What Are Impacts of Waste Treatment Option on Green Products' Prices by Sector?*

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Abstract: Closing the Green Gap is a necessary step if we are to create a sustainable society. Price is the number one reason of the green gap. To close the green gap, most of the existing literatures made their research from the respect of consumers. This study broke new ground by offering a choice criterion for producers to choose wastes treatment way with considering environmental costs and make full use of price advantage to close the green gap. A model was established to calculate price change rate of green products in 3 scenarios compared with their traditional price when environmental costs was not paid for. Applied the model in waste water treatment case in China, when all of 51 sectors took some actions to treat wastes, price change rates in 3 scenarios compared with their traditional prices in China in 2007 were calculated. The price increase rate of sector 12 (Chemicals) was the biggest. The number was 8.18% in scenario 1, 2.94% in scenario 2 and 4.46% in scenario 3. The producers were suggested to choose scenario 2 (pay charges for disposing waste water) to make production which could bring more price advantage for products. The model could help producers that offer green products strengthen their market positions and it could help policy makers that partly rely on markets to achieve sustainability objectives.

Keywords: Pricing; Green Products; Green Gap; Producers; Input-Output Analysis

1. Introduction

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Products which are produced without non-toxic chemicals or are recyclable, reusable, bio-degradable or having eco-friendly packaging and with low detrimental environmental impact at all stages of its life-cycle with the long term goal of preservation of natural environment are termed as green or environment friendly products (OECD, 2009). Green products often suffer a competitive disadvantage compared with mainstream products because they must cover ecological and social costs that their competitors leave to future generations (Olson, 2013; Paul Ingenbleek, 2015). From 1990s onwards, substantive researches have been undertaken to analyze consumers' buying behavior of green products (Davis, 1992; Ottaman, 1993). While we have been relatively good at getting people to believe in the importance of more sustainable behaviors, practices, and purchases, we have been unable to convert this belief fully into action. Figure 1calculated by comparing the percentage of consumers who stated that this green activity was very important or important to them to the percentage who stated they 'usually do' this activity—prove the point. Many research reports have also observed this phenomenon. For example, in its 2009 Green Brands Survey, Penn Schoen Berland found that 77% of Americans said they would like to consume in a more sustainable way, but their actions did not reflect these good intentions. An opinion survey by the Energy Savings Trust found that around 80% of the public believed that climate change was a major problem and wanted the government to let them know what they could do to save energy, but only 60% of the same sample was actually doing something to reduce their personal energy use. Similarly, an EcoPinon survey conducted by EcoAlign found 90% of Americans value energy efficiency but only 3% turn their PC off at night. This gap between stated importance and behavior or action is what OgilvyEarth called the Green Gap (Bennett and Williams, 2011). Closing the Green Gap is a necessary step if we are to create a sustainable society.

To close the green gap, most of the existing literatures made their research from the respect of consumers (Leire and Thidell, 2005; Gulbrandsen, 2006; D'Souza and Taghian, 2007; Rokka and Uusitalo, 2008; Thøgersen et al., 2010; Khare, 2015; Barbarossa and Pastore, 2015). For example, D'Souza and Taghian (2007) made examination of environmental beliefs and its impact on the influence of price, quality and demographic characteristics with respect to green purchase intention. Hughner et al. (2007) found that concerns regarding health, taste and price are often regarded as more important for the choice of green products than environmental concerns. Bennett and Williams (2011) found that price is the number one reason more Americans are not going green, 12 ways for consumers that will help close the green gap were suggested. Barbarossa and Pastore (2015) identified reasons why environmentally conscious consumers do not purchase green products. Biswas and Roy (2015) indicated that price sensitivity was high regardless of their choice preference in the developing nations of the East. Besides consumers, as the major force of commodity market, producers could also take some actions to close the green gap, especially in choosing their production way and pricing green products.

The wastes treatment during the process of green products production will increase the production cost and lead to the price difference between the green products and mainstream products which didn't pay for environmental costs. There usually have three scenarios in wastes treatment way. One is that the producers treat discharged wastes voluntarily during the production process (scenario 1). In this scenario, some costs like investment in infrastructure and equipment, operating costs *et al.* would be added to the producers. Another one is that the producers don't take any measure to waste treatment and they pay charges for disposing pollutants to the administration departments. The wastes would be treated centralized by some special institutes and the average treatment cost may be smaller than that of separate treatment by the producers (scenario 2). The third one is that some producers treated wastes voluntarily, some paid for discharged wastes (scenario 3). In these 3 scenarios, what's the difference between the prices of the green products and the mainstream products? Which treatment way has lower cost and makes the green products more competitive? With the input-output analysis method, this paper established a green price calculation model in the 3 scenarios. This study broke new ground by offering a choice criterion for producers to make production with considering environmental costs and make full use of price advantage to close the green gap. The framework could help producers that offer green products strengthen their market positions and policy makers that partly rely on markets to achieve sustainability objectives.

