# The CO$_2$ Emission Score Table
# for the Compilation of Household Accounts[*]

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### Abstract

The household consumption is the activity which has the largest induced CO$_2$ emission in Japan. The household directly emitts only 9% of the total CO$_2$ emission from consuming energy in activities such as cooking, heating and driving a car. Therefore people don't recognize explicitly their responsibilities for CO$_2$ emission. It is for this purpose that we construct the CO$_2$ emission score table to porvide information on CO$_2$ contents in the purchases of goods and services. The score table shows the CO$_2$ emission for every 10thousand yen of expenditure it reveals that a large differences exist between the commodities consumed.

## 1. Introduction

The induced emission of CO$_2$ in Japan is estimated to reach approximately 1 billion ton (in CO$_2$ conversion) per annum in 1985. If this is divided by the total population, the induced CO$_2$ emission amounted to 8.3 tons per capita. Within which, direct emission from consumption activities is only about 750kg per capita, which is less than 9% of the total[1]. However, the CO$_2$ emissions from consumption activities depend not only on the individual's direct consumption of energy. For instance, let us consider the households purchase of gasoline to be used as fuel in automobiles. CO$_2$ is emitted not only from its use in automobiles, but also during the process when gasoline is transported from the oil refinery to the gasoline station by tanker.

Further, CO$_2$ is also emitted in operating the petroleum distillation tower in refining petroleum, or in the transportation of petroleum by tankers. All these emissions are induced from the household consumption of gasoline. In addition, while many goods do not emit CO$_2$ directly, CO$_2$ is nevertheless emitted from the production of these goods. Therefore, we need to include these derived CO$_2$ emissions in the estimation of induced CO$_2$ emissions from consumption activities. The input-output analysis is, in particular, effective in analyzing the above composite effects. The aim of this paper is thus to review the induced CO$_2$ emissions in the household consumption of various goods via input-output analysis.

Recently, with the increased awareness in environmental problems, discussions on issues such as how to save the earth's environment, or how should life styles be changed to solve the problem have attracted much attention. As a solution to the above issues,

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[1]Direct emission from household consumption activities refers to CO$_2$ emission induced from, for instance, the consumption of energy in cooking and heating facilities, and the use of gasoline in automobiles.

it is suggested that the present level of daily consumption should be constrained, and individuals should refrain from the use of say, automobiles or papers. However, as a broad range of changes in individual awareness is necessary, it is time consuming to implement these painful measures. Thus, what is urgently required at this moment is the information on how could the environment be preserved without sacrificing too much of the present standard of living. Moreover, these information need to be presented in concrete forms indicating the daily patterns of consumption.

This is similar to the concept of 'food calorie score table' prepared by doctors or nutritionists. For the prevention of adult diseases, individuals are required to pay attention to their intakes of food, controlling the level of calorie intakes, without lowering the necessary nutrition level. Similarly, it is thus useful to consider the preservation of the environment by considering the different combination of consumption goods which reduced $CO_2$ emissions, without reducing the present standard of living.

In recent years, there are movements promoting the purchase of goods which are 'friendly to the environment'. However, it is not clear how much of $CO_2$ is emitted by the various goods. Thus, we try to answer questions similar to the above through the construction of the $CO_2$ emission score table. Through the above table, we could obtain the knowledge on the actual level of induced $CO_2$ emission from our daily unconscious consumption of the various goods. From this, we could also obtain the important indicators which will help us to correct our daily consumption patterns.

## 2. Per Capita Induced $CO_2$ Emission from Household Consumption

Based on our estimations, the total induced $CO_2$ emission in Japan amounted to 1 billion ton in 1985[2]. Within which, direct emission from household consumption of energy consisted of 90 million tons or about 9% of the total. As it has been mentioned above, $CO_2$ is emitted not only from direct household consumption alone. $CO_2$ is emitted during the production and distribution processes of the various goods used in household consumption. Thus, we should reconsider the induced $CO_2$ emission by taking into account these indirect effects in the various production processes.

Figure 1 shows the induced $CO_2$ emission with the indirect effects taken into account. While the total induced $CO_2$ emission is 1 billion ton, we are able to know the share contributed by each final demand items from the figure. The induced $CO_2$ emission from household consumption amounted to 450 million ton or 44.9% of the total. The induced emissions from investment activities (private and public) amounted to 260 million ton (19.9%). Another 200 million ton (19.9%) is induced from exports. Therefore, it is clear that household consumption has the largest induced $CO_2$ emission.

Next, we shall look at the detailed $CO_2$ emission from household consumption activities in terms of different goods and different uses[3].

In this paper, the induced $CO_2$ emissions from different uses refer to the induced $CO_2$ emissions based on 8 expenditure items used in the national economy accounts of the

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[2] In $CO_2$ conversion value. This include $CO_2$ from fossil fuels, rubbish and coal. It does not include $CO_2$ emitted from plants and volcanoes, etc.

[3] Although the input-output tables include both domestic products and imports, for the calculation of induced $CO_2$ emission of imports in foreign countries, as information is not complete, we have to make various assumptions in our estimations. Assuming that the input coefficients are constant, we only estimate the amount of $CO_2$ emitted from imports in the importing country. We also assumed that all households consumption consisted of only domestic goods. Please refer to the Technical Appendix for calculation illustration.

