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A Comparison of CO_2 Emission Structure between Japan and Germany

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The purpose of this paper is to compare the emission structure of carbon dioxide between Japan and Germany at the most detailed classification ever of the industrial branches. To do that, the input-output table and data relating with CO_2 emitted from each industrial branch were aggregated, transformed and adjusted into 54 comparable branches. After that, the intertemporal changes and the differences between Japan and Germany were decomposed into factors and analyzed.

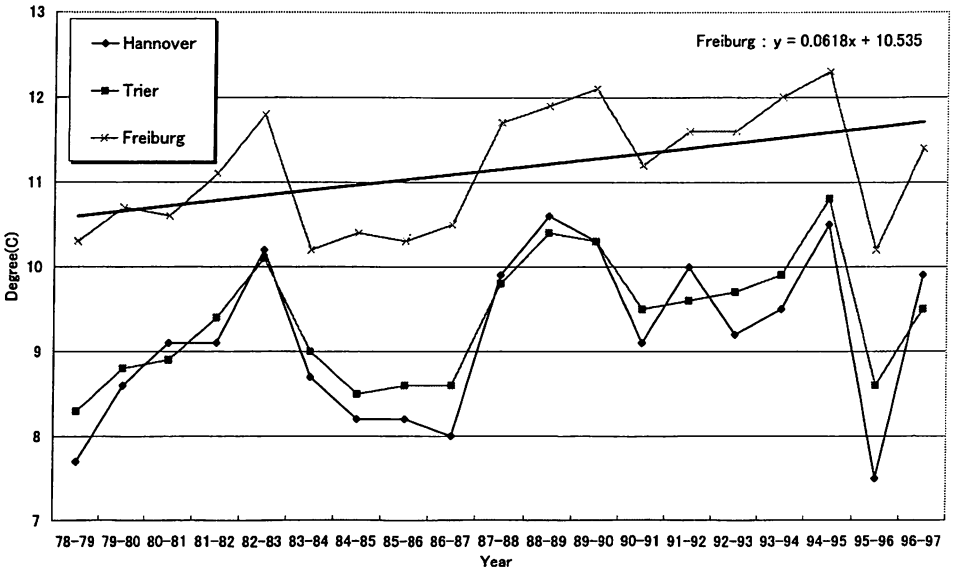
Keywords: Carbon dioxide, CO_2, Energy, Input-Output-Analysis, Germany, Japan

1. Introduction[1)]

It has been a long time since the crisis of the global warming was pointed out. In 1992 United Nations Conference on Environment and Development (Earth Summit) was held and in 1997 the 3rd Session of the Conference of the Parties (COP3) for the International Framework Convention on Climate Change was held to discuss the target and policy to reduce the carbon dioxide (CO_2) which is the main cause of the global warming. However it seems that the effective concrete measures have not yet been taken. In the meantime, unusual weather which seems due to the global warming has been observed in many parts of the planet and it has become topics of the everyday conversation[2)]. It is clear from Fig.1 and Fig.2 that the annual average temperature is in increasing tendency with ups and downs, both in Japan and in Germany. The increase is remarkable especially from the latter half of 1980's.

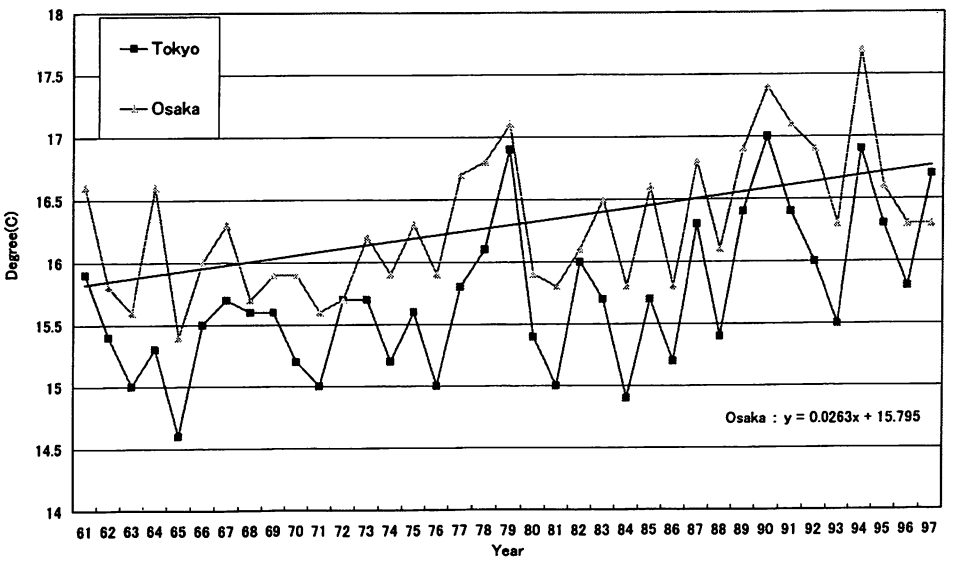
The purpose of this paper is to compare and consider CO_2 emission structure of Japan with that of Germany which is often said to be environmentally more advanced, using the input-output analysis. In Japan, Germany is often referred to in discussions of environment. In fact Germany has built environmentally friendly economy in many ways. For example, as is clear from the Fig.3, the CO_2 emission level of Germany in 1989 is lower than

Fig. 1: Average Temperature in Germany



Source) Statistiches Bundeamt: Statistisches Jahrbuch für die Bundesrepublik Deutschland

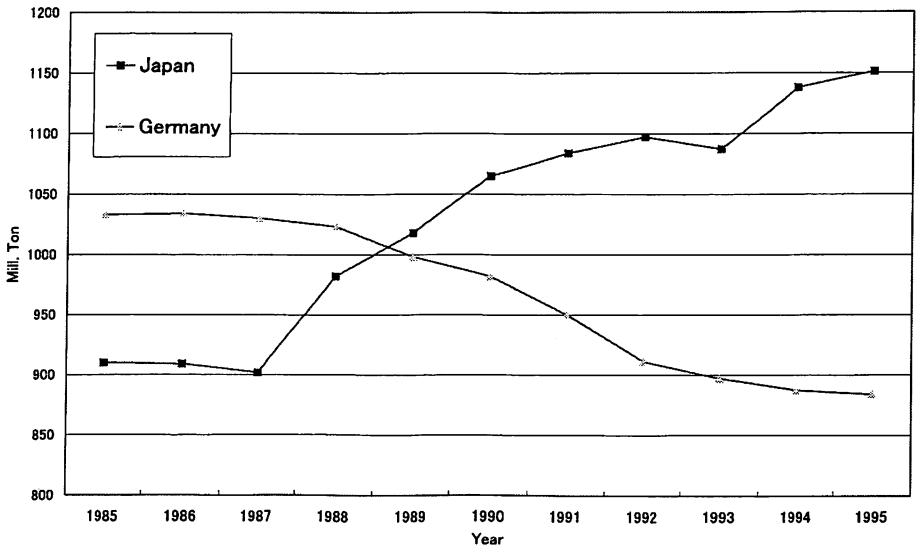
Fig. 2: Average Temperature in Japan



Source) National Astronomical Observatory (1998)

that of Japan. And while Japan's emission is on the increase, the emission of Germany is on the decrease to the contrary[4]. The gap becomes bigger in this way. Where does this difference come from? Usually the explication is given from a table of rough classification like the Table 1[5]. According to the Table 1, in Japan, all the 4 items show an increase between 1980 and

Fig. 3: CO_2 Emissions from Energy Use



Source) OECD (1997): Environmental Data, Compendium 1997.