The following parts of the paper are organized as follows. Section 2 provides the model. Section 3 makes application. Section 4 gives conclusions.

2. Model

Assumed in one region the producers produced n kinds of products, m kinds of wastes were discharged. The framework of wastes discharge Input-Occupancy-Output (IOO) table was presented by Table 1.

Table 1. The framework of wastes discharge Input-Occupancy-Output (IOO) table

<table>
<tr><td colspan="2">Input \ output</td><td>Intermediate Demands</td><td>Final Demands</td><td>Total output</td></tr>
<tr><td rowspan="8">Input</td><td>Intermediate input</td><td>$Z_{n\times n}$</td><td>$Y_{n\times t}$</td><td>$X_{n\times 1}$</td></tr>
<tr><td rowspan="4">Primary input</td><td>$D_{1\times n}$</td><td></td><td></td></tr>
<tr><td>$W_{1\times n}$</td><td></td><td></td></tr>
<tr><td>$T_{1\times n}$</td><td></td><td></td></tr>
<tr><td>$S_{1\times n}$</td><td></td><td></td></tr>
<tr><td>Wastes treatment costs by producer</td><td>$C_{m\times n}$</td><td></td><td></td></tr>
<tr><td>Payments for discharged wastes</td><td>$P_{1\times n}$</td><td></td><td></td></tr>
<tr><td>Total input</td><td>$X_{1\times n}$</td><td></td><td></td></tr>
<tr><td>Occupancy</td><td>Volume of Discharged Wastes</td><td>$R_{m\times n}$</td><td></td><td></td></tr>
</table>

In Table 1, Z is intermediate inputs matrix, Y is final demand matrix, X is total output matrix, D denotes depreciation of fixed asset matrix, W denotes employees compensation matrix, T denotes the net taxes matrix, S denotes operating surplus matrix, C means the costs of wastes treatment, R means the volume of discharged wastes, P means payments for discharged wastes.

If no measures were taken to treat wastes, C=P =0 in Table 1. If all the producers treated wastes voluntarily (scenario 1), then P=0, C >0 in Table 1. If all the producers paid for discharged wastes (scenario 2), then P >0, C=0. If some producers treated wastes voluntarily, some paid for discharged wastes (scenario 3), then the corresponding vector of P_i >0 or C_i >0. With Table 1, equations to calculate price change rates of green products compared with mainstream products in three scenarios were as follows.

$$A_{ij}=Z_{ij}/X_j \quad (i=1,2\ldots n;\ j=1,2\ldots n) \tag{1}$$

$$DR_{ij}=R_{ij}/X_j \quad (i=1,2\ldots m;\ j=1,2\ldots n) \tag{2}$$

$$L = DR*(I-A)^{-1} \tag{3}$$

$$d_j = \frac{D_j}{X_j} \quad (j=1,2\ldots n) \tag{4}$$

$$w_j = \frac{W_j}{X_j} \quad (j=1,2\ldots n) \tag{5}$$

$$t_j = \frac{T_j}{X_j} \quad (j=1,2\ldots n) \tag{6}$$

$$s_j = \frac{S_j}{X_j} \quad (j=1,2\ldots n) \tag{7}$$

Where d_j means the depreciation of fixed asset of unit product j, w_j means the employees compensation of unit product j, t_j means the net taxes of unit product j, s_j means operating surplus of unit product j, c_j means the total cost of wastes treatment to produce unit product j. A is the direct consumption coefficient matrix, DR is the direct waste discharge coefficient matrix, L is the total waste discharge coefficient matrix, E is the coefficient matrix of the unit wastes treatment costs, EL_j means the total treatment cost to m kinds of wastes when produce unit product j. F is the coefficient matrix of wastes charges should be paid when unit of waste j was discharged. FL_j means the total charges should be paid to m kinds of discharged wastes when produce unit product j.