Figure 1: CO$_2$ emission induced by each Final Demand Type(1985)

Figure 2: Induced CO$_2$ emission by Household Consumption per se(1985)

Table 1: $CO_2$ Emissions by Expenditure-Item

| SNA 8 Expenditure-items Classification | Induced $CO_2$ Emissions | | Consumption | |
|---|---|---|---|---|
| | kg/person | % | 10,000 yen/person | % |
| 1  Food, Beverge and Tabacco | 653.74 | 17 % | 34.38 | 22 % |
| 2  Cloths and Shoes | 216.18 | 6 % | 10.75 | 7 % |
| 3  Housing, Heating, Lighting and Water Supply | 1062.54 | 27 % | 27.90 | 18 % |
| 4  Furniture and House Instruments | 229.92 | 6 % | 7.73 | 5 % |
| 5  Medical and Health Care | 325.07 | 8 % | 18.21 | 12 % |
| 6  Transportation and Communication | 757.58 | 19 % | 16.32 | 11 % |
| 7  Recreation, Education and Cultural Service | 315.82 | 8 % | 17.25 | 11 % |
| 8  Others | 350.10 | 9 % | 22.08 | 14 % |
| Total | 3910.85 | 100 % | 154.61 | 100 % |

Unit : $CO_2$ kg/person  (1985)


Economic Planning Agency. Figure 2 thus shows the per capita induced $CO_2$ emission in consumption classified in 8 expenditure items[4].

Based on the results of our analysis, 3.9 tons of $CO_2$ is emitted in per capita consumption in 1985. As per capita consumption is 1.55 million yen, this amounted to approximately 25 kg of induced $CO_2$ emission for every 10 thousand yen of consumption.

Moreover, the detailed classifications showed that the highest $CO_2$ emission is contributed by the 3rd expenditure item (rent, water supply and utilities), 1,063kg or 27% of the total. The second largest is contributed by the 6th item (transport and communications), 758kg or 19% of the total. The first item (food, beverages and tobacco) is the third largest emitter of $CO_2$, accounting for 654kg or 16.7% of the total. The above 3 expenditure items thus accounted for slightly more than 60% of the total emission.

Table 1 compares these induced $CO_2$ emission with the values of household consumption. According to this table, it can be seen that in general, the 1st (food, beverages and tobacco) and the 3rd (rent, water supply and utilities) expenditure items which have high consumption expenditures, have also a high level of induced $CO_2$ emission. However, a closer examination reveals quite a different picture. Firstly, for the 3rd expenditure item (rent, water supply and utilities), while its induced $CO_2$ emission ranked the highest at 27%, its consumption expenditure ranked second, constituting 18% of the total expenditure. Moreover, for the 6th expenditure item (transport and communications), its induced $CO_2$ emission ranked second highest at 20%, while its consumption expenditure constituted only 11%, at the 6th position.

Further, it should be noted that for services related expenditures such as expenditure item 5, 7 and 8 which are also items with relatively high weights in consumption expenditure, they made up the items with relatively low level of induced $CO_2$ emission.

Next, we shall look at more detailed data based on commodity classification. Appendix

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[4] Consumption in 8 expenditure items refer to the values of the household consumption in the input-output table reclassified in 8 expenditure categories. The consumption converters used in the classification was developed by Prof. H. Sakuramoto of the Keio University. Further, the scrap output from the household consumption sector was not taken into account in the reclassification. Consequently, the aggregate consumption by expenditure items in this paper is larger than the expenditure aggregated under the SNA expenditure items.

1 at the end of this paper shows the induced CO$_2$ emission from the consumption activities of per population in 1985, illustrated in terms of the detailed commodity items included in each expenditure item. The column on induced emission from households indicates the direct induced CO$_2$ emission from the per capita consumption of the various goods. (Hence, only figures on commodities, such as kerosene and gasoline, which are combusted within households are included.) Further, the column on CO$_2$ emitted during the process of production and distribution shows the per capita emission resulted from production and distribution processes. Total induced emission is shown in the first column to the left.

