Inter-Industry Analysis, Consumption Structure, and the Household Production Structure

by

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ABSTRACT

The standard waste input-output models for single region and multi-regions do not endogenously treat the dependent relationship between income distribution (household consumption) and household waste generation. As in Miyazawa and Masegi (1963), I introduce the propagation process of income distribution and household waste generation into the extended input-output analysis and reveal the hidden money flow resulting from the household waste disposal behaviour.

From the empirical analysis, we find the endogenous income propagation effect resulting from the household waste treatments induced by unit household consumption (one million yen) was only a 220 yen and remarkably small, comparing with that for ordinary commodity productions (753 thousand yen).

We also find that the contribution of industrial and household waste treatment and recycling activities to the 1995 Japanese economy was about one trillion yen (0.1% of the gross domestic output), considering the endogenous income propagation effects induced by the consumption behaviour of labors engaging in the waste treatments.

Key words: Social accounting multipliers, municipal solid waste, industrial waste

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1. Introduction

Recalling the path-breaking approach in extended input-output multipliers by Miyazawa and Masegi (1960), I understand the dependency between income distribution (household consumption) and household waste production can be introduced into waste input-output analysis (see Batey and Rose (1990) for an overview of the extended input-output analysis and Nakamura and Kondo (2002) for the waste input-output analysis). The endogenous treatment enables us not only to more definitely account for intermediate inputs required for industrial waste and municipal solid waste (MSW) recycling (treatments) but also to describe household waste production structure relating to the household consumption structure. Especially, the latter is crucial in measuring inter-industry effects of MSW generated by the household consumption and in examining the relationship between household (employment) types and waste generations.

Quoting the Model (regional social accounting system) illustrated by Batey and Rose (1990, p. 31), I extend the Model to the input-output model with goods and bads. Figure 1 shows that not only intensive and extensive households gain an income from value added and spend the money on consuming goods and services such as foods, clothes, refrigerator, healthcare, and so forth, but also the production activities and the household consumption activities directly and indirectly induce the industrial wastes such as scrap plastics and scrap irons and the municipal solid wastes such as food wastes, cloth wastes, and refrigerator residue, respectively throughout the entire inter-industry transactions (see the dotted line of Figure 1). The waste recycling (treatment) activities reproduce not only commodities from the wastes but also provide employment opportunities. The regional waste managements consequently benefit regional economies by providing the waste disposal service, producing final and intermediate products from the wastes, and saving production cost through material and thermal recycling.

In this paper, I introduce the propagation process of income distribution and household waste generation into the waste input-output analysis and show the advantage of our model, performing the empirical analysis. Consequently, I succeed in decomposing the standard multi-sector income multiplier into the household expenditure-related income multiplier and the household waste-related income multiplier and measuring them.

The present paper is organized as follows: following the introduction, section 2 formulates the model, section 3 provides the empirical analysis, and finally section 4 is the conclusion.

Figure 1 here
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2. The Model

In what follows, I will formulate the dependent relationship between the income distribution and the waste generations.

The standard *extended* input-output framework for a single region (country) can be written as:

$$\begin{bmatrix} \mathbf{f} \\ \mathbf{y} \end{bmatrix} = \begin{bmatrix} \mathbf{I}_n - \mathbf{A} & -\mathbf{h} \\ -\mathbf{l} & \mathbf{I}_k \end{bmatrix} \begin{bmatrix} \mathbf{q} \\ \mathbf{g} \end{bmatrix} \tag{1}$$

where $\mathbf{A} = \{a_{ij}\}$ is the technical coefficient matrix with dimension *n* of the number of commodities; $\mathbf{h} = \{h_{ij}\}$ is the consumption coefficient matrix representing the consumption of commodity *i* per unit of total income of household type *j*; $\mathbf{l} = \{l_{ij}\}$ is the income coefficient matrix representing household type *i*-related labor compensation per unit of gross output of commodity *j*; $\mathbf{q} = \{q_i\}$ is the gross commodity output vector; $\mathbf{g} = \{g_i\}$ is the total household income vector; $\mathbf{f} = \{f_i\}$ is the net commodity output vector; $\mathbf{y} = \{y_i\}$ is the exogenous household income vector; $\mathbf{I}_n$ is the ($n \times n$) identity matrix and $\mathbf{I}_k$ is the ($k \times k$) identity matrix where *k* denotes the number of household types.

As in Madden and Batey (1983) and Batey, Madden and Weeks (1987), social accounting multipliers from equation (1) are very useful in quantitatively capturing the static and dynamic economic-demographic link. I further propose the economic-demographic-environment link, focusing on the industrial and household waste flow. Recalling the well-known Nakamura-Kondo scheme

(2002) and further defining the waste allocation matrices for industrial and household waste as $\mathbf{S}_w$ and $\mathbf{S}_m$, respectively, equation (1) can be extended into

$$\begin{bmatrix} \mathbf{f}_c \\ \mathbf{f}_w \\ \mathbf{y} \end{bmatrix} = \begin{bmatrix} \mathbf{I}_l - \mathbf{A}_{cc} & -\mathbf{A}_{cw} & -\mathbf{h}_c \\ -\mathbf{S}_w\mathbf{A}_{wc} & \mathbf{I}_m - \mathbf{S}_w\mathbf{A}_{ww} & -\mathbf{S}_h\mathbf{h}_w \\ -\mathbf{l}_c & -\mathbf{l}_w & \mathbf{I}_k \end{bmatrix} \begin{bmatrix} \mathbf{q}_c \\ \mathbf{q}_w \\ \mathbf{g} \end{bmatrix} \tag{2}$$