Table 1: CO_2 Emission by Source (1980-1995)

(unit: Mill.Ton)

		Transport	Energy transformation	Industry	Other
Japan	1980	160.3	311.2	310.7	162.9
	1995	251.9	393.3	317.6	189.6
Germany	1980	137.8	425.0	258.4	264.0
	1995	185.3	358.5	160.0	198.9

Source) OECD Environmental Data, Compendium 1997

Note) These data are CO_2 emissions from energy use only. Oil and gas for non-energy purposes and the use of biomass fuels are excluded.

1995, while in Germany all the items except for the transport show an decrease. This contributes to the great difference on the whole.
In this way, from a table of rough classification like the Table 1, we can see a tendency to a certain extent. However this paper aims at a comparison based on more detailed classification. It aims to grasp factors of intertemporal changes and differences between Germany and Japan, using the input-output analysis.
For this purpose the input-output table was recompiled to have 54 branches comparable between Japan and Germany[6]. Besides harmonizing the definitions of the branches, this recompilation includes also adjusting the treatment of imputed interests and by-products to ESA type, regrouping Japanese fixed capital formation under categories of equipment investment and construction investment as in Germany, addition of consumption expenditure out of the household peculiar to the Japanese table to the branch of "Other Market Services", estimation of the input-output flow in the prices of 1990, etc.
And it is also necessary to recompile the data of CO_2 emitted from each branch. The original data were prepared and published by the Federal Statistical Office in Germany and the National Institute for Environmental Study in Japan[7]. However these data cannot be used for a comparison as they are. It is necessary to make a following adjustment[8].

(a) Unification of the definitions of 54 branches in the input-output table.
(b) The unit of the Japanese data is "carbon(C)ton", whereas that of Germany is "CO_2 ton". It was necessary to convert Japanese unit to the German unit.
(c) The quantity table to calculate the CO_2 emission (original data) of Japan treats the self-transportation as an independent branch. But in the German input-output table, the self-transportation is not an independent branch and included in each producing activity. To make an adjustment of this, it was necessary to allot CO_2 emitted from the self-transportation to each branch[10].

From the next section, it will be considered in the following order. First in the section 2, we will compare directly the CO_2 data recompiled on the basis of the input-output table of the 54 branches and consider the increase or the decrease, etc. Next in the section 3, the CO_2 emitted at the private final consumption will be considered, which is one of the great differences between Japan and Germany. Here the question is not production but con-

sumption of energy by households or private non-profit institutions which emit CO_2 directly. The section 4 considers the structures of CO_2 induced through the production for each final demand including the private final consumption. The section 5 and the section 6 consider the variation of CO_2 during the period from 1980's to 1990's and the background of the difference of emission between Japan and Germany. Lastly in the section 7, the author compares the quantity of CO_2 emitted outside of the country because of the importation by Japan and Germany.

2. Direct Comparison of the Emission Structure

The Table 2 shows CO_2 emitted from each branch, adjusted to the input-output table comparable between Japan and Germany and the Table 3 shows their proportions[11]. As is clear from the both tables, the branch of the greatest CO_2 emission both in Japan and in Germany is the electricity. In Germany it occupies almost 40% of the total emission and in Japan it accounted for almost 30% in 1990. However in Germany the emission from this branch was on the decrease. Though it increased because of the Reunification in 1991, it decreased again 2 years later. On the other hand in Japan, it was in an increasing tendency as is shown in the Table 1, exceeding German emission in 1990.

In the following branches, Germany had more emission at first but decreased their emission later while Japan increased their emission, exceeding the emission of Germany in 1990: glass products, general machinery, automobile, leather products, foods, etc. On the contrary, in the branches of other mining, aircraft, telecommunication, etc., Japan had more emission at first but the situation was reversed in 1990.

The branch which emits the second most CO_2 in Germany is the private final consumption, which is one of the biggest differences from Japan. It emits more than 20% of the total and exceeds 60% in 1990, combined with the electricity. However, though the emission increased as the electricity and the overall tendency because of the Reunification, it decreased a little afterward. On the other hand in Japan, though the proportion in the total itself is about 10%, it is at an increasing tendency. As for CO_2 emission at the private final consumption, Germany exceeds largely Japan in its absolute volume. The background will be examined in the next section.

In Japan the branch which emits the second most CO_2 is the iron and steel,

Table 2: CO_2 Emission by Branch

(unit: 1000 · CO_2t)

