

Foreign direct investment and environmental pollution in China:
a simultaneous equations estimation *

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APPENDIX

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Appendix 1 FDI and pollution emissions by provinces: 1992-2004

	<i>fdi / gdp</i>	<i>fdi</i>	<i>so₂</i>	<i>smoke</i>	<i>water</i>	<i>solid</i>	<i>cod</i>
Hainan	1.047%	6.27	2.21 (-0.26)	1.39 (-0.10)	0.76 (-0.34)	0.01 (-0.00)	3.30 (-5.32)
Guangdong	0.946%	113.76	72.96 (61.51)	23.63 (2.4)	12.89 (2.27)	0.17 (0.08)	29.51 (-12)
Fujian	0.878%	34.25	18.55 (16.93)	8.24 (3.00)	6.79 (5.18)	0.19 (0.26)	14.67 (-9.81)
Tianjin	0.842%	15.70	22.18 (-2.88)	8.12 (-0.40)	2.04 (0.15)	0.05 (0.03)	6.29 (-5.74)
Shanghai	0.774%	37.77	38.82 (-16.41)	10.24 (-9.56)	9.29 (-8.06)	0.13 (0.06)	10.02 (-15.84)
Jiangsu	0.666%	61.73	112.92 (-1.46)	46.03 (-14)	22.38 (3.86)	0.31 (0.22)	35.01 (-13.43)
Beijing	0.486%	16.21	22.16 (-24.38)	7.65 (-7.7)	2.90 (-2.70)	0.11 (0.04)	4.79 (-9.07)
Liaoning	0.445%	22.44	81.38 (-42.48)	56.54 (-33.1)	11.96 (-6.12)	0.75 (0.08)	29.66 (-23.82)
Shandong	0.377%	34.73	174.73 (-71.28)	55.13 (-6.6)	10.42 (4.22)	0.53 (0.39)	68.79 (-28.03)
Zhejiang	0.308%	20.86	56.80 (27.71)	20.27 (2.80)	12.45 (4.86)	0.13 (0.13)	29.12 (-6.55)
Jiangxi	0.278%	6.11	31.86 (15.23)	21.72 (-8.50)	5.51 (-1.97)	0.44 (0.31)	11.95 (-13.11)
Hubei	0.267%	10.72	49.38 (11.95)	24.86 (4.40)	11.95 (4.71)	0.24 (0.13)	27.77 (-19.8)
Guangxi	0.246%	6.10	66.91 (28.02)	36.82 (25.00)	9.37 (2.89)	0.20 (0.19)	56.85 (27.14)
Hunan	0.191%	7.47	57.67 (21.86)	33.97 (17.5)	13.41 (-5.52)	0.22 (0.12)	31.43 (-12.4)
Qinghai	0.184%	0.52	2.87 (4.30)	4.60 (2.10)	0.45 (-0.18)	0.03 (0.02)	0.40 (-0.34)
Hebei	0.160%	7.76	109.27 (28.56)	54.12 (8.60)	9.53 (3.73)	0.77 (1.11)	36.18 (11.78)

Shanxi	0.151%	1.82	94.27 (35.05)	64.72 (49.4)	3.76 (-0.91)	0.61 (0.62)	16.98 (-21.67)
Jilin	0.146%	3.16	22.32 (-1.87)	29.63 (-3.3)	3.94 (-1.18)	0.16 (0.05)	20.69 (-14.13)
Heilongjiang	0.112%	4.14	26.41 (-2.48)	43.63 (-11.9)	6.04 (-3.22)	0.31 (-0.06)	19.56 (-15.23)
Anhui	0.110%	3.69	38.74 (1.82)	23.74 (-3.5)	7.30 (-3.32)	0.29 (0.12)	22.15 (-25.8)
Henan	0.087%	5.02	71.50 (53.55)	52.33 (27.70)	10.10 (2.23)	0.33 (0.29)	45.06 (-5.76)
Shaanxi	0.083%	3.03	63.57 (3.79)	35.21 (-2.9)	3.40 (-0.14)	0.23 (0.22)	11.03 (6.68)
Ningxia	0.083%	0.25	20.63 (4.23)	9.93 (-2.40)	0.92 (0.16)	0.04 (0.02)	6.57 (2.33)
Sichuan	0.067%	4.82	153.40 (6.25)	73.23 (20.50)	17.90 (0.32)	0.49 (0.31)	49.32 (7.29)
Yunnan	0.062%	1.06	31.31 (15.07)	17.93 (-1.20)	3.97 (-0.56)	0.26 (0.22)	19.56 (-7.35)
Neimenggu	0.051%	1.26	66.78 (29.61)	40.40 (-48.40)	2.46 (-0.41)	0.27 (0.26)	17.04 (5.24)
Gansu	0.045%	0.61	36.21 (8.35)	14.57 (-1.30)	2.98 (-1.92)	0.15 (0.09)	5.06 (-2.40)
Guizhou	0.037%	0.69	66.04 (-11.50)	27.37 (-5.70)	2.40 (-1.28)	0.22 (0.32)	5.26 (-2.99)
Xinjiang	0.022%	0.75	23.01 (7.95)	12.80 (0.10)	1.73 (-0.09)	0.07 (0.07)	12.46 (5.83)

Note: We use the panel data consisting of 29 provinces in China during 1992~2004. We list the mean value of each indicator during 1992-2004, and the figures in parentheses are the emission levels in 2004 minus that in 1992 for each pollutant, which measure the changes of pollution emission over this period. *water* is industrial polluted water; *solid* is industrial solid wastes, and their unit is 100 billion kilograms. *so₂* is industrial sulphur dioxide emission; *smoke* is industrial smoke; *cod* is chemical oxygen demand in industrial water pollution, and their unit is 10 million kilograms. The sources of pollution emission data source are various issues of China's Environment Yearbook. The unit of FDI is 100 million U.S. dollars, and they are taken from various issues of China Statistical Yearbook. The 29 provinces are ranked by the descending order of the proportions of FDI in their total GDP.