where $\mathbf{A}_{cc} = \{(a_{cc})_{ij}\}$ is the $(l \times l)$ technical coefficient sub-matrix showing the intermediate input of commodity *i* per unit of gross output of commodity *j*; $\mathbf{A}_{cw} = \{(a_{cw})_{ij}\}$ is the $(l \times m)$ technical coefficient sub-matrix showing the intermediate input of commodity *i* per unit of waste intermediately disposed of by waste treatment *j*; $\mathbf{A}_{wc} = \{(a_{wc})_{ij}\}$ is the $(o \times l)$ industrial waste generation coefficient matrix showing the output of industrial waste *i* per unit of gross output of commodity *j*; $\mathbf{A}_{ww} = \{(a_{ww})_{ij}\}$ is the $(o \times m)$ residual coefficient matrix showing the residual of waste *i* per unit of waste intermediately disposed of by waste treatment *j*; $\mathbf{S}_w = \{(S_w)_{ij}\}$ is the $(m \times o)$ non-negative rectangular allocation matrix representing the share of industrial waste *j* disposed of by the waste treatment *i*; $\mathbf{h}_c = \{(h_c)_{ij}\}$ corresponds to $\mathbf{h}$ of equation (1) mentioned above; $\mathbf{h}_w = \{(h_w)_{ij}\}$ is the $(p \times h)$ household waste generation coefficient matrix showing the output of household waste *i* per unit of total consumption of household type *j*; and $\mathbf{S}_h = \{(S_h)_{ij}\}$ is the $(m \times p)$ non-negative rectangular allocation matrix representing the share of household waste *j* disposed of by the waste treatment *i*. Given the exogenous commodity final demand vector $\mathbf{f}_c$, exogenous waste generation vector representing the release to the environment $\mathbf{f}_w$ and the total household income vector, the total commodity production vector $\mathbf{q}_c$, then the total waste treatment activity vector and the total household income vector can be determined by equation (2). It should be noted that *m*, *o*, and *p* are the numbers of waste treatment techniques, industrial waste, and household waste, respectively.

If the jointly-generated industrial and household wastes are completely disposed by the available waste treatment techniques and the exogenous household income is neglected and it hold $\mathbf{f}_w = \mathbf{0}$ and $\mathbf{y} = \mathbf{0}$ where $\mathbf{0}$ is the appropriate zero vector, the following two relationships can be obtained from equation (2).

$$\mathbf{q}_c = (\mathbf{I}_l - \mathbf{A}_{cc} - \mathbf{h}_c \mathbf{l}_c)^{-1} \mathbf{f}_c + (\mathbf{I}_l - \mathbf{A}_{cc} - \mathbf{h}_c \mathbf{l}_c)^{-1} (\mathbf{A}_{cw} + \mathbf{h}_c \mathbf{l}_w) \mathbf{q}_w \tag{3}$$

$$\mathbf{q}_w = (\mathbf{I}_m - \mathbf{S}_w \mathbf{A}_{ww} - \mathbf{S}_h \mathbf{h}_w \mathbf{l}_w)^{-1} (\mathbf{S}_w \mathbf{A}_{wc} + \mathbf{S}_h \mathbf{h}_w \mathbf{l}_c) \mathbf{q}_c \tag{4}$$

The proof is straightforward. Furthermore, defining the Miyazawa internal matrix multipliers for goods and bads as $\mathbf{B}_c = (\mathbf{I}_l - \mathbf{A}_{cc})^{-1}$ and $\mathbf{B}_w = (\mathbf{I}_m - \mathbf{S}_w \mathbf{A}_{ww})^{-1}$, respectively, yield:

$$\mathbf{q}_c = \mathbf{B}_c(\mathbf{I}_l - \mathbf{h}_c\mathbf{l}_c\mathbf{B}_c)^{-1}\mathbf{f}_c + \mathbf{B}_c(\mathbf{I}_l - \mathbf{h}_c\mathbf{l}_c\mathbf{B}_c)^{-1}(\mathbf{A}_{cw} + \mathbf{h}_c\mathbf{l}_w)\mathbf{q}_w \tag{5}$$

$$\mathbf{q}_w = \mathbf{B}_w(\mathbf{I}_m - \mathbf{S}_h\mathbf{h}_w\mathbf{l}_w\mathbf{B}_w)^{-1}(\mathbf{S}_w\mathbf{A}_{wc} + \mathbf{S}_h\mathbf{h}_w\mathbf{l}_c)\mathbf{q}_c\,. \tag{6}$$

Interestingly, if the household expenditure-related income multiplier and the household waste-related income multiplier can be defined as $\mathbf{K}_c = (\mathbf{I}_k - \mathbf{L}_c)^{-1} = (\mathbf{I}_k - \mathbf{l}_c\mathbf{B}_c\mathbf{h}_c)^{-1}$ and $\mathbf{K}_w = (\mathbf{I}_m - \mathbf{L}_w)^{-1} = (\mathbf{I}_m - \mathbf{l}_w\mathbf{B}_w\mathbf{S}_h\mathbf{h}_w)^{-1}$, respectively, then we finally have:

$$\mathbf{q}_c = \mathbf{B}_c(\mathbf{I}_l + \mathbf{h}_c\mathbf{K}_c\mathbf{l}_c\mathbf{B}_c)\mathbf{f}_c + \mathbf{B}_c(\mathbf{I}_l + \mathbf{h}_c\mathbf{K}_c\mathbf{l}_c\mathbf{B}_c)(\mathbf{A}_{cw} + \mathbf{h}_c\mathbf{l}_w)\mathbf{q}_w \tag{7}$$

$$\mathbf{q}_w = \mathbf{B}_w(\mathbf{I}_m + \mathbf{S}_h\mathbf{h}_w\mathbf{K}_w\mathbf{l}_w\mathbf{B}_w)(\mathbf{S}_w\mathbf{A}_{wc} + \mathbf{S}_h\mathbf{h}_w\mathbf{l}_c)\mathbf{q}_c\,. \tag{8}$$