	Germany (United Germany since 1991)					Japan		
	1980	1985	1990	1991	1993	1980	1985	1990
1 Agriculture	8745	8626	7870	12812	11790	7304	6083	7162
2 Forestry and fishery	3154	2406	2325	2451	2798	16636	12964	17057
3 Electricity	274819	255879	254159	383466	350796	235924	239542	309515
4 Gas	1070	244	453	2626	543	1725	1151	1135
5 Water	123	115	117	139	155	291	533	415
6 Coal and cokes	10318	7420	6089	13317	12339	14796	12123	14381
7 Other mining	1044	846	821	1255	1029	1053	771	641
8 Crude oil and natural gas	1006	1098	1063	1169	1175	190	241	34
9 Chemical products	22033	22784	21706	28364	27053	33697	40057	47008
10 Petroleum products	23581	14227	13244	16840	16724	33932	35875	23288
11 Plastic products	1345	1299	1535	2259	1521	3250	1586	2155
12 Rubber products	1338	1156	964	1459	859	1799	862	1740
13 Stone and clay products	22945	18578	17103	21981	22665	91846	65720	73661
14 Ceramic products	1588	1160	1224	2252	1643	2102	1531	1895
15 Glass products	6287	5458	4192	4447	4771	4396	5035	4944
16 Iron and steel	62692	51436	46987	49041	42294	153406	137646	142380
17 Non-ferrous metals	3661	3642	3133	3685	3575	8946	5669	6380
18 Metal products	10211	7548	7236	9734	8168	22857	19405	19214
19 General machinery	5487	4508	4040	7415	5117	4960	3583	5154
20 Office machine	211	238	190	227	245	618	503	522
21 Automobile	5444	4834	3970	5415	4541	4030	5312	5397
22 Ship	251	157	145	129	268	505	349	318
23 Aircraft	218	180	188	217	220	263	150	143
24 Electric machinery	4172	3548	3299	5029	4058	7447	4772	5140
25 Precision machinery	534	455	406	473	470	826	427	680
26 Musical instrument, etc.	204	171	164	195	192	4584	2564	3037
27 Timber	1844	1124	1092	1286	1211	727	206	888
28 Wooden products	1654	1431	1441	1612	1696	1174	444	687
29 Pulp and paper	5536	5451	6153	7539	6884	14584	17198	15993
30 Paper products	1361	1091	1165	1254	1152	469	1188	1036
31 Printing and publishing	708	675	744	870	828	505	715	1119
32 Leather products	374	289	216	224	210	173	232	302
33 Textile products	3918	3189	2818	4144	2704	7648	6730	4725
34 Wearing apparel	810	596	482	1136	651	1101	1507	1340
35 Foodstuffs and feeds	13572	11386	10536	14239	12590	9798	9646	12221
36 Beverages	3565	3064	2793	3702	3405	2242	2415	2916
37 Tobacco	156	137	130	144	142	354	225	243
38 Construction	8785	7601	7374	13534	12649	18047	21229	31481
39 Wholesale	9417	9673	10679	13180	14453	12879	16809	16975
40 Retail trade	8890	9230	9871	11748	12935	22757	19629	17252
41 Railway transport	3124	2633	1966	4528	3342	2532	2450	1483
42 Maritime transport	3318	3051	2699	2825	2932	38725	34383	34657
43 Post and communication	982	944	1155	1409	1241	1043	796	1018
44 Other transport services	17807	18950	25127	29642	34106	30977	39218	63134
45 Financial services	872	981	1044	1802	1591	436	376	778
46 Insurance	475	535	555	698	727	280	210	468
47 Real estate and house rent	243	239	218	262	322	809	1287	3466
48 Hotel and restaurant	3220	3001	2776	4370	3884	9103	10320	8395
49 Research and education	1036	1125	1056	1353	1240	7913	9911	13853
50 Health and medical services	1567	1573	1453	1683	1949	4380	5516	6218
51 Other market services	3937	4918	7102	9563	12012	36468	31194	26970
52 Public administeration	19809	20297	17895	23603	23486	16450	16487	20286
53 Social insurance	389	411	462	573	616	510	788	523
54 Private non-profit services	2489	2458	2353	2977	3257	4607	6226	4049
55 Total intermediate branches	592339	534066	523978	736297	687224	904098	861814	985900
56 Private final consumption	177075	181500	175405	225139	223154	86619	87485	115785
57 Total	769414	715566	699383	961436	910378	990718	949300	1101685

Source) Calculated from Manegement and Coordination Agency of Japan (1989) (1994) (1999), Administerative Manegement Agency of Japan (1979) (1984), Kondo, Y. & Moriguchi, Y. (1997), Statistisches Bundesamt (1981) (1984) (1990) (1994) (1995) (1997).

Table 3: Structure of CO_2 Emission

(unit: %)

	Germany (United Germany since 1991)					Japan		
	1980	1985	1990	1991	1993	1980	1985	1990
1 Agriculture	1.1	1.2	1.1	1.3	1.3	0.7	0.6	0.7
2 Forestry and fishery	0.4	0.3	0.3	0.3	0.3	1.7	1.4	1.5
3 Electricity	35.7	35.8	36.3	39.9	38.5	23.8	25.2	28.1
4 Gas	0.1	0.0	0.1	0.3	0.1	0.2	0.1	0.1
5 Water	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
6 Coal and cokes	1.3	1.0	0.9	1.4	1.4	1.5	1.3	1.3
7 Other mining	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8 Crude oil and natural gas	0.1	0.2	0.2	0.1	0.1	0.0	0.0	0.0
9 Chemical products	2.9	3.2	3.1	3.0	3.0	3.4	4.2	4.3
10 Petroleum products	3.1	2.0	1.9	1.8	1.8	3.4	3.8	2.1
11 Plastic products	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2
12 Rubber products	0.2	0.2	0.1	0.2	0.1	0.2	0.1	0.2
13 Stone and clay products	3.0	2.6	2.4	2.3	2.5	9.3	6.9	6.7
14 Ceramic products	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
15 Glass products	0.8	0.8	0.6	0.5	0.5	0.4	0.5	0.4
16 Iron and steel	8.1	7.2	6.7	5.1	4.6	15.5	14.5	12.9
17 Non-ferrous metals	0.5	0.5	0.4	0.4	0.4	0.9	0.6	0.6
18 Metal products	1.3	1.1	1.0	1.0	0.9	2.3	2.0	1.7
19 General machinery	0.7	0.6	0.6	0.8	0.6	0.5	0.4	0.5
20 Office machine	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0
21 Automobile	0.7	0.7	0.6	0.6	0.5	0.4	0.6	0.5
22 Ship	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
23 Aircraft	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24 Electric machinery	0.5	0.5	0.5	0.5	0.4	0.8	0.5	0.5
25 Precision machinery	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.1
26 Musical instrument, etc.	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.3
27 Timber	0.2	0.2	0.2	0.1	0.1	0.1	0.0	0.1
28 Wooden products	0.2	0.2	0.2	0.2	0.2	0.1	0.0	0.1
29 Pulp and paper	0.7	0.8	0.9	0.8	0.8	1.5	1.8	1.5
30 Paper products	0.2	0.2	0.2	0.1	0.1	0.0	0.1	0.1
31 Printing and publishing	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
32 Leather products	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 Textile products	0.5	0.4	0.4	0.4	0.3	0.8	0.7	0.4
34 Wearing apparel	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1
35 Foodstuffs and feeds	1.8	1.6	1.5	1.5	1.4	1.0	1.0	1.1
36 Beverages	0.5	0.4	0.4	0.4	0.4	0.2	0.3	0.3
37 Tobacco	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 Construction	1.1	1.1	1.1	1.4	1.4	1.8	2.2	2.9
39 Wholesale	1.2	1.4	1.5	1.4	1.6	1.3	1.8	1.5
40 Retail trade	1.2	1.3	1.4	1.2	1.4	2.3	2.1	1.6
41 Railway transport	0.4	0.4	0.3	0.5	0.4	0.3	0.3	0.1
42 Maritime transport	0.4	0.4	0.4	0.3	0.3	3.9	3.6	3.1
43 Post and communication	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1
44 Other transport services	2.3	2.6	3.6	3.1	3.7	3.1	4.1	5.7
45 Financial services	0.1	0.1	0.1	0.2	0.2	0.0	0.0	0.1
46 Insurance	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0
47 Real estate and house rent	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3
48 Hotel and restaurant	0.4	0.4	0.4	0.5	0.4	0.9	1.1	0.8
49 Research and education	0.1	0.2	0.2	0.1	0.1	0.8	1.0	1.3
50 Health and medical services	0.2	0.2	0.2	0.2	0.2	0.4	0.6	0.6
51 Other market services	0.5	0.7	1.0	1.0	1.3	3.7	3.3	2.4
52 Public administeration	2.6	2.8	2.6	2.5	2.6	1.7	1.7	1.8
53 Social insurance	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0
54 Private non-profit services	0.3	0.3	0.3	0.3	0.4	0.5	0.7	0.4
55 Total intermediate branches	77.0	74.6	74.9	76.6	75.5	91.3	90.8	89.5
56 Private final consumption	23.0	25.4	25.1	23.4	24.5	8.7	9.2	10.5
57 Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

