Krueger (1995)

$$Y_{it} = \beta_1 G_{it} + \beta_2 G_{it}^2 + \beta_3 G_{it}^3 + \beta_4 \underline{G}_{it} + \beta_5 \underline{G}_{it}^2 + \beta_6 \underline{G}_{it}^3 + \beta_7 X_{it} + \epsilon_{it}$$

- **Our Model**

$$Y_i = D_i \beta_1 + G_i 1_{(G_i \leq \lambda)} \beta_{21} + G_i 1_{(G_i > \lambda)} \beta_{22} + CO_i \beta_3 + R_i \beta_4 +$$

$$CC_i \beta_5 + I_i \beta_6 + \epsilon_i$$

Y_i is a measure of water or air pollution in station i ,

D_i is population density,

G_i is GDP per capita in the country in which station i is located;

CO_i is coastal dummy;

R_i , CC_i and I_i are other location dummies indicating residential, center of city, and industry, respectively;

{All these variables are included in the Grosmann and Krueger (1995) model above under X_{it} .}

ϵ_i is the error term.

Data

We have used the same GEMS data as in Grosmann and Krueger (1995). The panel data from the Global Environmental Monitoring System's (GEMS) tracking of urban air quality in different cities in the developing and developed world includes data collected from 42 different countries. Water quality data, especially on rivers, includes a large number of stations in 58 different countries.

Estimation Results

- Decompose data across time and use cross-sectional data for each time period

Table I. Threshold estimation for sulfur dioxide emissions.

Year	Beta Before Threshold, β_{21}	Beta After Threshold, β_{22}	Threshold	Number of Observations
1977	45.587 (1.233)*	2.676 (1.339)*	2883 ^a	123
1978	11.248 (1.902)	1.461 (0.349)	4422 ^a	126
1979	3.331 (1.180)	-0.084 (0.560)	10423 ^b	127
1982	10.261 (2.154)	1.20 (0.483)	4591 ^a	142
1984	15.675 (3.927)	0.390 (0.551)	3526 ^b	145

* Standard errors in parenthesis.

^a Significant at 0.001.

^b Significant at 0.01.

Findings (cont.)

- In case of Dissolved Oxygen :

For 1981: threshold significant, but no EKC type outcome

For 1982: threshold significant, we get EKC type outcome:
(coefficient after threshold insignificant, close to 0)

For 1985: no threshold (at 5 percent)

- In case of BOD:

Fails threshold test for 1982--1985

- In case of Fecal Coliform:

For 1980: threshold significant, but no EKC type outcome

For 1981: no threshold (at 5 percent)

For 1982: threshold significant, we get EKC type outcome:

For 1983: no threshold (at 5 percent)

For 1985: no threshold (at 5 percent)

Is there EKC in Openness Index ?

- Openness Index, $OP = (\text{Exports} + \text{Imports}) / \text{GDP}$
- Model

$$Y_i = D_i \beta_1 + G_i \beta_2 + CO_i \beta_3 + R_i \beta_4 + CC_i \beta_5 + I_i \beta_6 + OP_i 1_{(OP_i \leq \lambda)}$$

$$\beta_{71} + OP_i 1_{(OP_i > \lambda)} \beta_{72} + \epsilon_i$$

- Estimation with SO2 data:

Table II. Threshold estimation for sulfur dioxide emissions.
(Threshold for Openness)

Year	Beta before Threshold, β_{71}	Beta after Threshold, β_{72}	Threshold	Number of Observations
1977	0.01 (0.006)*	-0.077 (0.011)*	28.42 ^b	118
1981	0.137 (0.023)	-0.0015 (0.005)	24.21 ^a	132
1983	0.036 (0.012)	-0.005 (0.006)	10.76 ^c	110
1984	0.561 (0.111)	-0.0007 (0.007)	19.5 ^b	112
1985	0.281 (0.070)	-0.007 (0.006)	16.43 ^b	97

* Standard errors in parenthesis.

^a Significant at 0.001.

^b Significant at 0.01.

^c Significant at 0.05.

Conclusions

- EKC – type relationship between pollution and openness to trade may exist
- developed countries may be shifting their dirty production processes to the developing ones through more liberalized trade
- this kind of “pollution abatement” not sustainable
- EKC relationship between income and pollution is uncertain
- the impact of income growth and trade liberalization on the stringency of environmental regulations

A Reminder on Environmental Consequences of Trade Liberalization

- Scale Effect (size of the economic activities)
- Composition Effect (bundle of goods being produced)
- Technique Effect (production technology)