$$E_{ij} = \frac{C_{ij}}{R_{ij}} \quad (i=1,2\ldots m;\ j=1,2\ldots n) \tag{8}$$

$$EL_j = \sum_{i=1}^{m} E_{ij} * L_{ij} \quad (i=1,\ 2\ldots m;\ j=1,2\ldots n) \tag{9}$$

$$\Delta p_{1j} = \sum_{i=1}^{n} a_{ij} * \Delta p_{1i} + \Delta d_j + \Delta w_j + \Delta t_j + \Delta s_j + EL_j, (j = 1,2 \Lambda\ n) \quad \text{(in scenario 1)} \tag{10}$$

$$F_{ij} = \frac{P_{ij}}{R_{ij}} \quad (i=1,2\ldots m;\ j=1,2\ldots n) \tag{11}$$

$$FL_j = \sum_{i=1}^{m} F_{ij} * L_{ij} \quad (i=1,2\ldots m;\ j=1,2\ldots n) \tag{12}$$

$$\Delta p_{2j} = \sum_{i=1}^{n} a_{ij} * \Delta p_{2i} + \Delta d_j + \Delta w_j + \Delta t_j + \Delta s_j + FL_j, (j = 1,2 \Lambda\ n) \quad \text{(in scenario 2)} \tag{13}$$

$$\Delta p_{3j} = \sum_{i=1}^{n} a_{ij} * \Delta p_{3i} + \Delta d_j + \Delta w_j + \Delta t_j + \Delta s_j + \begin{cases} FL_j & \text{If } FL_j > 0 \\ EL_j & \text{If } EL_j > 0 \end{cases} (j = 1,2 \Lambda\ n) \quad \text{(in scenario 3)} \tag{14}$$

$$cr = \min\left(\sum_{j=1}^{n} \Delta p_{ij}\right) \quad (i=1,2,3) \tag{15}$$

In equation (15), cr is the criterion to determine the production way, it means if $cr = \sum_{j=1}^{n} \Delta p_{ij}$, the producer was suggested to choose scenario i to produce product j.

3. Application

The aquatic ecosystem has been severely damaged in many parts of China, threatening public health and economic development. To reduce pollutants, improve drinking water and promote water saving, the Action Plan for Water Pollution Prevention and Control intensifying the government fight against water pollution in China was released on 2015 April 16th. Targets for improvements by the end of 2020 include reducing the amount of severely polluted water and containing groundwater contamination. When producers implement this plan, there are three scenarios for the polluted water treatment in China as that in the model.

With the framework in Table 1, China waste water discharge Input-Occupancy-Output (IOO) table in 2007 was compiled. The sector classification of the IOO table was shown by Appendix 1. The compile method referred to Water conservancy economy input-occupancy-output table of China (Chen *et al*., 2002 and Liu *et al*., 2009). The input-output table of China in 2007 as a base was published by China Statistical Bureau. The treatment cost for polluted water was cited from Tan X *et al.* (2015). With the survey from 227 sewage treatment plants, the treatment cost for unit polluted water by producers was in the range 1.01-6.97 RMB/ton in China in 2012. The average was 2.73 RMB/Ton. In the surveyed regions, the centralized treatment cost for industrial waste water was in the range 0.4-2.5 RMB/ton in China in 2012. The average was 0.98 RMB/ton (Tan X *et al.*, 2015). From Environment Statistics Yearbook 2012, treatment cost for waste water of 42 industries was published, from which treatment cost of industrial waste water of sectors 1-25 in IOO table can be deduced.

Table 2. The value of EL_j and FL_j in 4 scenarios (Unit: RMB/ton)

	scenario 1	scenario 2	scenario 3	scenario 4
EL_j	2.73 (j=1, 2…51)	-	2.73 (j=1, 2…12)	a. Sourced from Environment Statistics Yearbook 2012 when j=1, 2…25 b. 2.73 when j=26, 27…51.
FL_j	-	0.98 (j=1, 2…51)	0.98 (j=13, 14…51)	

With the survey and published data, the value of EL_j and FL_j in 4 scenarios was assumed. With China waste water discharge Input-Occupancy-Output (IOO) table in 2007, applied equations (1)-(14), Δp_{ij}(i=1,2,3,4; j=1,2…51) could be calculated (Results see Table 3).