Figure 2thus shows a summary of the commodity items with an annual emission of more than 15kg per person based on the data from Appendix 1. Our analysis shows that 654kg/person of CO$_2$ is emitted from the 1st expenditure item (food, beverages and tobacco). Within which, CO$_2$ emitted from the consumption of frozen fishes and shellfishes constituted the largest share, about 10%, followed by bread and confectionery, other foods (bean curd, cooked food, lunch box for take away and school meals), grain, sparkling and still beverages, vegetables, and slaughtering and meat processing, which together account for about half of the total induced emission from this expenditure item. However, the major commodities in the 1st expenditure item are commodities with relatively low induced CO$_2$ emissions, compared to commodities in the other expenditure groups.
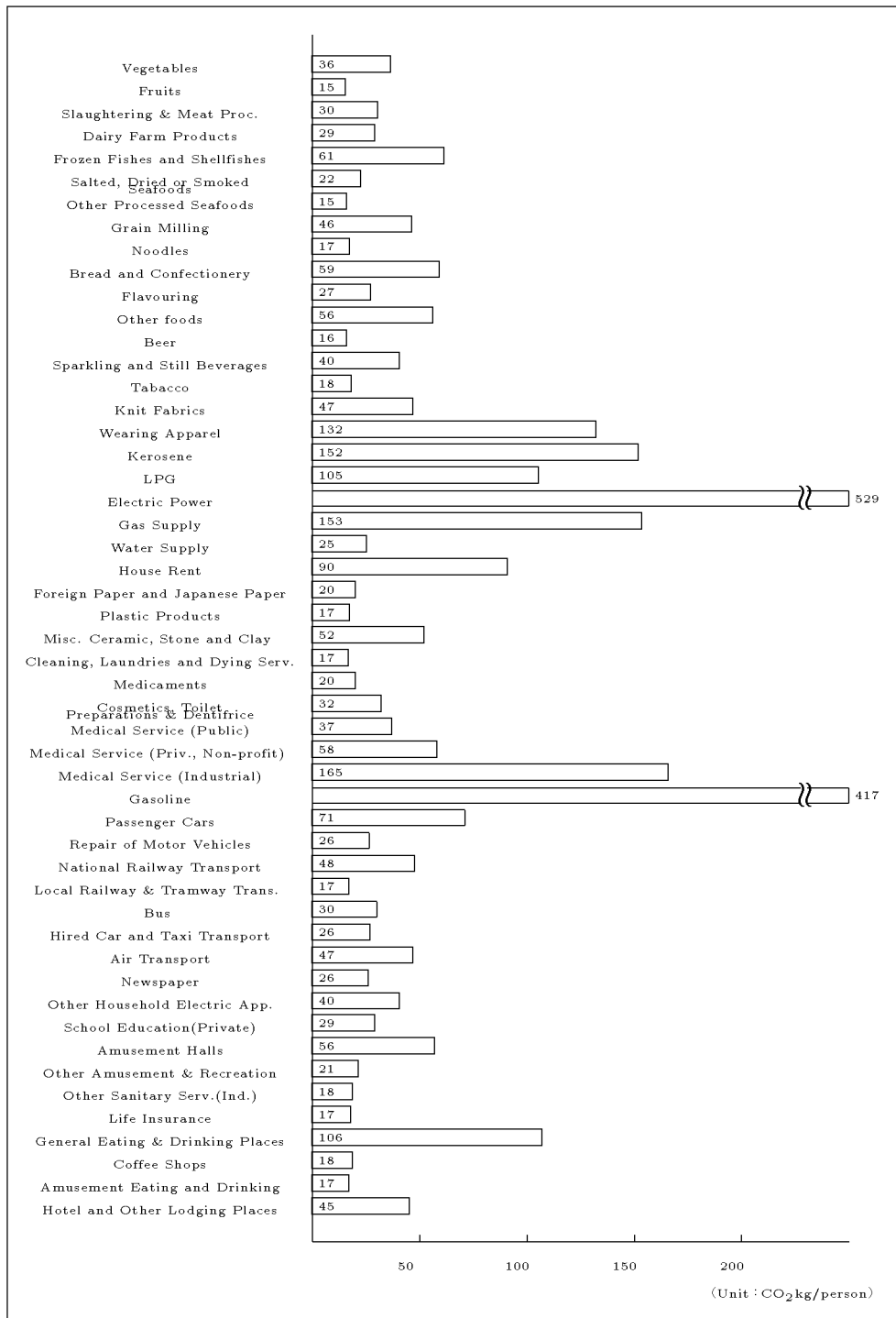
Next, the annual induced CO$_2$ emission from the 2nd expenditure item, wearing apparel and footwear, is 216 kg/person, the lowest within the 8 expenditure items. However, the induced emission from wearing apparel is relatively large at 132 kg/person, with the induced CO$_2$ emission from wearing apparel and knit fabrics accounting for slightly more than 80% of the total emission by this group.

The induced CO$_2$ emission from the 3rd expenditure item (rent, water supply, utilities) is 1,063 kg/person, the highest among the 8 expenditure items. Of which, the highest rate of induced emission comes from electric power, which amounted to 529.2 kg/person, constituting approximately 50% of the total from the 3rd expenditure item. Further, the goods in this group also have the highest induced emission per item, for instance, 151.6 kg from kerosene, 104.9 kg from LPG and 153.0 kg from gas supply. In sum, with the exception of water supply, this expenditure item consisted of mainly goods with high induced CO$_2$ emission.

As for the 4th expenditure item, the induced emission per capita is 230 kg, of which the induced emission from ceramic, stone and clay (e.g. enamel etc.), foreign paper and Japanese paper, plastic products, cleaning, laundries and dying services, and wooden furniture and accessories accounted for about half of the total emission from this expenditure item. As this expenditure item group consisted of many items, the remaining are emitted by the other items in the group. As shown in Section 3, the induced CO$_2$ emission from per unit (10 thousand yen) purchase are high for ceramics, stone and clay, and paper. However, it should be noted that as the weight of the above item in consumption is small, the per capita induced emission is not very high.

As for the induced CO$_2$ emission from the 5th expenditure item, it amounted to 325 kg per capita. Within which, about 80% come from the purchase of medical services. As reviewed in Section 3, the induced CO$_2$ emission from the medical industry is low at 15.5 kg per 10 thousand yen of output. Nevertheless, due to its high value in consumption, the induced CO$_2$ emission per capita from the medical industry reached 165.4 kg, the third highest among all the goods and services considered.