showing how much the production of iron and steel emits CO_2. Though in Germany the iron and steel is the third branch in the quantity of emission, the volume is smaller than Japan by one digit. The Japanese immense emission is conspicuous there. As for the emission in the iron and steel, Germany shows a remarkable decrease while in Japan it fluctuates.
The 4th branch in the volume of the emission in Japan and in Germany is the other transport centered on the land transport and air transport. Though the both countries continue to produce CO_2, the increase of Japan was particularly significant between 1985 and 1990 and she more than doubled the emission of Germany in 1990. As for the maritime transport, Japan's emission is more than 10 times as much as Germany because Japan is an island country and emits much CO_2 by the transportation of its imports and exports. On the contrary, in the rail road transport, the both countries show a decreasing tendency, Germany producing more[12].
As branches which emit much CO_2 in the both countries, there are chemical products, stone and clay products, petroleum products, construction, foods, public administration, etc. In Japan the branch of the stone and clay products emits particularly much CO_2. Although the proportion is in a decreasing tendency, it accounted for as much as 9.3% of the total in 1980. This is mainly due to a considerable consumption of energy by the cement production. In the emission from the branch of construction which uses much of those stone and clay products, Germany shows a decreasing tendency, while Japan a remarkable increase. In the chemical products and the foods, too, Japan increases CO_2 emission, contrary to Germany. On the other hand, in Germany there are rare branches such as the retail trade and the other market services which show an increasing tendency, contrary to the reverse tendency in Japan.

3. Direct Energy Use at the Private Final Consumption

The previous section found that the CO_2 volume emitted at the private final consumption in Germany is much greater than that in Japan. CO_2 is emitted not only by the energy use but also by the incineration of the wastes, the respiration of animals, smoking, etc. The author consider here only the direct energy use at the private final consumption, which constitutes the most important factor of the emission. The Table 4 shows the main energy consumption at the private final consumption, calculated from the physical

quantity table which is attached to the input-output table[13]. It is to be noted that these calculations include not only the energy use by the households but by the private non-profit institutions.

First, at the top zone of the table, we can see easily that Japan uses more electricity than Germany every year influenced also by the population size. As for the petroleum, Germany uses it a little more than Japan exceptionally in 1980, but in other years Japan uses it more than Germany. Surprisingly enough, however, the other energies were more used by Germany. It is true of the heat supply, gas or kerosene for heating. Especially in the Japanese households, the coal is rarely used these days while in Germany it is still used in fairly large quantity. This makes a big difference. In the diesel fuel as well, Germany consumes more than Japan. This comes also from a fact that the German households own more diesel cars[14]. And there is more consumption of the kerosene for heating in Germany. This can be related to the difference of the average temperature of the year and the climate.

If we see the tendency, the consumption of almost every energy by the both countries was on the increase. On the other hand, the consumption of the kerosene for heating was fluctuating and that of the coal/brown coal decreased in the both countries. In Germany in 1991 the consumption of the coal/ brown coal increased rapidly because of the Reunification but it decreased considerably in 1993.

If we make a comparison with different physical units of the branches, we cannot compare quantitatively the different kinds of energy used. The middle zone of the Table 4 shows comparisons with calorific unit (Joule) after conversion. The table shows that as for the private final consumption in Japan, the consumption of the gasoline had been the most in calorie since the beginning of 1975. On the other hand in Germany, the consumption of the kerosene for heating had been the most until 1985 but since 1990 that of the gasoline had been the most as in Japan. The second most consumption was the kerosene for heating since 1990 in Germany and the electricity since 1980 in Japan.

Lastly, the calculations of per capita energy consumption are shown at the bottom zone of the Table 4. We can see that in each energy except for the liquidated gas, the German consumption level is overwhelmingly greater. Especially the difference is big in the use of the gasoline and the kerosene for heating. Though the consumption of the heat supply and the coal is

Table 4: Direct Energy Use at the Private Final Consumption

	Unit	Germany (United Germany since 1991)						Japan				
		1975	1980	1985	1990	1991	1993	1975	1980	1985	1990	1995
		Energy use in each physical unit										
Electricity	Mill. kWh	70333	88474	100016	102362	125112	129432	89965	107325	134969	139941	179063
Heat supply	Terajoule	37200	64399	75645	81307	166246	170600	54	76	859	1288	10878
Gas	Mill. m^3	6807	13202	16905	17827	22510	25195	4249	4767	7198	8496	9288
Coal & lignite	1000 t	9204	6514	4986	2453	12766	7132	347	273	62	30	9
Gasoline	1000 t	14742	17808	18061	21776	25503	25698	15006	17187	18062	24263	28866
Diesel oil	1000 t	766	1095	1957	3174	3246	3793	71	175	452	530	2578
Kerosene for heating	1000 t	22691	24305	22761	17301	20141	20522	9577	8938	7121	9554	14189
Liquid gas	1000 t	362	540	596	521	614	885	5289	3860	3360	5057	6371
		Energy use in Terajoule										
Electricity	Terajoule	253200	318506	360058	368503	450403	465955	323874	386370	485889	503787	644627
Heat supply	Terajoule	37200	64399	75645	81307	166246	170600	54	76	859	1288	10878
Gas	Terajoule	239400	464301	594532	565758	714377	799588	149439	167641	253149	269630	294749
Coal & lignite	Terajoule	224500	158894	120549	59300	265600	152506	8469	6663	1503	721	188
Gasoline	Terajoule	641900	775414	786430	948192	1110476	1118967	653391	748388	786465	1056492	1256919
Diesel oil	Terajoule	32700	46762	83574	135546	138620	161980	3017	7462	19288	22645	110099
Kerosene for heating	Terajoule	969000	1037945	972009	738853	860122	876392	408994	381713	304086	408019	605923
Liquid gas	Terajoule	17300	25823	27349	23907	28175	40610	252922	184572	154200	232069	292332
Total	Terajoule	2415200	2892044	3020146	2921366	3734019	3786598	1800160	1882885	2005438	2494651	3215715
		Per capita energy use in Megajoule										
Electricity	Megajoule	4095	5166	5901	5783	5611	5729	2893	3301	4014	4076	5134
Heat supply	Megajoule	602	1044	1240	1276	2071	2097	0	1	7	10	87
Gas	Megajoule	3872	7530	9743	8878	8899	9830	1335	1432	2091	2181	2347
Coal & lignite	Megajoule	3631	2577	1976	931	3309	1875	76	57	12	6	1
Gasoline	Megajoule	10382	12576	12888	14879	13833	13757	5837	6393	6497	8547	10010
Diesel oil	Megajoule	529	758	1370	2127	1727	1991	27	64	159	183	877
Kerosene for heating	Megajoule	15672	16834	15929	11594	10715	10775	3654	3261	2512	3301	4825
Liquid gas	Megajoule	280	419	448	375	351	499	2259	1577	1274	1877	2328
Total	Megajoule	39063	46905	49494	45843	46516	46554	16081	16085	16567	20181	25609