The propagation mechanism is more complicated than that of the standard multi-sector income multiplier developed by Miyazawa and Masegi (1963). The commodity final demand impulse stimulates commodity productions through the inter-industry transactions $\mathbf{B}_c\mathbf{f}_c$ and the propagations resulting from each household types consumption expenditures $\mathbf{B}_c\mathbf{h}_c\mathbf{K}_c\mathbf{l}_c\mathbf{B}_c\mathbf{f}_c$. The initial total impact $\mathbf{q}_c^{(0)} \equiv \mathbf{B}_c\mathbf{f}_c + \mathbf{B}_c\mathbf{h}_c\mathbf{K}_c\mathbf{l}_c\mathbf{B}_c\mathbf{f}_c$ subsequently affects waste treatments through the four propagation processes from equation (8) (see (i), (ii), (iii) and (iv) of Figure 2). The accumulated waste treatment levels further stimulate commodity productions through the inter-industry transactions and the income propagations induced by the *intermediate inputs for the waste treatment activities* $\mathbf{B}_c\mathbf{A}_{cw}\mathbf{q}_w^{(0)} + \mathbf{B}_c\mathbf{h}_c\mathbf{K}_c\mathbf{l}_c\mathbf{B}_c\mathbf{A}_{cw}\mathbf{q}_w^{(0)}$ and induced by the *consumption expenditures of labors engaging in the industrial and household waste treatment activities* $\mathbf{B}_c\mathbf{h}_c\mathbf{l}_w\mathbf{q}_w^{(0)} + \mathbf{B}_c\mathbf{h}_c\mathbf{K}_c\mathbf{l}_c\mathbf{B}_c\mathbf{h}_c\mathbf{l}_w\mathbf{q}_w^{(0)}$ from equation (7) (see (v), (vi), (vii) and (viii) of Figure 2). Then, the first-round commodity production vector $\mathbf{q}_c^{(0)}$ changes (increases) into a second-round commodity production vector $\mathbf{q}_c^{(1)}$. The second-round commodity production vector again leads to a second-round accumulated waste treatment vector $\mathbf{q}_w^{(1)}$. In this way, the recursive propagation processes continue, until the commodity production levels and the waste treatment levels converge to equilibrium values. If the number of the finite recursive processes is *r*, the processes can be described as follows.

Figure 2 here

Substituting equation (8) into the second term on the right-hand side of equation (7) yield the equilibrium production activity levels and substituting the solution into equation (8) reads to the equilibrium waste treatment levels.

3. An Application to the 1995 Japanese Economy

3.1. Data construction

For the empirical analysis, I constructed the 1995 extended input-output table. Basically, the table was made by aggregating the 1995 nine regions waste input-output table estimated by Kagawa et al. (2004). By doing so, the four sub-matrices $\mathbf{A}_{cc}$, $\mathbf{A}_{cw}$, $\mathbf{S}_w\mathbf{A}_{wc}$, and $\mathbf{S}_w\mathbf{A}_{ww}$ can be directly obtained from the aggregations. Furthermore, the household consumption expenditure coefficient vector $\mathbf{h}_c$ and the labor income coefficient vector for commodity productions $\mathbf{l}_c$ can also be obtained by dividing household consumption expenditure of each commodity from the aggregated table by total disposable income and by dividing labor income for each commodity production by gross commodity output in question, respectively. The troublesome problem is to estimate the labor income coefficient vector for waste treatment activities $\mathbf{l}_w$, household waste generation coefficient vector $\mathbf{h}_w$ and its allocation matrix $\mathbf{S}_h$, because we have to arrange enormous treatment data from waste surveys.

In order to estimate labor income coefficient vector for waste treatment activities, firstly I set the *average* number of labors engaging in a representative waste treatment plant, using the relevant waste treatment data. The present study focused on the waste treatment sectors as Incineration (J43); Dehydration (J44); Sun-drying (J45); Machine-drying (J46); Oil-water separation (J47); Waste fluid-neutralizing (J48); Waste-shredding (J49); Waste-compressing (J50);

Waste-separating and classifying (J51); Waste-melting (J52); Waste-cutting (J53); Waste-composting (J54); Waste landfill (J55); and, Other waste treatments (J56). Secondly, I estimated the number of labors engaging in the industrial waste treatment activity in question by multiplying the *average* number of labors per a waste treatment plan by the actual number of the industrial waste treatment plants in Japan. Finally, the labor income for each industrial waste treatment activity was estimated by multiplying the number of labors engaging in the industrial waste treatment activity by average wage considering the number of days worked from the other waste treatment reports. For the municipal solid waste treatment activities, since the number of labors engaging in the MSW treatment activities can be obtained from the regular survey report on the MSW treatments provided by Ministry of the Environment of Japan, we used the data and estimated by multiplying the number of labors engaging in the MSW treatment activity by average wage considering the number of days worked in the same way.

Table 1 and 2 show the results for the industrial and household waste treatment activities estimated by the procedure. I estimated the total labor income for the industrial and household waste treatment activities as about 246 (billion yen) (149 billion yen for total income of the industrial waste treatments and 97 billion yen for total income of the household waste treatments). For the industrial waste treatments, the waste-shredding activity show the highest labor income of 28 billion yen, the dehydration activity and the incineration activity show subsequently show the high values, 23 billion yen and 9 billion yen, respectively. On the other hand, the household waste largely depends on the incineration activity at least in 1995 and consequently remarkable contributes to the labor income (72 billion yen) of the incineration activity.