Table 3. Price change rates in 4 scenarios compared with their traditional prices

Sector Code	Δp_{1j}	Δp_{2j}	Δp_{3j}	Δp_{4j}	Sector Code	Δp_{1j}	Δp_{2j}	Δp_{3j}	Δp_{4j}
1	3.33%	1.20%	2.37%	3.39%	27	1.98%	0.71%	0.93%	2.06%
2	2.38%	0.85%	1.53%	2.21%	28	0.60%	0.21%	0.22%	0.60%
3	3.31%	1.19%	1.78%	4.01%	29	2.54%	0.91%	1.26%	2.75%
4	2.15%	0.77%	1.48%	1.53%	30	2.03%	0.73%	0.97%	2.18%
5	1.50%	0.54%	1.29%	1.27%	31	1.48%	0.53%	0.67%	1.55%
6	2.75%	0.99%	1.86%	2.70%	32	2.03%	0.73%	1.00%	2.21%
7	3.00%	1.08%	2.62%	2.86%	33	0.46%	0.17%	0.22%	0.49%
8	1.37%	0.49%	1.16%	1.20%	34	2.26%	0.81%	0.94%	2.35%
9	1.54%	0.55%	1.29%	1.84%	35	0.80%	0.29%	0.32%	0.81%
10	4.56%	1.64%	4.01%	5.65%	36	0.72%	0.26%	0.30%	0.74%
11	3.76%	1.35%	1.80%	4.52%	37	0.60%	0.22%	0.24%	0.62%
12	9.63%	3.46%	5.24%	10.50%	38	0.40%	0.14%	0.15%	0.41%
13	2.19%	0.79%	0.94%	1.79%	39	0.41%	0.15%	0.15%	0.41%
14	7.04%	2.53%	3.20%	7.44%	40	0.69%	0.25%	0.29%	0.70%
15	2.29%	0.82%	1.05%	2.90%	41	0.59%	0.21%	0.27%	0.61%
16	3.54%	1.27%	1.75%	3.80%	42	0.32%	0.11%	0.11%	0.32%
17	2.51%	0.90%	1.11%	2.85%	43	1.06%	0.38%	0.38%	1.06%
18	2.62%	0.94%	1.15%	3.58%	44	0.25%	0.09%	0.09%	0.25%
19	3.39%	1.22%	1.43%	4.55%	45	0.39%	0.14%	0.14%	0.39%
20	1.32%	0.48%	0.55%	1.46%	46	0.58%	0.21%	0.21%	0.58%
21	0.47%	0.17%	0.18%	0.43%	47	0.15%	0.06%	0.06%	0.16%
22	1.19%	0.43%	0.48%	2.49%	48	0.90%	0.32%	0.34%	0.91%
23	1.03%	0.37%	0.58%	1.24%	49	1.40%	0.50%	0.56%	1.47%
24	6.01%	2.16%	2.83%	7.64%	50	0.87%	0.31%	0.31%	0.87%
25	0.59%	0.21%	0.24%	1.00%	51	0.77%	0.28%	0.30%	0.77%
26	0.98%	0.35%	0.37%	0.99%					

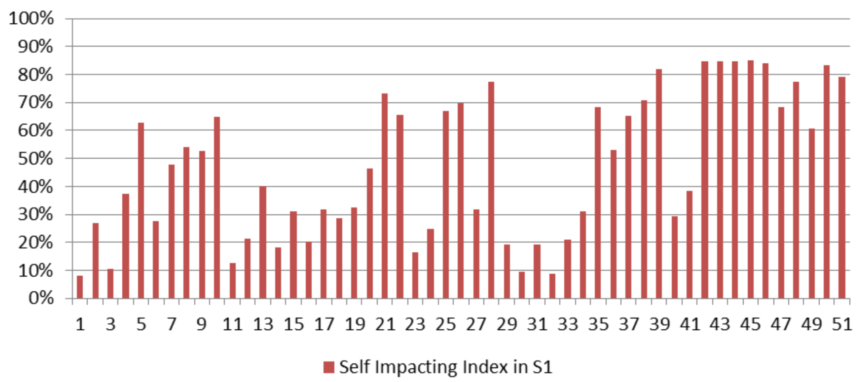
3.1 price change rates

From Table 3, one can find that the top 3 sectors of price change rates in 4 scenarios (See Table 4). The price increase rate of sector 12 was the biggest in 51 sectors. The number was 9.63% in scenario 1, 3.46% in scenario 2, 5.24% in scenario 3and 10.50% in scenario 4. Following with sector 14, sector 24 or sector 10.