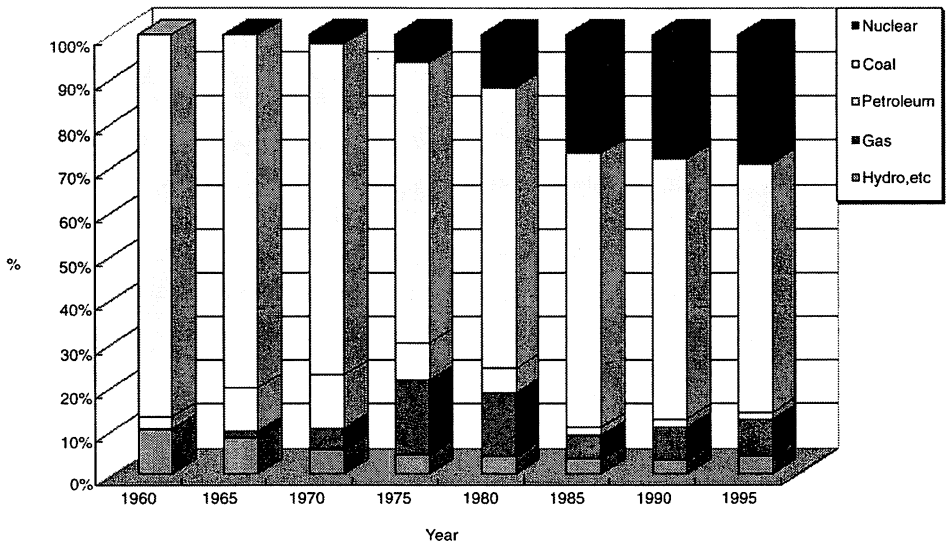
Note) Calculated from Manegement and Coordination Agency of Japan (1989) (1994) (1999), Administerative Manegement Agency of Japan (1979) (1984). Kondo, Y. & Moriguchi, Y. (1997), Statistisches Bundesamt (1981) (1984) (1990) (1994) (1995) (1997).

also considerably different, it may be attributable to the differences of reserve of the resources and the history.
As is shown in the middle zone of the Table 4, the total consumption of Germany of the major energies mentioned here is consistently above that of Japan. It is sure that this is linked to the difference of CO_2 emission between the two countries at the private final consumption. However the electricity and the heat supply are a clean energy with no emission of CO_2 at the stage of the private final consumption. They should be excluded from the consideration of CO_2 emitted directly at the stage of the private final consumption. At the stage of their production, the uses of different kinds of energy induce CO_2 emission indirectly[15]. This point will be considered in detail in the next section.

4. Structure of Inducement of CO_2 Emission by Final Demand

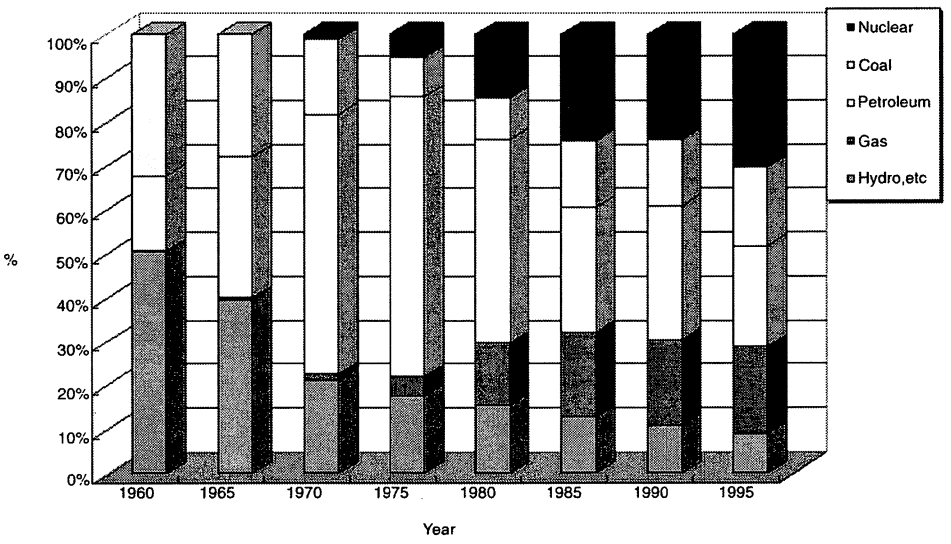
First, the comparison of Fig.4 and Fig.5 shows that Japan and Germany use different types of energy to generate the electricity. In Germany the use of atomic power is increasing and the proportion of the other energy uses is on the decrease. However Germany has a structure which still depends overwhelmingly on the coal/brown coal. In 1995 57% of the total electricity was generated by the coal/brown coal. The proportion of generation by petroleum and natural gas is small. On the other hand in Japan, the proportion of the use of atomic power is increasing as in Germany, occupying in 1995 30%, the biggest proportion ever. The use of petroleum on which the electricity depended overwhelmingly in the 1970's was on the decrease, occupying only 23% in 1995. And the dependency on natural gas was approximately 20%.
This difference of energy type for the generation of electricity must influence a lot on the emission of CO_2. For example, even if the consumption of the electricity in the households in Japan and in Germany is the same, Germany must emit more CO_2 because this country uses more coal/brown coal. Next this point will be analyzed in simulation.
The left hand side of the Table 5 shows comparisons between Japan and Germany in the domestic production and CO_2 emission induced when 10,000 units of demand for electricity occurs as the final demand[16]. The total amount of the production induced at each branch is greater in Germany. The amount of CO_2 emission is still greater in Germany, attain-

Fig. 4: Energy Structure in Generating Electricity (Germany)



Source) OECD (1999): Statistical Compendium (CD-ROM).