The 6th expenditure item (transport and communications) emitted 758 kg or 19.4% of the total CO$_2$ induced, the item with the third largest induced CO$_2$ emission among the 8 expenditure groups. The induced CO$_2$ emissions from this group include the CO$_2$ emitted

| Category | Value |
|---|---|
| Vegetables | 36 |
| Fruits | 15 |
| Slaughtering & Meat Proc. | 30 |
| Dairy Farm Products | 29 |
| Frozen Fishes and Shellfishes | 61 |
| Salted, Dried or Smoked Seafoods | 22 |
| Other Processed Seafoods | 15 |
| Grain Milling | 46 |
| Noodles | 17 |
| Bread and Confectionery | 59 |
| Flavouring | 27 |
| Other foods | 56 |
| Beer | 16 |
| Sparkling and Still Beverages | 40 |
| Tabacco | 18 |
| Knit Fabrics | 47 |
| Wearing Apparel | 132 |
| Kerosene | 152 |
| LPG | 105 |
| Electric Power | 529 |
| Gas Supply | 153 |
| Water Supply | 25 |
| House Rent | 90 |
| Foreign Paper and Japanese Paper | 20 |
| Plastic Products | 17 |
| Misc. Ceramic, Stone and Clay | 52 |
| Cleaning, Laundries and Dying Serv. | 17 |
| Medicaments | 20 |
| Cosmetics, Toilet Preparations & Dentifrice | 32 |
| Medical Service (Public) | 37 |
| Medical Service (Priv., Non-profit) | 58 |
| Medical Service (Industrial) | 165 |
| Gasoline | 417 |
| Passenger Cars | 71 |
| Repair of Motor Vehicles | 26 |
| National Railway Transport | 48 |
| Local Railway & Tramway Trans. | 17 |
| Bus | 30 |
| Hired Car and Taxi Transport | 26 |
| Air Transport | 47 |
| Newspaper | 26 |
| Other Household Electric App. | 40 |
| School Education(Private) | 29 |
| Amusement Halls | 56 |
| Other Amusement & Recreation | 21 |
| Other Sanitary Serv.(Ind.) | 18 |
| Life Insurance | 17 |
| General Eating & Drinking Places | 106 |
| Coffee Shops | 18 |
| Amusement Eating and Drinking | 17 |
| Hotel and Other Lodging Places | 45 |

(Unit : $CO_2$ kg/person)

Note : 1)Goods and services with $CO_2$ emissions greater than 15 kg/person.

Figure 3: $CO_2$ Emissions Per Capita in 1985

during the production of automobiles purchased by households and the $CO_2$ emitted from the combustion of gasoline used in these vehicles. As shown in Tables 2–2, 71 kg per capita of $CO_2$ is emitted from the production of the automobiles purchased by households, constituting about 10% of the total emission from the 6th expenditure item. However, it should be noted that the $CO_2$ emitted from moving the automobiles using gasoline reached 417 kg, about 6 times of that emitted during the production process. In other words, while the $CO_2$ emitted from the production process of automobile cannot be ignored, a far greater amount of $CO_2$ is, however, emitted from the combustion of fuel. Thus, while there is a tendency for us to consider the long term usage of durable goods as a way to save energy, it may be more important to us to aim for technological improvement which could raise the efficiency of energy combustion in durable goods such as automobile.

As for the 7th expenditure item (recreation, leisure, education and cultural services), per capita emission amounted to 316 kg (8.1%), with the largest emission contributed by game centers (e.g. pachinko parlour, etc.), amounting to 56 kg. Besides, the induced $CO_2$ emission from school education (private), 29 kg per capita, and newspaper, 26 kg per capita are also surprisingly high.

The 8th expenditure item (others) consisted largely of services, and the induced $CO_2$ emission amounted to 350 kg per capita or 8.9% of the total. Within which, the emission from general eating and drinking places (106 kg per capita) and hotel and other lodging places (45 kg per capita), are larger than the other items in the groups. On the other hand, the induced $CO_2$ emissions from the consumption of the other services are generally low at less than 10 kg per capita.

## 3. The $CO_2$ Emission Score Table for Household

For the consumers, the purchase and consumption of goods and services are, in general, carried out without considering the level of $CO_2$ induced. Thus, data showing the amount of induced $CO_2$ emitting from per 10 thousand yen of consumption will be useful to consumers. While some goods may not seems to be creating any negative effects on the environment, $CO_2$ is nevertheless emitted indirectly from these goods. As mentioned in the introduction of this paper, the induced $CO_2$ emission from per unit of final consumption could be estimated from our calculation. The calculation is based on the Input-output Table For Environmental Analysis and the latest 1989 Input-output Table (extension table).

First, we calculate the direct induced $CO_2$ emission from the production, distribution and consumption of per 10 thousand yen of jth good purchased in 1989[5]. Next, the induced $CO_2$ emission is recorded as $1kg = 1$ point in the score table. Tables 2–2 show the results classified by purpose and by commodity.

As shown in the Tables 2–2, the induced $CO_2$ emission from each household could be recorded just as expenditure by commodity are recorded in the household account book. Thus, summing the induced $CO_2$ emission by the various commodities gives the total induced $CO_2$ emission from consumption. Hence, by comparing these values with the per capita induced emission as shown in the previous section, households with higher than average induced emissions could thus set their targets for reducing $CO_2$ emissions. In such cases, households could thus increase or reduce the consumption of the various goods based on the level of induced $CO_2$ emission of each good indicated in the score table.