The household waste generation vector and the allocation matrix were basically made by the regular survey report on the MSW treatments and the other reports. The industrial and household waste sectors were defined as shown in Tables A1 of Appendix A and the above-mentioned 14 waste treatments by 21 wastes allocation matrix for Japan was consequently generated (see Appendix B for the allocation patterns of the industrial and household waste). It should be noted that we referred to the report on the MSW composition and defined the household waste sectors by meeting definitions of the industrial wastes. The present study focused on 41 commodity sectors shown in Tables A2.

The next section presents the major findings.

Table 1 here

Table 2 here

3.2. Empirical findings

As I formulated in section 2, the actual economic system with goods and bads is complicated more than we have imagined. Although the standard input-output table considers waste treatment service sectors and records intermediate inputs for the waste treatment activities, value added and final demand for the treatment services in monetary base, the information at least in Japan is not so useful in discussing the waste management problem, because not only the sectoral definitions are very rough but also the physical amount of waste flowing to waste treatment processes and disposed there are unclear. More concretely, the 1995 Japanese input-output table treats only two waste treatment service sectors (public and private). From this table, we cannot know how much is the contribution of waste treatment and recycling activity in question to gross domestic product, national income, and environment in a modern material-cycle society.

Using our framework, we can estimate the contribution of the waste treatment and recycling activities resulting from the commodity final demand impulse. Table 3 shows the result estimated by applying to the 1995 Japanese extended input-output table. The result shows that the commodity final demand impulse of 270.4 trillion yen *indirectly* led to the inter-industry transaction effect for commodity productions of 230.0 trillion yen and the endogenous income propagation effect relating to the inter-industry transaction of 441.0 trillion yen (see second and third row of Table 3). The final demand impulse *totally* stimulated the commodity production of 671.0 trillion yen (see the sub-total).

Our analysis further reveals that the inter-industry transactions for the commodity productions contributed to the increases in the domestic outputs through the waste treatment and recycling processes of industrial and household waste jointly produced by firm's production behaviour and household consumption behaviour. Considering each commodity output multiplier developed in section 2, we can understand the strength of a structural path between the waste treatment activities and commodity production activities. The indirect inter-industry transaction effect and the endogenous income propagation effect resulting from the *intermediate goods productions for waste treatments*, which correspond to commodity output multiplier type (v) and (vi), were 0.27 and 0.26, respectively, while the endogenous income propagation effect resulting from the *labor compensations for waste treatments* was totally 0.46, which corresponds to commodity output multiplier type (vii) plus (viii).

In particular, the three production activities of transportation, manufacturing, and electricity and heat supply sector remarkably contributed to the multiplier (v) through the indirect intermediate goods productions for the waste treatment activities, while commerce, real estate, and service sector largely affected the multipliers (vi), (vii) and (viii) through the direct consumption behaviour of labors engaging in the waste treatments and engaging in the intermediate goods productions for the waste treatment activities (see Figure 3). It especially shows that the transportation activity for the waste treatments indirectly raised domestic output by 0.17 trillion yen and played a key role in the sound material-cycle economy of Japan.

The two cores of our commodity output multipliers are the income multipliers $\mathbf{K}_c = (\mathbf{I}_k - \mathbf{L}_c)^{-1}$ and $\mathbf{K}_w = (\mathbf{I}_m - \mathbf{L}_w)^{-1}$. In the present study, since we deal with one household sector and disposable income for the household sector, the income propagation effects can be estimated as $K_c = (1 - L_c)^{-1}$ and $K_w = (1 - L_w)^{-1}$ where the italic variables represent scalar values. These values structurally affect the commodity productions and the waste treatments. I finally show the estimated values and explain about its structural importance in our formulation. Recalling the two formulations, $L_c = \mathbf{l}_c\mathbf{B}_c\mathbf{h}_c$ and $L_w = \mathbf{l}_w\mathbf{B}_w\mathbf{S}_h\mathbf{h}_w$, the values can be estimated as 0.42960 and 0.00022, respectively and the income propagation effects can be estimated as $K_c = (1 - 0.42960)^{-1} = 1.75316$ and $K_w = (1 - 0.00022)^{-1} = 1.00022$. The former implies that a household sector received 753 thousand yen through the endogenous income propagation induced by the household commodity consumption of one million yen, while the latter indicates that a household sector received only 220 yen through the waste treatment activities for the household waste jointly produced by the unit household consumption. Multiplying the 1995 total disposable income of Japan 259 trillion yen by 0.00022, we can estimate the *pure* endogenous income propagation effect as 56,914 million yen. Although it can be understood that the endogenous income propagation for the household waste treatment activities is very small, comparing with the ordinary commodity production activities, we find that the contribution of industrial and household waste treatment and recycling activities to the 1995 gross output was *totally* about one trillion yen (0.1% of the gross domestic output), considering the endogenous income propagation effects induced by the consumption behaviour of labors engaging in the industrial and household waste treatments (see Figure 5 for the detailed inter-industry propagation effects). We can further estimate income redistribution effects by multiplying the total gross output effects by sectoral income coefficients. Figure 4 shows that the total income redistribution effect was 0.28 trillion yen. From Tables 2 and 3, it should be noted that the direct labor compensation relating to the intermediate treatment activities is 0.23 trillion yen.

The important thing is that even if the direct labor compensation was employed as an economic indicator representing the macro-economic impact of waste recycling market, this was only 45 percent of the total income distribution effect which amounts to 0.51 trillion yen at least in 1995. If the household income-consumption structure significantly affects waste allocation patterns and consequently brings about economic benefit and environmental loads, the proposed model would be very useful in empirically investigating the structural changes under Material Cycle Oriented Society.