Fig. 5: Energy Structure in Generating Electricity (Japan)



Source) OECD (1999): Statistical Compendium (CD-ROM).

ing one and half times as much as Japan. Seen by branch, CO_2 emission from the generation of electricity is different by one and half times, reflecting the difference of energy types used. Moreover CO_2 is emitted by the production to generate that energy. For example, for the production of the coal, Germany emits 4 times as much CO_2 as Japan while for the production of the petroleum products, Japan emits 4 times as much CO_2 as Germany.

Unlike the left hand side of the Table 5, the right hand side shows calculations of the production and CO_2 induced by the actual demand for electricity at the private final consumption. In 1990 the actual electric demands at the private final consumption was 25billion 354million D-Marks in Germany while in Japan it was 39billion 426 million D-Marks, about 1.5 times as much as in Germany. As we can imagine from the simulation at the left hand side of the Table 5, Germany produces about 1.5 times as much CO_2 as Japan. For this reason we can see in the bottom zone of the Table 5 that this actual final demand for electricity produces nearly the same amount of CO_2 on the whole.

Like this, the clean electric energy at the stage of the private final consumption emits much CO_2 at the stage of its production. The author found that German emission coefficient is higher than Japanese one, influenced by the difference of energy type used, too.

Next, besides the electricity, the author will calculate and compare CO_2 emitted directly or indirectly from the production for various final demands. The Table 6 shows the calculations of CO_2 emitted directly or indirectly from the production to satisfy each final demand. And the Table 7 shows which final demand and to what extent induces CO_2 emission of each branch, by calculation of the proportions from the Table 6.

In the whole of the economic activity, the private final consumption produces the most of CO_2 both in Japan and in Germany attaining about 45% as is shown in the Table 7. This percentage will still go up if CO_2 emitted from energy directly used at the private final consumption is included. This shows how deeply economic activities of household is concerned with the environment. CO_2 emitted from the generation of electricity, among others, shows a considerably high level compared with other branches. Naturally this is because electricity is used for the productions of many different branches[17]. The other major branches in Japan which emit much of CO_2 induced by the private final consumption are the other transport, chemical

Table 5: CO_2 Emission Induced by Private Final Consumption for Electricity

(unit: 1000 · CO_2t)

Branch	Induced domestic output and CO_2 emission by 10,000 unit of private final consumption for electricity				Induced domestic output and CO_2 emission by actual private final consumption for electricity			
	Germany 1990		Japan 1990		Germany 1990		Japan 1990	
	Output	CO_2	Output	CO_2	Output	CO_2	Output	CO_2
1 Agriculture	12	2	15	1	30	4	58	3
2 Forestry and fishery	15	2	8	3	37	6	31	11
3 Electricity	10767	32643	10076	20517	27299	82763	39724	80891
4 Gas	339	7	8	0	861	19	30	2
5 Water	28	0	16	0	71	1	62	1
6 Coal and cokes	1886	481	232	129	4782	1220	916	508
7 Other mining	3	1	0	0	6	2	1	1
8 Crude oil and natural gas	39	11	11	0	100	28	43	2
9 Chemical products	142	15	73	12	359	39	289	46
10 Petroleum products	126	27	500	112	319	70	1972	440
11 Plastic products	58	1	39	1	148	4	154	3
12 Rubber products	22	1	14	1	55	3	57	3
13 Stone and clay products	82	31	43	31	209	80	169	121
14 Ceramic products	6	2	3	1	16	4	12	2
15 Glass products	9	3	5	1	23	7	21	5
16 Iron and steel	256	132	42	69	649	334	167	273
17 Non-ferrous metals	32	3	10	3	82	8	41	11
18 Metal products	383	16	250	9	971	41	985	37
19 General machinery	320	6	740	11	812	15	2916	43
20 Office machine	13	0	20	0	32	0	78	0
21 Automobile	31	0	66	1	79	1	262	3
22 Ship	2	0	3	0	5	0	11	0
23 Aircraft	6	0	1	0	14	0	4	0
24 Electric machinery	464	8	72	1	1175	21	285	3
25 Precision machinery	12	0	7	0	30	0	26	0
26 Musical instrument, etc.	2	0	46	2	6	0	183	6
27 Timber	12	1	15	0	31	3	57	1
28 Wooden products	17	1	18	0	43	1	71	1
29 Pulp and paper	19	5	40	10	49	14	156	38
30 Paper products	26	1	16	0	66	2	64	1
31 Printing and publishing	55	1	133	1	139	2	523	4
32 Leather products	2	0	3	0	4	0	10	0
33 Textile products	10	1	12	1	26	2	48	3
34 Wearing apparel	6	0	12	0	16	0	47	1
35 Foodstuffs and feeds	33	2	28	1	84	5	110	4
36 Beverages	14	1	16	1	36	3	62	2
37 Tobacco	4	0	2	0	10	0	9	0
38 Construction	407	12	355	11	1033	29	1401	44
39 Wholesale	292	15	263	8	741	39	1039	32
40 Retail trade	15	1	46	2	39	2	183	8
41 Railway transport	115	14	24	1	292	36	95	2
42 Maritime transport	31	6	82	54	79	15	323	212
43 Post and communication	110	2	356	1	278	5	1403	6
44 Other transport services	173	37	187	44	439	93	739	175
45 Financial services	146	1	546	2	371	3	2155	7
46 Insurance	96	1	41	0	244	2	161	1
47 Real estate and house rent	178	0	174	1	451	0	685	4
48 Hotel and restaurant	83	3	117	4	211	8	461	14
49 Research and education	81	1	194	18	205	3	764	69
50 Health and medical services	20	0	3	0	51	1	12	0
51 Other market services	1327	23	890	29	3365	59	3509	116
52 Public administeration	141	7	8	0	357	17	31	1
53 Social insurance	0	0	0	0	0	0	0	0
54 Private non-profit services	11	0	19	0	27	1	74	2
55 Total	18482	33532	15900	21094	46859	85018	62687	83166

Note) Actual private final consumption for electricity in 1990 Germany is 25,354 Mill. DM, whereas that in Japan is 39,426 Mill. DM.

products, iron and steel, other market services and retail trade in this order. In Germany they are the other transport, chemical products, retail trade, foods, agriculture, showing a slight difference in order.

The second final demand in CO_2 emission, after the private final consumption, shows the greatest difference between Japan and Germany. In Germany export shows the second most emission after the private final consumption, exceeding solely Japanese emission by export. That is, CO_2 emission induced by all the other final demand items in Japan exceed those of Germany. By German exportations, electricity, iron and steel, chemical products, other transport, wholesales, pulp and paper emit much of CO_2 in this order. Each of these branches emits more of CO_2 than the corresponding Japanese branch in exportation. On the other hand, Japan emits CO_2 induced by the exportation in the branches of electricity, iron and steel, maritime transport, chemical products and other transport in this order, maritime transport emitting much of CO_2 as Japan is an island country. And the emission level from the exportation in agriculture and foods are considerably different between these two countries, reflecting their proportions occupied by them in the exportation.