Table 2–2 summarized the results with the commodities classified by purpose. Thus the commodities with high emission scores, or in other words, those items which emit high

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[5] Please refer to the Technical Appendix for details of the method of calculation.

levels of $CO_2$ during consumption could be seen clearly from Table 2–2. In the following section, we review the level of induced $CO_2$ emission from each expenditure item based on Table 2–2.

Within the 1st expenditure item (food, beverages and tobacco), salt has the highest emission score of 253 points[6]. The next point worth taking note of is that, the scores for inland water culture[7], coastal fisheries and distant water fisheries (32.0–40.7 points) are high. On the contrary, slaughtering and meat processing is low at 17.7 points. Further, for agricultural commodities, the induced emission of vegetables is relatively high (17.5 points), while that of cereals, potatoes and sweet potatoes, fruits and pulses (in sequence) are low (16.5–13.4 points). In the case of alcohol, the emission score (25.6 points) of other liquor (e.g. wine) is higher than refined sake, beer, and whisky and brandy (13.5–15.2 points). On the other hand, it is surprising that the emission score for tobacco is the lowest in the group. However, the score for tobacco does not take into account the $CO_2$ emitted during smoking.

As for the 2nd expenditure item (wearing apparel and footwear), the emission score ranged between 10 to 30 points. The emission score for wearing apparel, which has a high per capita emission, is low at 19.4 points.

In contrast to the 1st and the 2nd expenditure items which consisted of goods with relatively low emission scores, the score of the goods in the 3rd expenditure group (rent, water supply and utilities) are more than 30 points, with the exception of only one item. In addition, the emission scores for energy related goods are all greater than 3 digits. In particular, the emission score for coal is high at 1,653 points. However, as very few households at present are using coal, the annual per capita emission is low at 1.3 kg, as shown in the previous section.

Next, for the 4th expenditure item (furniture, household appliances, and household miscellaneous fees), the emission scores for miscellaneous ceramic, stone and clay (277 points) and foreign paper and Japanese paper (112 points) are especially high. Further, the emission score as a whole for this expenditure group is raised considerably by the large number of heavy chemical products included. For instance, this consisted of ceramics products such as glass, chemical products such as dyes and adhesives, and metallic machinery products such as tools, plumber's supplies, and kitchen equipment.

The emission score for the 5th expenditure item (medical and insurance fees) is the lowest among the 8 groups considered. For medical services, which has a high per capita induced $CO_2$ emission, its emission score is around 20 points.

As for the 6th expenditure item (transport and communications), it should be noted that the score table shows not only the emission scores when the transport equipment (e.g. private cars, trucks, and two-wheeled automobiles, etc.) are purchased by households, but also the emission scores when these equipment are mobilized using light oil and volatile oil. The emission scores when transport services such as the railways and shipping vessels are utilized, are also shown in Table 2–2. It is shown that the emission scores of light oil and volatile oil are 300 points and 190 points, respectively. This is 9 to 15 times the emission from private cars and two-wheel automobiles (about 20 points). As for transport services, the emission scores are high for ocean transport (158 points) and air transport,

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[6] The reason for the high emission score for salt lies in the manufacturing method of salt. Slightly less than 20% of the total salt output is produced domestically by the distillation of sea-water, using the ion exchange membrane process. This method requires a large amount of electricity. The remaining 80% are manufactured by first dissolving and then the refining of imported crude salt. A large amount of heavy oil-B is needed. Hence, the salt producing industry is a high energy consuming chemical industry, resulting in the high emission score for salt.

[7] This refers to fish culture activities in inland sea water.

as compared to bus transport (30 points), hired car and taxi transport (21 points), and railway transport (JR) (41 points).

Within the 7th expenditure item (recreation, leisure and education expenses), combined and compound fertilizer ranked the highest with an emission score of 62 points. It is followed by paper products, inland water culture, other educational institutes (e.g. job training facilities) and publication (30-40 points). Emission scores are low (less than 8 points) for other amusement and recreation services (e.g. amusement halls, horse racing and car racing facilities, etc.), school education (central and private) and the activities of theatrical companies[8]. Finally, as for the 8th expenditure item (others), other sanitary services (public) has the highest emission score of 161.4 points within the group. Whereas the emission score for other sanitary services (private) is also relatively high at 59.4 points, it is only one-third of the emission from public sanitary services[9]. Further, the emission scores for sewage disposal (51 points) and public baths (44 points) are also high. The other services utilize by households, such as barber shops, beauty shops, finance and car rental, are low at less than 10 points. However, for the usage of volatile oil in car rental, the emission score should be obtained from the 6th expenditure item.

## 4. Conclusions

In the above sections, we have reviewed the induced $CO_2$ emission from households in 1985, based on data from the Input-output Table for environmental analysis. Further, we have also estimated the $CO_2$ emission score for every 10 thousand yen consumed in the household respectively (1 point= 1 $CO_2$ kg), using data from the 1989 Input-output Table (Extension Table). Firstly, we noted that for a similar 10 thousand yen of consumption, the $CO_2$ emission score varies greatly with the goods purchased. Thus for utilities such as electricity, gas and LPG, and goods classified under transportation fees such as light oil and gasoline, the emission scores are high at above 200 points. On the other hand, goods with an emission score of less than 10 points scattered among the 8 expenditure items. This shows that the $CO_2$ emission from household consumption could be reduced according to the types of consumption. Secondly, the analysis of detailed information has also lead to unexpected findings. For instance, the $CO_2$ emission score for salt and sugar respectively differ widely. Salt has an emission score of 253 points in contrast to 24 points for sugar. Similarly, a comparison between meat and fish shows that fish has a higher $CO_2$ emission score. Hence, these information are not only useful in improving the consumption behaviour of households, but they are also useful as indicators for producers in improving the efficiency in utilizing energy.