4. Conclusion

The present paper contributes to modeling the waste input-output model considering the dependent relationship between income distribution (household consumption) and household waste generation. The model clarified the *hidden* money flow resulting from the household waste disposal behaviour. The empirical analysis reveals that the endogenous income propagation effect resulting from the household waste treatments induced by unit household consumption (one million yen) was only a 220 yen and remarkably small, comparing with that for ordinary commodity productions (753 thousand yen). We also find that the contribution of industrial and household waste treatment and recycling activities to the 1995 Japanese economy was about one trillion yen (0.1% of the gross domestic output), considering the endogenous income propagation effects induced by the consumption behaviour of labors engaging in the waste treatments.

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Figures

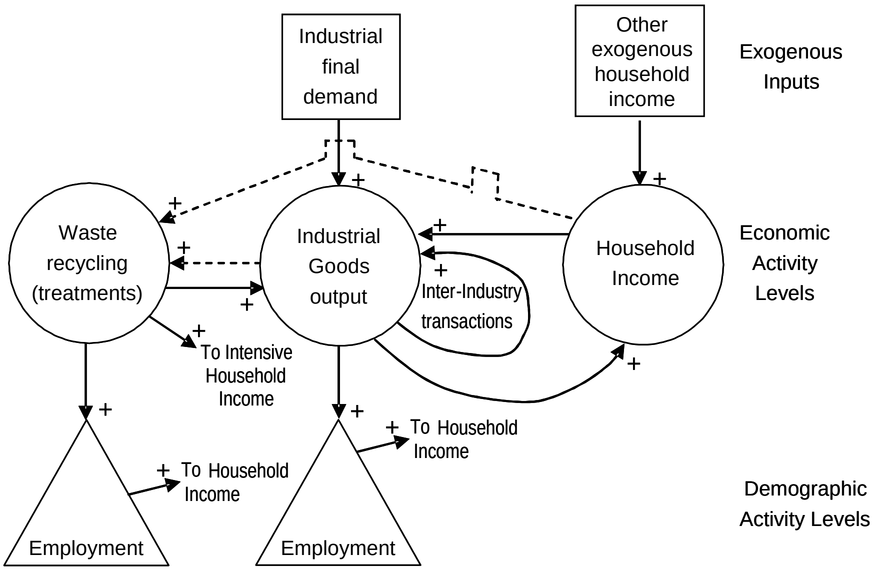
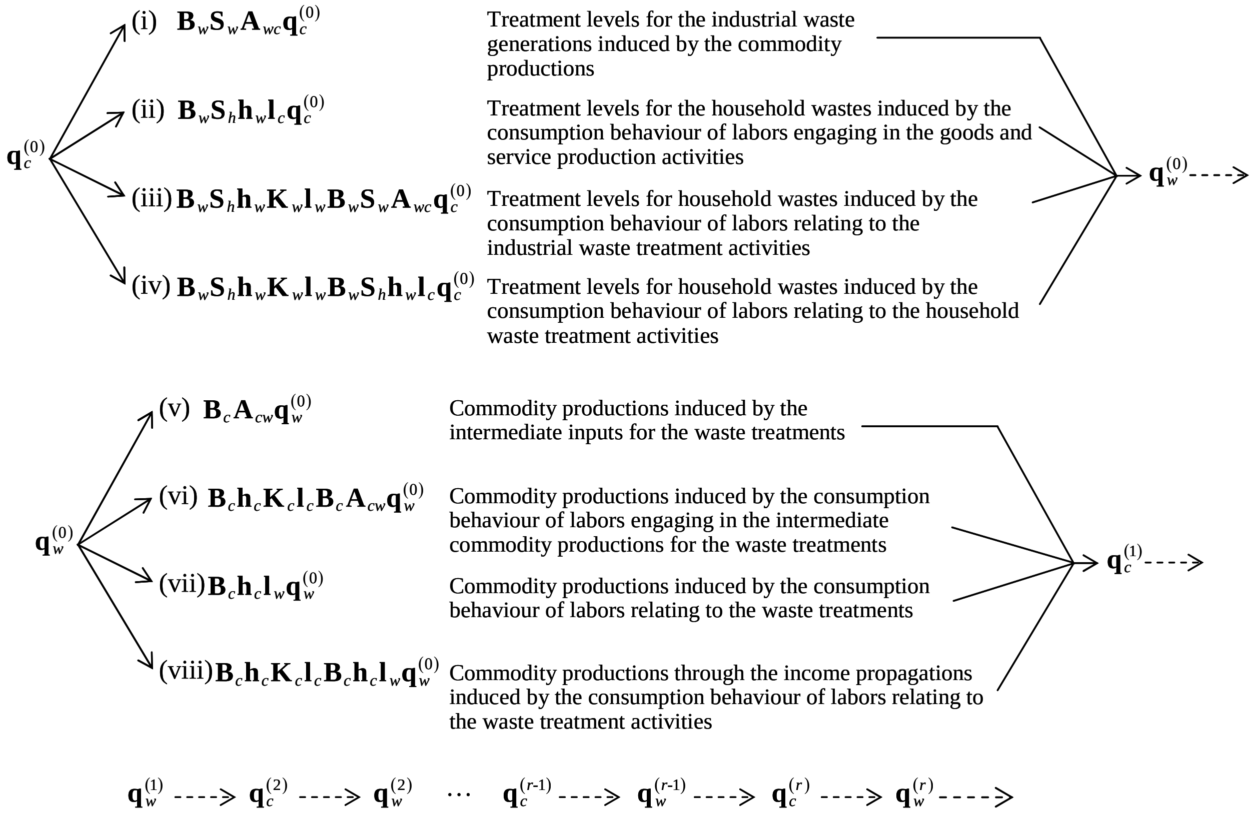


Figure 1. The proposed framework



Treatment levels for the industrial waste generations induced by the commodity productions