In Japan the emission level of the construction investment among the fixed capital formation is much higher than exportation, accounting for 27.3% in the whole. Originally the construction investment is overwhelmingly more than in Germany. It is equally because materials for construction investment such as cement and iron and steel need much energy and emit much CO_2. As a matter of fact, Japan emits CO_2 in stone and clay products, iron and steel, electricity, construction and transport in this order. In Germany also these branches occupy high ranking with a difference in that in Germany generation of electricity emits the most of CO_2 among the branches.

As for other final demand items, Japan's CO_2 emission by the equipment investment is overwhelmingly more than those in Germany as in the construction investment, whereas the government final consumption has almost the same emission as a characteristic.

Lastly, we will see which final demand produces most CO_2 by branch in the Table 7. In Germany there are many branches whose emission induced by exportation exceed 50% of their total emission. Maritime transportation of 86.7% at the head, non-ferrous metals, iron and steel, chemical products, mining, rubber products, machinery, aircraft, pulp and paper, automobile,

Table 6: CO_2 Emission Induced by Each Final Demand

(unit: 1000 · CO_2t)

Branch	Germany 1990					Japan 1990				
	Private final consumption	Governmental final consumption	Fixed capital formation		Export	Private final consumption	Governmental final consumption	Fixed capital formation		Export
			Equipment	Construction				Equipment	Construction	
1 Agriculture	5661	282	42	55	1845	6458	153	240	196	140
2 Forestry and fishery	1035	116	72	212	499	12749	372	418	2642	559
3 Electricity	148522	22726	11329	11353	60099	187530	17119	30177	40487	32364
4 Gas	280	41	13	18	100	942	34	41	69	47
5 Water	71	16	4	7	20	301	34	21	36	23
6 Coal and cokes	2625	415	308	397	2571	3224	384	2254	5997	2367
7 Other mining	227	23	20	32	523	193	22	96	132	204
8 Crude oil and natural gas	636	72	28	44	311	24	1	2	3	3
9 Chemical products	4656	1723	507	974	14008	25056	2843	3994	4293	10392
10 Petroleum products	9131	538	282	682	2950	13975	1074	1562	3869	2516
11 Plastic products	373	49	119	184	806	854	59	347	426	446
12 Rubber products	335	44	74	19	579	596	37	304	195	590
13 Stone and clay products	2845	715	254	9865	3362	7675	795	2526	57684	4266
14 Ceramic products	397	27	20	201	567	530	35	136	746	414
15 Glass products	1360	208	239	271	2127	1818	118	735	1006	1176
16 Iron and steel	5008	916	4337	4204	32194	23694	3543	32854	49328	30501
17 Non-ferrous metals	265	65	293	193	2218	1247	148	1344	1706	1549
18 Metal products	1145	266	1222	1548	3054	3198	478	4436	6661	4071
19 General machinery	182	54	1341	88	2375	646	87	2605	525	1176
20 Office machine	14	7	89	2	86	45	2	236	12	220
21 Automobile	1127	55	565	22	2132	1823	47	1116	307	2056
22 Ship	12	30	43	1	72	18	20	100	5	165
23 Aircraft	18	49	9	2	104	20	57	38	3	22
24 Electric machinery	508	91	809	198	1640	1120	50	1989	368	1556
25 Precision machinery	101	119	41	3	165	152	8	240	18	248
26 Musical instrument, etc.	122	5	6	2	63	1472	109	504	433	494
27 Timber	297	28	83	250	351	142	13	61	637	34
28 Wooden products	751	27	252	210	259	205	15	143	271	34
29 Pulp and paper	1779	511	194	209	3414	8406	758	1684	2563	2529
30 Paper products	510	79	40	62	443	640	32	116	111	132
31 Printing and publishing	393	81	33	30	205	684	85	117	108	116
32 Leather products	87	7	3	3	83	242	4	12	12	26
33 Textile products	937	76	60	56	1471	3228	60	333	266	818
34 Wearing apparel	368	12	1	2	117	1148	20	68	52	40
35 Foodstuffs and feeds	7897	297	53	65	2314	11300	366	118	185	243
36 Beverages	2428	88	33	35	373	2704	29	51	83	62
37 Tobacco	112	1	1	1	16	234	1	2	3	3
38 Construction	829	289	48	5938	271	1445	217	207	29406	195
39 Wholesale	4670	572	1284	690	3461	7730	357	4318	2469	1983
40 Retail trade	8881	507	240	82	163	15368	154	961	517	242
41 Railway transport	923	80	93	105	763	1136	60	93	111	79
42 Maritime transport	255	30	25	49	2339	6777	463	2043	3910	21289
43 Post and communication	789	97	36	54	179	606	60	112	124	112
44 Other transport services	11928	1318	1165	1478	9219	37351	1907	6303	8897	8372
45 Financial services	865	59	20	29	71	459	26	74	100	116
46 Insurance	452	24	10	20	49	415	4	11	24	14
47 Real estate and house rent	190	9	3	4	12	3143	23	106	104	88
48 Hotel and restaurant	1989	126	104	84	472	6889	156	340	556	442
49 Research and education	671	104	31	38	212	5808	389	2996	1472	3058
50 Health and medical services	332	1103	2	3	12	6171	7	11	18	11
51 Other market services	3156	691	471	968	1819	15904	1253	2729	4467	2519
52 Public administeration	1638	15685	74	154	343	2490	17673	35	53	33
53 Social insurance	0	462	0	0	0	54	469	0	0	0
54 Private non-profit services	1212	1110	4	8	19	3895	10	37	58	47
55 Total	241000	52124	26429	41201	162922	439929	52242	111394	233724	140204

Note) Emission induced by Changes in Stocks were omitted here from the relation of the space.

Table 7: Structure of CO_2 Emission Induced by Each Final Demand

(unit: %)