The induced $CO_2$ emission score table as reviewed in Section 3 is useful in the following ways. The consumers are able to calculate the total induced $CO_2$ emission score through entering the value of purchase of the various goods into the book-keeping account. Hence, individual could thus compare his own household emission with the average per capita

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[8] Care must be taken in interpreting this result. For instance, the emission score from private school education is 13 points, 2 times the emission score of central school education. This has to do with the fact that the expenditures of central schools are not borne totally by households but a substantial amount is borne by the government. However, we are still in the process of analyzing the factors leading to the above emission score results.

[9] The difference in the emission scores between private and public sanitary services highlights the problems in the sanitary service systems. In Japan, the expenditures incurred in the disposal of rubbish are borne by local self-governed bodies. It is only in exceptional cases that these are borne by households. Similar to the problem in school education, we are still working on the interpretation of the above results.

emission of 3.9t in 1985. Further, the comparison could also be carried for each expenditure item. For households which use private cars, $CO_2$ emission is likely to increase with emission from transportation and communications, and hence these data could be used to find out the possible compensating areas in household consumption. At present, information on $CO_2$ emission is based on household average. Thus future research need to focus on the effect of regional differences, household's average, and differences in income on induced $CO_2$ emission.

## 5.  Technical Appendix 1

The induced $CO_2$ emission from the per capita consumption expenditure by different commodities are estimated as follows

$$C^{FC_j} = \mathbf{E^{prod}_{CO_2}} \cdot [\mathbf{I} - (\mathbf{I} - \mathbf{M})\mathbf{A}]^{-1} \mathbf{FC_j} + \mathbf{E^{fuel}CO_2} \cdot \mathbf{FC_j} \tag{1}$$

where

$C^{FC_j}$ :the induced $CO_2$ emission from per capita ($CO_2$ conversion of kg/person) consumption expenditure (1985) of jth good

$\mathbf{E^{prod}_{CO_2}}$ :the row vector showing the $CO_2$ output coefficients of per 10 thousand yen of output ($CO_2$ conversion of kg/10 thousand yen, in 1985 producers' prices)

$\mathbf{A}$ :the input coefficients matrix of the 406 categories

$\mathbf{M}$ :the diagonal matrix indicating the import coefficients

$\mathbf{I}$ :a unit matrix

$\mathbf{E^{fuel}_{CO_2}}$ :the row vector showing the output coefficients of $CO_2$ from household consumption of fuels ($CO_2$ conversion of kg/10 thousand yen, in 1985 producers' prices)

$\mathbf{FC_j}$ :vector representing the per capita consumption expenditure, transportation fees and commercial mark-ups of jth good in 1985 producers' prices

$Cons_j$ :the per capita consumption expenditure of jth good in producers' prices

$Margin_j$ :the per capita commercial margin of jth good (in 2 forms)

$Freight_j$ :the per capita transportation fees of jth good (in 7 forms)

However, the vector notation for $\mathbf{FC_j}$ is written as follows,

$$\mathbf{FC_j} = \begin{pmatrix} \vdots \\ Cons_j \\ \vdots \\ Margin_j \\ Freight_j \\ \vdots \end{pmatrix} \tag{2}$$

## 6. Technical Appendix 2

The $CO_2$ Emission Score Table is derived as follows. First, the $CO_2$ emission by product, induced from each 10 thousand yen of products purchased at purchasers' prices in 1985 are estimated as follows,

$$C_j^{fc85} = \mathbf{E}_{\mathbf{CO_2}}^{\mathbf{prod}} \cdot [\mathbf{I} - (\mathbf{I} - \mathbf{M})\mathbf{A}]^{-1} \mathbf{fc85_j} + \mathbf{E}_{\mathbf{CO_2}}^{\mathbf{fuel}} \cdot \mathbf{Fc_j^{85}} \tag{3}$$

where

$C_j^{fc85}$ :the induced $CO_2$ emission from the purchase of per 10 thouthand yen of $j$th good, in 1985 producers' prices (in $CO_2$ conversion kg/ten thousand yen, in 1985 purchasers' prices)

$\mathbf{Fc_j^{85}}$ :vector representing the consumption expenditure transportation fees and commercial mark-ups, in producers' prices, when ten thousand yen of $j$th good in purchasers' prices is consumed in 1985

$Cons_j^{85}$ :the consumption expenditure in producers' prices when 10 thousand yen of $j$th good in purchasers' prices is consumed in 1985

$Margin_j^{85}$ :the commercial margin when 10 thousand yen of $j$th good in purchasers' prices is consumed in 1985 (in 2 forms)