Treatment levels for the household wastes induced by the consumption behaviour of labors engaging in the goods and service production activities

Treatment levels for household wastes induced by the consumption behaviour of labors relating to the industrial waste treatment activities

Treatment levels for household wastes induced by the consumption behaviour of labors relating to the household waste treatment activities

Commodity productions induced by the intermediate inputs for the waste treatments

Commodity productions induced by the consumption behaviour of labors engaging in the intermediate commodity productions for the waste treatments

Commodity productions induced by the consumption behaviour of labors relating to the waste treatments

Commodity productions through the income propagations induced by the consumption behaviour of labors relating to the waste treatment activities

Figure 2. The propagation mechanism

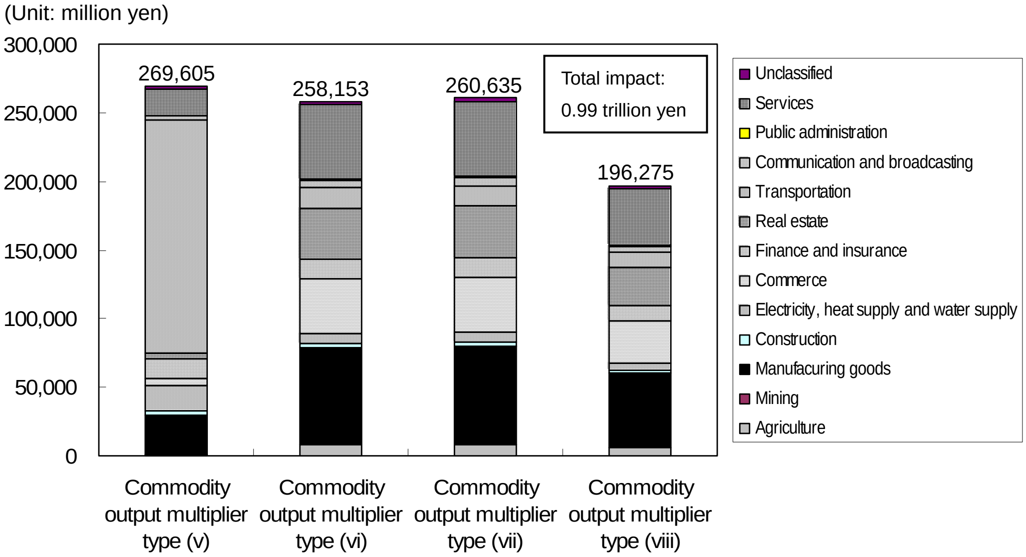


Figure 3. Commodity gross output multiplier effects

induced by the waste treatment activities

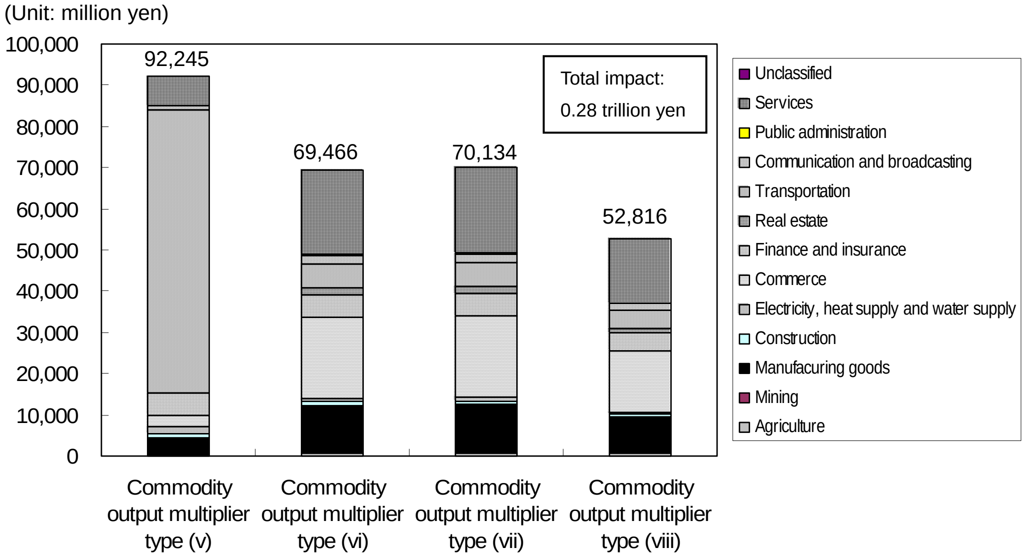


Figure 4. Sectoral income redistribution effects

induced by the waste treatment activities

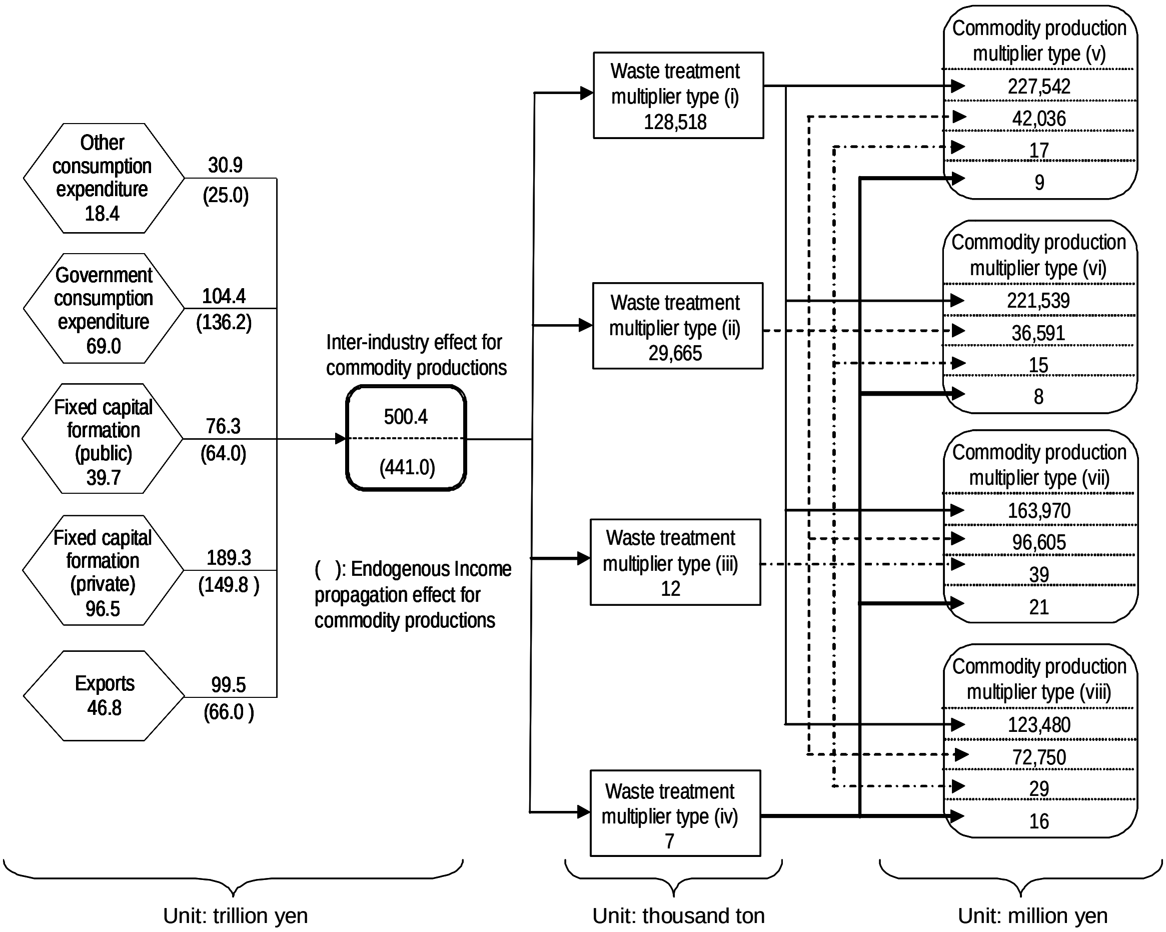


Figure 5. The inter-industry propagation effects

Tables

Table 1. 1996 labor income for the industrial waste treatment activities

	Number of days worked	Number of labors (persons)	Average wage (thousand yen)	Labor income (million yen)
Incineration	300	1,364	6,780	9,247
Dehydration	300	3,358	6,780	22,767
Sun-drying	200	8	4,520	38
Machine-drying	300	72	6,780	487
Oil-water separation	300	40	6,780	273
Waste-neutralizing	300	356	6,780	2,416
Waste-shredding	250	4,950	5,650	27,966
Waste-compressing	250	64	5,650	360
Waste-classifying	250	285	5,650	1,613
Waste-melting	300	30	6,780	203
Waste-cutting	250	15	5,650	82
Waste-composting	300	80	6,780	545
Other treatments	300	11,236	6,780	76,178
Waste landfill	300	972	6,780	6,590
Total	-	22,830	-	148,764

