Ch. 5 Endogenous Policy Pollution Haven

Code File: phavenEndog.gms

Description:
This is the pollution haven model with endogenous pollution policy of section 5.3 of the book.
I assume trade from the start, both economies identical at the start and increase North's endowments (neutrally) and watch the effect.

In this model there are two countries (N and S) identical in every respect except for the endowments. Here I have basically replicated the single country model of earlier sections of the book allowing each country to have its own variables but sharing model parameters and endowments. There is a single world price of each good (Px,Py), each country produces both goods and total world demand equals total world supply. We start out with identical endowments and then increase North's endowments.

The technology for production in each is Cobb-Douglas but with different factor shares. Dirty good production includes the production of pollution. Utility is also Cobb-Douglas. The market clearing conditions state that endowments must be used up in goods production and that income from endowments equals total expenditure on goods. Good Y is the numeraire good.

Model:
There are 2 countries (N,S) represented. Each is represented by its own copy of the model equations. Variables in S are distinguished by having a prefix of *s_* added to the corresponding N variable. The parameters $\alpha, \beta, \gamma, p_x, p_y, K, L$ are shared between the 2 countries.

Shared Parameters and Variables:

L, K - labor and capital endowments

p_x, p_y - prices of dirty, clean good

β - labor share in dirty good

σ - labor share in clean good

α - pollution share in dirty good

ω - share of expenditure on dirty good

γ - disutility of pollution parameter

Country Specific Variables :

r, w - rent, wage

τ - pollution permit price

X_s, X_d - supply/demand of dirty good

Z_x, Z_s - pollution supply/demand in dirty good production

Y_s, Y_d - supply/demand of clean good

L_x, K_x - labor, capital used in dirty good production

L_y, K_y - labor, capital used in clean good production

u - total utility

i - total income

e - pollution intensity

θ - fraction of resources devoted to abatement

Country Specific Supply side equations

$$X_s = Z_x^{\alpha}(L_x^{\beta}K_x^{(1-\beta)})^{1-\alpha}$$

$$\tau Z_x = \alpha p_x X_s$$

$$rK_x = p_x(1-\alpha)(1-\beta)X_s$$

$$wL_x = p_x(1-\alpha)\beta X_s$$

$$Y_s = L_y^{\sigma}K_y^{(1-\sigma)}$$

$$rK_y = p_y(1-\sigma)Y_s$$

$$wL_y = p_y\sigma Y_s$$

Country Specific Demand side equations

$$u = \omega\log(X_d) + (1-\omega)\log(Y_d) - \frac{Z_s^{\gamma}}{\gamma}$$

$$p_x X_d = \omega i$$

$$p_y Y_d = (1-\omega)i$$

$$MD = iZ_s^{(\gamma-1)}$$

$$\tau = MD$$

Country Specific Clearing conditions

$$K = K_x + K_y$$

$$L = L_x + L_y$$

$$wL + rK + \tau Z_x = i$$

$$Z_s = Z_x$$

Variable Definitions

$$X_s e = Z_x$$

$$\theta = 1 - (\frac{\alpha p_x}{\tau})^{\frac{\alpha}{1-\alpha}}$$

Global Clearing Conditions :

$$X_d + s\_X_d = X_s + s\_X_s$$

$$Y_d + s\_Y_d = Y_s + s\_Y_s$$

Output:

The model is run repeatedly starting with identical economies in N and S. In each cycle the endowments (K and L) in North are increased. They increase incrementally over a range from 1 to 3 times the endowments of South.

We observe that as N's endowment of labor and capital increases:

- Tau > s_Tau and increasing in difference
- e < s_e and increasing in difference
- N imports an increasing amount of dirty good
- pollution in N decreases
- pollution in S increases
- welfare in N increases
- welfare in S increases
- global pollution increases

Output from the run using the following parameters is contained in the subsequent table:

```
parameter
* These hold for both N and S
beta   labor share in f    / 0.3 /,
sigma  labor share in y    / 0.7 /,
alpha  polln share in x    / 0.2 /,
omega  income share of x   / 0.6 /,
gamma  convexity           / 2 /,
l      labor endowment           / 1 /,
k      capitalendowment    / 1 /,
s_l    labor endowment           / 1 /,
s_k    capitalendowment    / 1 /,
xprice price of good x           / 1 /,
yprice price of good y           / 1 /;
```