Source: Authors' own calculations based on the data taken from various statistical sources.

Appendix 2

The Decomposition of the Environmental Effects of FDI: a Graphic Analysis

Using the similar graphic analysis on the environmental effects of international trade in Copeland and Taylor (2003), we show below how FDI affects pollution emissions in host countries through the three channels which are graphically described in Figure A.

In Figure A X represents a pollution-insensitive good, and Y is the clean good. Z represents the level of pollution emission, which depends on both output of X and pollution intensity e , and hence we have $z = e.X$. e_0 and e_1 are the pollution intensities before and after the entry of FDI respectively. Before FDI enters, the equilibrium point is A; and the domestic relative price is $P = P_X / P_Y$. It is assumed that pollution-intensive goods X is capital-intensive (Copeland and Taylor, 2003), thus inflow of foreign investment will cause the domestic production possibility frontier to expand more towards X than Y . The new equilibrium point becomes C and the relative price is P' , which is smaller than P in terms of X . Figure A1 shows how the environmental effect of FDI can be decomposed into three effects. First, with the entry of foreign firms, the pollution emission level decreases from z_1 to z_2 , resulting from the technique effect since only pollution intensity falls in this case. Second, the scale effect measures the expansion of production level rising from A to B, reflected in an increase in the emission level from z_2 to z_3 accordingly. Finally, the composition effect can be identified by the movement from B to C (towards more pollution-intensive goods) which is reflected in the change of emission level from z_3

Appendix 3

Definition of various indicators

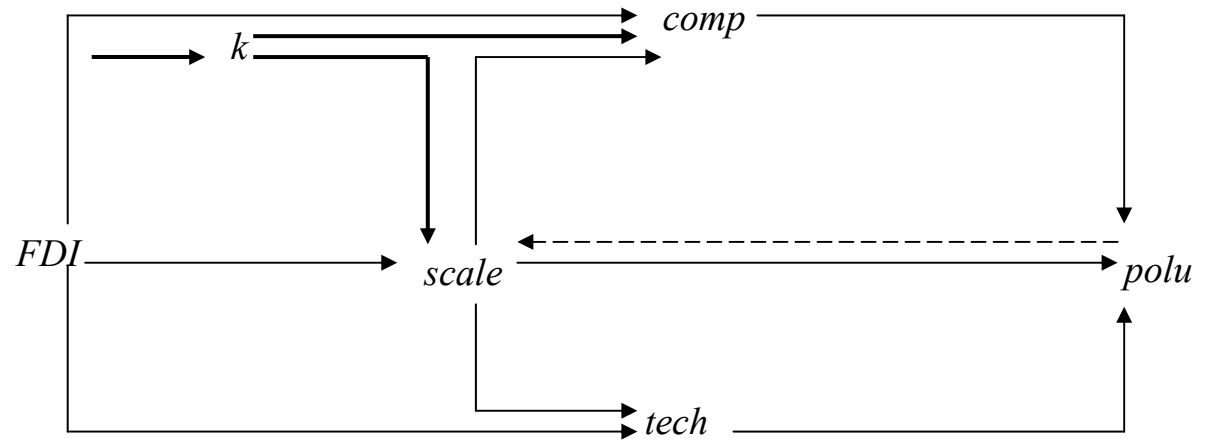
Endogenous variables			
Variables	Definition	Unit	Data source
<i>so₂</i>	Industrial sulphur dioxide	10 million kg	CEY
<i>smoke</i>	Industrial smoke	10 million kg	CEY
<i>water</i>	Industrial polluted water	100 billion kg	CEY
<i>solid</i>	Industrial solid wastes	100 billion kg	CEY
<i>cod</i>	Chemical oxygen demand in industrial water pollution	10 million kg	CEY
<i>fdi</i>	Foreign direct investment	10 thousand USD	CSY
<i>gdp</i>	Gross domestic products	100 million Yuan	CSY
<i>tech</i>	Pollution per unit of industrial output	100 million Yuan	AOC
<i>comp</i>	Industrial output/gdp	-	AOC
<i>k</i>	Physical capital stock	100 million Yuan	Zhang et al. (2004)
Exogenous variables			
<i>l</i>	Labour	10000 person	CSY
<i>h</i>	Human capital	Education year/person	CSY
<i>prd</i>	Environment-related R&D	10000 Yuan	CEY
<i>dens</i>	Population density	Person/km ²	CSY
<i>num</i>	Number of employees in environmental institutions	person	CEY
<i>trd</i>	Total R&D expenditure	Million Yuan	CSY
<i>wage</i>	Average wage	Yuan	CSY
<i>rail</i>	Railway	kilometer	CSY
<i>road</i>	Road	kilometer	CSY
<i>gov</i>	Special funds for pollution abatement	10000 Yuan	CEY
<i>bud</i>	State budget for environmental protection	10000 Yuan	CEY

Note: CSY denotes *China Statistical Yearbook*; CEY denotes *China Environment Yearbook*; AOC denotes *authors' own calculation*. Yuan is China's currency unit.

Source: Authors' own preparation.

Appendix 4

How FDI affects pollution in host countries



Source: Authors' own schema.