Note: According to the 1996 Establishment and Enterprise Census, the number of labors engaging in the industrial waste treatment industries is 57,005 (persons) and includes the number of labors engaging in the industrial waste collection service industry. Since we treat the collection service industry as a transportation industry in the present study, we excluded the labors engaging in the industrial waste collection service industry by assuming the percentage of them is 40%.

Table 2. 1996 labor income for the MSW treatment activities

	Number of days worked	Number of labors (persons)	Average wage (thousand yen)	Labor income (million yen)
Incineration	292	10,887	6,599	71,844
Dehydration	292	0	6,599	0
Sun-drying	292	0	6,599	0
Machine-drying	292	0	6,599	0
Oil-water separation	292	0	6,599	0
Waste-neutralizing	292	0	6,599	0
Waste-shredding	292	832	6,599	5,492
Waste-compressing	292	0	6,599	0
Waste-classifying	292	0	6,599	0
Waste-melting	292	0	6,599	0
Waste-cutting	292	0	6,599	0
Waste-composting	292	291	6,599	1,919
Other treatments	292	1,498	6,599	9,886
Waste landfill	292	1,158	6,599	7,643
Total	-	14,666	-	96,784

Note: According to the 1996 Establishment and Enterprise Census, the number of labors engaging in the MSW waste treatment industries is 106,546 (persons) and includes the number of labors engaging in the MSW collection service industry. Subtracting the number of labors engaging in the MSW waste treatment plants directly obtained from the regular survey report on the MSW treatments from 106,546, we can indirectly estimate the number of labors engaging in the MSW collection service industry as 106,546-14,666=91,880 (persons).

Table 3. Inter-industry multiplier effects by the final demand impulse (unit: trillion yen)

Commodity final demand impulse	270.40
Indirect inter-industry effect for commodity productions	230.00
Endogenous income propagation effect for commodity Productions	441.00
Sub-total	671.00
Indirect inter-industry effect resulting from intermediate goods productions for waste treatments (multiplier type (v))	0.27
Endogenous income propagation effect resulting from intermediate goods productions for waste treatments (multiplier type (vi))	0.26
Endogenous income propagation effect 1 for waste treatments (multiplier type (vii))	0.26
Endogenous income propagation effect 2 for waste treatments (multiplier type (viii))	0.20
Sub-total	0.99
Total	942.39

Appendix A.