Table 4. The top 3 sectors of price change rates in 4 scenarios

Scenarios	Top 1	Top 2	Top 3
scenario 1	Sector 12(9.63%)	Sector 14 (7.04%)	Sector 24 (6.01%)
scenario 2	Sector 12(3.46%)	Sector 14 (2.53%)	Sector 24 (2.16%)
scenario 3	Sector 12(5.24%)	Sector 10(4.01%)	Sector 14 (3.20%)
scenario 4	Sector 12(10.50%)	Sector 24(7.64%)	Sector 14 (7.44%)

3.2 Self-impacting or other impacting



Not only the wastes treatment costs of sector 12 but also the costs from other sectors contributed to its price increase. If only sector 12 treated the waste water individually, its price would increase 2.05% in scenario 1 and 0.74% in scenario 2, accounting for 25.1% and 25.2% of its price increase in each scenario respectively. It means that the waste treatment costs from other sectors mainly contributed to the price increase of sector 12. This is not the same for all the sectors. It can also be calculated that if only sector 10 treated the waste water individually, its price would increase 2.95% in scenario 1 and 1.06% in scenario 2, accounting for 76.2% and 76.3% of its price increase in each scenario respectively. This indicated that the waste treatment cost of sector 10 itself made the main contribution to its price increase.

Table 3 also showed that the price increase rate for each sector in scenario 2 was the smallest in 4 scenarios. The reason was $\mathrm{FL}_j \leq \mathrm{EL}_j$ (j=1,2…51) in 4 scenarios. And the results led to cr $=\sum_{j=1}^{51} \Delta p_{2j} = 0.35 = \min(0.99, 0.35, 0.53, 1.09)$, so the producer was suggested to choose scenario 2 to make production.

Scenario 1 and scenario 2 can be seen two special cases in scenario 3. Except them, there were (2^{51}-2) kinds of possible combination of waste water treatment way for 51 sectors in scenario 3. $\mathrm{EL}_j > \mathrm{FL}_j$ (j=1,2…51) led to cr $=\sum_{j=1}^{51} \Delta p_{2j}$.

4. Conclusions

This study broke new ground by offering a choice criterion for producers to make production with considering environmental costs and make full use of price advantage to close the green gap. A model to calculate price change rate of green products compared with their traditional price in 3 scenarios was established in the paper. And the criterion to determine production way was provided for producers. In the application, the price increased rates of 51 sectors in 3 scenarios were calculated. Compared among 51 sectors, the price increase rate of sector 12 (Petroleum processing and coking) was the biggest. The results showed that in 2012 situation in China, producers were suggested to pay charges for disposing pollutants which could bring more price advantage. The results also revealed that the waste treatment cost of one sector may be the main factor of its price increase, or may be the leading factor of other sectors' price increase. The highlight of the model is that it provided the criterion to determine production way for producers. The main advantage of the model is that it considered the indirect impacts of wastes treatment costs from other sectors on one sector's green price. With the detailed data of wastes treatment costs for each sector, the model can be a useful tool for producers to determine the price of the green products and choose the production way and make full use of price advantage which will be helpful to close the green gap.

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Appendix 1: Sector Classification of wastes discharge Input-Occupancy-Output (IOO) table

1 Agriculture (excluding freshwater fish farming and ecological forest)

2 Coal mining and processing

3 Crude petroleum and natural gas products

4 Metal ore mining

5 Non-ferrous mineral mining

6 Manufacture of food products and tobacco processing

7 Textiles

8 Clothing, leather, furs, down and related products

9 Sawmills and furniture

10 Paper and products, printing and recording medium production

11 Petroleum processing and coking

12 Chemicals

13 Nonmetal mineral products

14 Metal smelting and pressing

15 Metal products

16 Machinery and equipment

17 Transport equipment

18 Electric equipment and machinery

19 Electronic and telecommunications equipment

20 Instruments, meters, cultural and office machinery

21 Maintenance and repair of machine and equipment

22 Other manufacturing products

23 Scrap and waste

24 Electricity, steam, and hot-water production and supply (excluding hydroelectric power)

25 Gas production and supply

26 Construction (excluding water conservancy construction)

27 Freight transport and warehousing (excluding river freight transport)

28 Post and telecommunications

29 Wholesale and retail trade

30 Dining and drinking places

31 Passenger transport (excluding river passenger transport)

32 Finance and insurance

33 Real estate

34 Social services (excluding wastewater treatment)

35 Health services, sports, and social welfare

36 Education, culture and arts, radio, film, and television

37 Scientific research

38 General technical services (excluding management on water conservancy and water ecological environment protection non-construction)

39 Public administration and other sectors

40 Construction of flood and drought control

41 Management of flood and drought control

42 Construction of ecological water environment protection

43 Ecological water environment protection (non-construction)

44 Wastewater treatment

45 Construction of water supply and comprehensive use projects

46 Management of water supply and comprehensive use projects

47 Agriculture and rural household water supply

48 Urban and industrial water supply

49 Hydroelectric power

50 River transport

51 Freshwater fish farming