$Freight_j^{85}$ :the transportation fees when 10 thousand yen of $j$th good in purchasers' prices is consumed in 1985 (in 8 forms)

where, the vector notation of $\mathbf{Fc_j^{85}}$ is written as follows,

$$\mathbf{Fc_j^{85}} = \begin{pmatrix} \vdots \\ Cons_j^{85} \\ \vdots \\ Margin_j^{85} \\ Freight_j^{85} \\ \vdots \end{pmatrix} \tag{4}$$

The results obtained for 1985 is converted into 1989 prices using the extension table of the 1989 Input-output Table, by the following calculation. Namely, the induced $CO_2$ emission by product from per 10 thousand yen of output in 1989 purchasers' prices are estimated using the respective 1989 purchasers' prices deflators as follows,

$$C_j^{fc89} = \frac{C_j^{fd85}}{def_j^{89}} \tag{5}$$

$C_j^{fc89}$ :the induced $CO_2$ emission per 10 thousand yen of $j$th good in 1989 purchasers' prices (in $CO_2$ conversion kg/10 thousand yen, in 1989 purchasers' prices)

$def_j^{89}$ :the 1989 purchasers' prices deflator for $j$th good (1985= 1.0) (a Laspeyres price index using the consumption expenditure evaluated at 1985 producers' prices, transportation fees and commercial margins as weights)

Appendix Table 2–2 shows the above estimated induced $CO_2$ emission from per 10 thousand yen of output, with every 1 kg of $CO_2$ indicated as 1 point.

### Table 2: $CO_2$ Point Table for Environmental Domestic Account Book

#### 1. Food, Beverage and Tabacco

| Points | Items |
|---|---|
| more than 100 | Salt(253 points) |
| 40 ~ 50 | Inland water fisheries, Coastal fisheries, Starch, Distant water fisheries, Animal oil and fat, Manufactured ice |
| 30 ~ 40 | Canned or bottled meat products, Frozen fishes and shellfishes, Vegetable oil and meal, Sparkling and still beverages, Layers, Flavouring, Other liquor(wine),Canned or bottled seafoods, Minor forest products (inc.hunting, mushroom, nuts), Canned or bottled vegetables and fruits, Off-shore fisheries, Fish paste, Sugar, Salted, dried or smoked seafoods, Dairy farm products, Retort foods, Noodles, Other Livestock-raising(honey), Marine culture |
| 10 ~ 20 | Other processed seafoods(laver,dried bonito), Tea and roasted coffee, Other vegetables and fruits products(frozen vegetables and pickles), Slaughtering and meat processing, Vegetables, Bread and confectionery, Inland water culture, Flour and other grain milled products, Grain milling, Processed meat products, Potatoes and sweet potatoes,Refind sake, Beer, Other foods(tofu, daily-fare shop, school lunch), Fruits, Whiskey and brandy, Pulses |
| less than 10 | Tobacco |

#### 2. Cloths and Shoes

| Points and Items | |
|---|---|
| 30 ~ 40 | Other fabricated textile products(lace etc.),Silk and artificial silk fablics |
| 20 ~ 30 | Knit fabrics, Carpets and floor mats, Cotton and staple fibers fabrics, Other woven fabric(linen etc.), Rubber footwears, Plastic footwears |
| 10 ~ 20 | Wearing apparel, Small personal adornments, Apparel accessories, Miscellaneous repairs, n.e.c.(Wearing apparel repairs), Leather footwears, Other personal services(tailor etc.) |

#### 3. Housing, Heating, Lighting and water Supply

| Points | Items |
|---|---|
| more than 1000 | Coal mining(1653 points) |
| more than 400 | Natural gas(656 points), LPG(413 points) |
| 200 ~ 400 | Kerosene(378 points), Gas supply(254 points), Electoric power(247 points) |
| 100 ~ 200 | Coal products(148 points),Steam and hot water supply(147 points) |
| less than 100 | Water supply, House rent |

Table 2: CO$_2$ Point Table for Environmental Domestic Account Book

4.Furniture and House Instruments

| Points | Items |
|---|---|
| more than 100 | Miscellananeous ceramic, stone and clay(pordelaon enamel,cloisonne,artificil gem)(277 points), Foreign paper and Japanese paper(112 points) |
| 50 ∼ 100 | Synthetic dyes,Other glass and glass products(table or kitchen glass products) |
| 40 ∼ 50 | Sheet glass and safety glass, Gas and oil appliances and heating and cooking apparatus, Bolts, nuts, rivets and springs, Other general machines and parts(fire extinguisher,plumbing parts), Other final chemical products(bond, candle, perfume), |
| 30 ∼ 40 | Machinists' precision tools, Ropes and nets,Rolled aluminium products, Other pulp,paper converted paper products(paper of daily use), Paint varnish and lacquer, Metal containers, fabricated plate and sheet metal,Pottery,china and earthenware, Non-ferrous metal casting and forgings, Batteries, Metal products for architecture, Other fabricated textile products(waterproof cloth etc.), Silk and artificial silk fablics |
| 20 ∼ 30 | Plumber's supplies, power metallurgy products and tools, Agricultural chemicals, Other metal products(tableware, pan, cashbox), Metalic furniture and accessories, Sewing machines and wool knitting machinery, Electric lighting fixtures and equipment, Carpets and floor mats,Minor forest products (inc.hunting)(lacquer, bamboo), Plastic products, Other fiber yarns(silk or flax yarn), Other rubber products(rubber belt or hose), Miscellaneous leather products(leather bag etc.), Cotton and staple fibers fabrics, Other woven fabric(flax fabric, narrow fabric), Miscellaneous manufacturing products(imitation flower,lacquer-ware,broom,etc.), Electric bulbs,Wiring devices and supplies, Woolen fabric, Cotton and bedding |
| 10 ∼ 20 | Repair of electric machinery, Organic fertilizers, Small personal adornments, Feeds,Other ready-made textile products(embroidery, bag, mosquito net), Wooden furniture and accessories, Other wooden products(cask, tub, bamboo-work, rattan-work), Analytical instruments, testing machines, measuring instruments,Miscellaneous repairs, n.e.c., Wooden fixtures,Cleaning, laundries and dying services, Straw and rush products, Other personal services(gardener,rental shop,servant) |
| less than 10 | Casualty insurance |