Table A1. Waste classification codes

21 industrial wastes	59 industrial wastes
1. Incineration ash	1. Waste active carbon’waste carbon
	2. Unclassified incineration ash
2. Sludge	3. Sewerage sludge
	4. Other organic sludge
	5. Construction sludge
	6. Waterworks sludge
	7. Other inorganic sludge
3. Waste oil	8. Mineral oil
	9. Oils and fats of animals and plants
	10. Benzene
	11. Unclassified general waste fluid
	12. Waste solvents
	13. Solid oil
	14. Oil mud
	15. Clothes including oil
4. Acid waste fluid	16. Inorganic acid waste fluid
	17. Waste fluid from photographic fixing
	18. Corrosive waste fluid
	19. Strong acid waste fluid
5. Alkaline waste fluid	20. Alkaline waste fluid
	21. Developing solution of photograph
	22. Strong alkaline waste fluid
6. Waste plastics	23. Synthetic fiber
	24. Fiber reinforced plastic
	25. Plastics plasticized by high heat
	26. Resins reinforced high heat
	27. General scrap plastics
	28. Synthetic rubber
	29. Agricultural plastic wastes
	30. Waste tires
7. Waste papers	31. Waste papers
8. Wood chips	32. Wood chips
9. Waste fiber	33. Waste fiber
10. Waste residuals of animals and plants	34. Waste residuals of animals
	35. Waste residuals of plants
	36. Unclassified waste residuals of animals and plants
11. Waste rubber	37. Waste rubber
12. Waste metal	38. Waste metal
13. Waste glass and ceramics	39. Waste glasses
	40. Waste ceramics
	41. Plaster board
	42. Asbestos etc.
	43. Unclassified waste glass and ceramics
14. Slag	44. Waste sand
	45. Blast furnace slag
	46. Slag
	47. Unclassified slag
15. Construction wastes	48. Waste concrete
	49. Waste asphalt
	50. Other construction wastes
16. General waste particles	51. General waste particles
17. Dung and urine of animals	52. Dung and urine of animals
18. Infectious medical wastes	53. Infectious medical wastes
19. Solid concrete wastes	54. Solid concrete wastes
20. Others	55. Shredder dust
	56. Unclassified wastes
	57. Melting wastes
21. Cinders	58. Cinders

Table A2. Commodity classification codes (13 and 41 sectors)

41 commodity sectors	13 commodity sectors	41 commodity sectors	13 commodity sectors
1. Agriculture	1. Agriculture	22. Heavy electrical equipment	
2. Mining	2. Mining	23. Automobile	
3. Food and tobacco products	3. Manufacturing	24. Other transportation equipment	
4. Apparel and textile products		25. Precision instrument	
5. Lumber and wood products		26. Other manufacturing	
6. Furniture and fixtures		27. Construction	4. Construction
7. Pulp, paper and paper products		28. Electricity supply	5. Electricity, heat supply
8. Printing and publishing		29. Gas and heat supply	
9. Chemical and allied products		30. Wholesale and retail	6. Commerce
10. Petroleum and coal products		31. Financial service and insurance	7. Finance and insurance
11. Plastic products		32. Real estate	8. Real estate
12. Rubber products		33. Transportation service	9. Transportation
13. Leather and leather products		34. Communication and Broadcasting	10.Communication and Broadcasting
14. Stone, clay and glass products		35. Public administration	11. Public administration
15. Primary metal products		36. Education and research	12. Services
16. Nonferrous metal products		37. Medical service and social insurance	
17. Metal products		38. Other public service	
18. Industrial machinery and equipment		49. Service for business	
19. Office machines and machinery		40. Services for people	
20. Household electric appliance		41. Others	13. Others
21. Electric and communication equipment			

Appendix B.

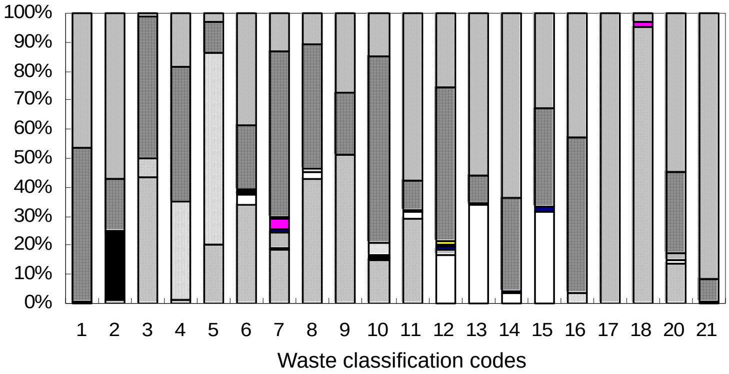


Figure B1. The allocation patterns of industrial waste

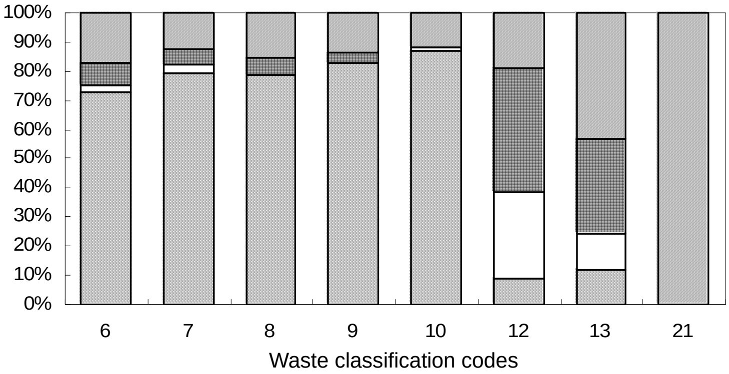


Figure B2. The allocation patterns of household waste