North's Economy

index	X Price	Xd	Xs	Yd	Ys	Util	Tau	Polln	MD	e
1	1.429	0.526	0.526	0.501	0.501	-0.722	0.434	0.346	0.434	0.658
2	1.443	0.569	0.559	0.548	0.563	-0.638	0.47	0.343	0.47	0.614
3	1.457	0.612	0.591	0.594	0.625	-0.561	0.506	0.34	0.506	0.576
4	1.471	0.653	0.622	0.641	0.687	-0.491	0.542	0.338	0.542	0.543
5	1.485	0.694	0.654	0.687	0.748	-0.425	0.578	0.336	0.578	0.514
6	1.498	0.735	0.685	0.734	0.81	-0.364	0.614	0.334	0.614	0.488
7	1.512	0.775	0.715	0.781	0.871	-0.307	0.65	0.333	0.65	0.465
8	1.525	0.814	0.746	0.828	0.932	-0.254	0.686	0.332	0.686	0.444
9	1.538	0.853	0.776	0.875	0.993	-0.203	0.723	0.33	0.723	0.426
10	1.551	0.892	0.806	0.922	1.054	-0.156	0.759	0.329	0.759	0.408
11	1.563	0.93	0.837	0.969	1.115	-0.11	0.796	0.329	0.796	0.393
12	1.575	0.967	0.866	1.016	1.175	-0.067	0.833	0.328	0.833	0.378
13	1.587	1.005	0.896	1.063	1.235	-0.026	0.87	0.327	0.87	0.365
14	1.599	1.042	0.926	1.11	1.295	0.013	0.907	0.327	0.907	0.353
15	1.61	1.078	0.955	1.158	1.355	0.051	0.944	0.326	0.944	0.341
16	1.622	1.114	0.985	1.205	1.415	0.087	0.981	0.326	0.981	0.331
17	1.633	1.15	1.014	1.252	1.475	0.121	1.018	0.325	1.018	0.321
18	1.644	1.186	1.043	1.3	1.534	0.154	1.056	0.325	1.056	0.311
19	1.654	1.221	1.073	1.347	1.593	0.187	1.093	0.325	1.093	0.303
20	1.665	1.256	1.102	1.395	1.652	0.217	1.131	0.324	1.131	0.294

South's Economy

index		s_Xd	s_Xs	s_Yd	s_Ys	s_Util	s_Tau	s_Polln	s_MD	s_e	global Polln
1		0.526	0.526	0.501	0.501	-0.722	0.434	0.346	0.434	0.658	0.693
2		0.525	0.535	0.505	0.489	-0.722	0.442	0.35	0.442	0.654	0.693
3		0.523	0.544	0.508	0.478	-0.721	0.449	0.353	0.449	0.649	0.694
4		0.522	0.553	0.512	0.466	-0.721	0.456	0.357	0.456	0.645	0.695
5		0.521	0.562	0.516	0.455	-0.721	0.464	0.36	0.464	0.64	0.696
6		0.52	0.57	0.519	0.444	-0.72	0.471	0.363	0.471	0.636	0.697
7		0.519	0.578	0.523	0.433	-0.72	0.478	0.366	0.478	0.632	0.699
8		0.518	0.586	0.527	0.422	-0.719	0.485	0.369	0.485	0.629	0.7
9		0.517	0.594	0.53	0.412	-0.718	0.492	0.371	0.492	0.625	0.702
10		0.516	0.602	0.534	0.402	-0.718	0.499	0.374	0.499	0.622	0.703
11		0.516	0.609	0.537	0.391	-0.717	0.506	0.376	0.506	0.618	0.705
12		0.515	0.616	0.541	0.382	-0.716	0.512	0.379	0.512	0.615	0.707
13		0.514	0.623	0.544	0.372	-0.715	0.519	0.381	0.519	0.612	0.708
14		0.514	0.629	0.548	0.363	-0.714	0.525	0.383	0.525	0.609	0.71
15		0.513	0.636	0.551	0.353	-0.713	0.531	0.386	0.531	0.606	0.712
16		0.513	0.642	0.554	0.344	-0.712	0.537	0.388	0.537	0.604	0.713
17		0.512	0.648	0.558	0.335	-0.711	0.543	0.39	0.543	0.601	0.715
18		0.512	0.654	0.561	0.327	-0.71	0.549	0.392	0.549	0.599	0.717
19		0.511	0.66	0.564	0.318	-0.709	0.555	0.394	0.555	0.596	0.718
20		0.511	0.666	0.567	0.31	-0.708	0.561	0.395	0.561	0.594	0.72