5.Medical and Health Care

| Points | Items |
|---|---|
| 20 ∼ 30 | Soap, synthetic detergents and surface active agents, Other rubber products(rubber products for medical or hygiene use), Medical service (private, non-profit) |
| 10 ∼ 20 | Medicaments, Cosmetics, toilet preparations and dentifrice, Other photographic and optical instruments(microscope, glasses), Textile for medical use, Medical service (industrial), Medical service (public) |
| less tuan 10 | Casualty insurance |

### Table 2: $CO_2$ Point Table for Environmental Domestic Account Book

6.Transportation and Communication

| Points | Items |
|--------|-------|
| 100~ | Light Oil(301), Gasoline(190), Ocean transport(158) |
| 50 ~ 100 | Coastal and inland water transport, Air transport |
| 40 ~ 50 | National railway transport(ex.passengers of national railway electric trains) |
| 30 ~ 40 | Tyres and inner tubes, Road freight Transport, Motor vehicle parts and accessories, Other transportation equipment (rear car etc.) |
| 20 ~ 30 | Bus transport, Trucks, buses and other cars,Other rubber products(rubber belt etc.), Bicycles, National railway electric train transport(passengers), Local railway and tramway transport, Passenger cars, Hired car and taxi transport, Two wheel motor vehicle,Repair of motor vehicles |
| 10 ~ 20 | International telecommunication, Miscellaneous repairs, n.e.c., Road transport facility service |
| ~ 10 | Postal service, Domestic telecommunication,Casualty insurance, Other servicies relating to communication |

7.Recriation and Education and Cultural Service

| Points | Items |
|--------|-------|
| 40 ~ 65 | Combind compound fertilizer, Corrugated cardboard, Other paper containers(wrappig paper etc.), Inland water fisheries |
| 30 ~ 40 | Other pulp, paper converted paper products(book binding cloth etc.), Pottery, china and earthenware,Photographic sensitive materials Other education(public)(job training center), Printing, engraving and book binding |
| 20 ~ 30 | Parts and accessories of electric audio equipment, Social education(public), Other education(private)(job training center), Sporting and athletic goods, Publishing, Wired communication equipment, Misc. leather products(carrying bag etc), Newspapers, Misc. manufacturing products, Magnetic recording and playback equipment(VTR), Other household electric appliances(iron,hairdressing machine etc.), Electric computing equipment(accessory devices), Movie theaters |
| 10 ~ 20 | Flowers and plants,Repair of elec. mach., Toy, Cable broadcast., Oth. education, Electric audio equipment, Other photographic and optical instruments, Amusement halls, Radio comm. equip., Radio and television sets,Veterinary service, Misc. repairs,n.e.c., Musical instr. and phonograph records, Camera,Oil seeds, Theater and entertainment facilities, Elec. computing equip., Seeds and seedlings, School education(private),Other amusement and recreation services, Other personal services(private lessons etc.), Public broadcasting, Photo studios |
| 10 ~ 20 | Other amusement and recreation services(amusement park,race horse track etc), School education(public), Theatrical companies |

Table 2: $CO_2$ Point Table for Environmental Domestic Account Book

8.Others

| Points | Items |
|--------|-------|
| 100 ~ | Other sanitary services (public)(161) |
| 40 ~ 60 | Other sanitary services (ind.), Sewage disposal, Public baths, Inland water culture |
| 30 ~ 40 | Other pulp, paper converted paper products(letter paper etc.), Road freight transport, Social insurance (private, non-profit), Other non-ferrous metals(precious metals etc.) |
| 20 ~ 30 | Electric lighting fixtures and equipment, Writing instrument and stationery, Office machines, Miscellaneous leather products(carrying bags etc.), Miscellaneous manufacturing products(match,billboard etc.), Funeral services |
| 10 ~ 20 | Small personal adornments, Watches and clocks, General eating and drinking places, Hotel and other lodging places, Packing,Coffee shops, Miscellaneous repairs,n.e.c., Public administration (central), Amusement eating and drinking places, Retail trade, Other business services(job search service,copy service), Other transport services(transport agency,travel agency), Private non-profit organizations serving serving households,n.e.c., public administration(local), Wholesale trade,Barber shops, Beauty shops, Other personal services(gardener rental service etc.) |
| ~ 10 | Real estate agencies and manegers,Social welfare (private, non-profit), Car renting, Judicial, financial and accounting services, Social welfare (public), Casualty insurance, Building maintenance services, Financial service, News syndicates and detective agencies, Life insurance |