Branch	Germany 1990					Japan 1990				
	Private final consumption	Governmental final consumption	Fixed capital formation		Export	Private final consumption	Governmental final consumption	Fixed capital formation		Export
			Equipment	Construction				Equipment	Construction	
1 Agriculture	71.9	3.6	0.5	0.7	23.4	90.2	2.1	3.4	2.7	2.0
2 Forestry and fishery	44.5	5.0	3.1	9.1	21.5	74.7	2.2	2.4	15.5	3.3
3 Electricity	58.4	8.9	4.5	4.5	23.6	60.6	5.5	9.7	13.1	10.5
4 Gas	61.7	9.0	2.9	4.0	22.0	83.0	3.0	3.6	6.1	4.1
5 Water	60.3	13.3	3.4	5.8	17.2	72.4	8.2	4.9	8.7	5.5
6 Coal and cokes	43.1	6.8	5.1	6.5	42.2	22.4	2.7	15.7	41.7	16.5
7 Other mining	27.6	2.8	2.5	3.9	63.7	30.1	3.4	15.0	20.6	31.8
8 Crude oil and natural gas	59.9	6.8	2.6	4.2	29.3	67.3	3.9	6.9	9.9	9.8
9 Chemical products	21.5	7.9	2.3	4.5	64.5	53.3	6.0	8.5	9.1	22.1
10 Petroleum products	68.9	4.1	2.1	5.1	22.3	60.0	4.6	6.7	16.6	10.8
11 Plastic products	24.3	3.2	7.8	12.0	52.5	39.6	2.8	16.1	19.8	20.7
12 Rubber products	34.7	4.5	7.6	1.9	60.0	34.2	2.1	17.5	11.2	33.9
13 Stone and clay products	16.6	4.2	1.5	57.7	19.7	10.4	1.1	3.4	78.3	5.8
14 Ceramic products	32.4	2.2	1.6	16.4	46.3	28.0	1.8	7.2	39.3	21.8
15 Glass products	32.5	5.0	5.7	6.5	50.7	36.8	2.4	14.9	20.4	23.8
16 Iron and steel	10.7	1.9	9.2	8.9	68.5	16.6	2.5	23.1	34.6	21.4
17 Non-ferrous metals	8.5	2.1	9.4	6.2	70.8	19.5	2.3	21.1	26.7	24.3
18 Metal products	15.8	3.7	16.9	21.4	42.2	16.6	2.5	23.1	34.7	21.2
19 General machinery	4.5	1.3	33.2	2.2	58.8	12.5	1.7	50.5	10.2	22.8
20 Office machine	7.5	3.7	47.0	1.0	45.2	8.5	0.4	45.2	2.2	42.1
21 Automobile	28.4	1.4	14.2	0.5	53.7	33.8	0.9	20.7	5.7	38.1
22 Ship	8.1	20.8	29.4	0.6	49.4	5.6	6.4	31.3	1.6	51.8
23 Aircraft	9.4	26.3	4.8	0.9	55.5	14.2	39.6	26.6	2.2	15.1
24 Electric machinery	15.4	2.8	24.5	6.0	49.7	21.8	1.0	38.7	7.1	30.3
25 Precision machinery	25.0	29.4	10.2	0.6	40.6	22.4	1.1	35.2	2.6	36.5
26 Musical instrument, etc.	74.2	2.8	3.6	1.2	38.6	48.5	3.6	16.6	14.3	16.3
27 Timber	27.2	2.5	7.6	22.9	32.1	16.0	1.4	6.8	71.8	3.9
28 Wooden products	52.2	1.9	17.5	14.6	18.0	29.8	2.1	20.9	39.4	4.9
29 Pulp and paper	28.9	8.3	3.2	3.4	55.5	52.6	4.7	10.5	16.0	15.8
30 Paper products	43.8	6.8	3.5	5.3	38.0	61.7	3.1	11.2	10.7	12.7
31 Printing and publishing	52.9	10.9	4.4	4.0	27.6	61.1	7.6	10.4	9.6	10.4
32 Leather products	40.4	3.5	1.6	1.3	38.4	79.8	1.4	4.0	4.0	8.6
33 Textile products	33.3	2.7	2.1	2.0	52.2	68.3	1.3	7.1	5.6	17.3
34 Wearing apparel	76.4	2.5	0.3	0.4	24.3	85.7	1.5	5.1	3.8	3.0
35 Foodstuffs and feeds	75.0	2.8	0.5	0.6	22.0	92.5	3.0	1.0	1.5	2.0
36 Beverages	86.9	3.2	1.2	1.3	13.3	92.7	1.0	1.8	2.9	2.1
37 Tobacco	86.4	0.4	0.5	0.4	12.7	96.4	0.3	0.7	1.2	1.2
38 Construction	11.2	3.9	0.7	80.5	3.7	4.6	0.7	0.7	93.4	0.6
39 Wholesale	43.7	5.4	12.0	6.5	32.4	45.5	2.1	25.4	14.5	11.7
40 Retail trade	90.0	5.1	2.4	0.8	1.7	89.1	0.9	5.6	3.0	1.4
41 Railway transport	46.9	4.1	4.7	5.3	38.8	76.6	4.1	6.3	7.5	5.3
42 Maritime transport	9.5	1.1	0.9	1.8	86.7	19.6	1.3	5.9	11.3	61.4
43 Post and communication	68.3	8.4	3.1	4.7	15.5	59.5	5.9	11.0	12.2	11.0
44 Other transport services	47.5	5.2	4.6	5.9	36.7	59.2	3.0	10.0	14.1	13.3
45 Financial services	82.9	5.6	1.9	2.7	6.8	59.0	3.3	9.5	12.8	14.9
46 Insurance	81.5	4.3	1.8	3.6	8.8	88.5	0.9	2.3	5.2	3.0
47 Real estate and house rent	87.2	4.0	1.5	1.6	5.7	90.7	0.7	3.0	3.0	2.5
48 Hotel and restaurant	71.7	4.5	3.7	3.0	17.0	82.1	1.9	4.0	6.6	5.3
49 Research and education	63.6	9.9	2.9	3.6	20.0	41.9	2.8	21.6	10.6	22.1
50 Health and medical services	22.8	75.9	0.2	0.2	0.8	99.2	0.1	0.2	0.3	0.2
51 Other market services	44.4	9.7	6.6	13.6	25.6	59.0	4.6	10.1	16.6	9.3
52 Public administeration	9.2	87.7	0.4	0.9	1.9	12.3	87.1	0.2	0.3	0.2
53 Social insurance	0.0	100.0	0.0	0.0	0.0	10.3	89.7	0.0	0.0	0.0
54 Private non-profit services	51.5	47.2	0.2	0.3	0.8	96.2	0.2	0.9	1.4	1.2
55 Total	46.0	9.9	5.0	7.9	31.1	44.6	5.3	11.3	23.7	14.2

Note) Emission induced by Changes in Stocks were omitted here from the relation of the space.

plastics, textile, etc., exceed 50%. This is a good example to show how much the exportation influences on the environment. On the other hand, in Japan, the branches exceeding 50% are only maritime transport and ship-building. In absolutely many branches the emission induced by domestic final demand is higher than that by exportation.

5. Decomposition of Factors for Variation of Emission

Next, we will see how variation of CO_2 emitted from each branch occurred and whether it is due to the variation of final demand, the variation of intermediate input structure in the production or the variation of the CO_2 emission coefficient in the production.

The factor decomposition formula used here is as follows.

First the demand-supply balance of the domestic production is expressed in the following equation:

$$X = A^d X + F + E \tag{1}$$

Here, X: Domestic production column vector, A^d: intermediate input coefficient matrix (non-competitive import type), F: Domestic final consumption (column vector), E: Imports (column vector)

Developing this equation, we get

$$X = (I - A^d)^{-1}(F + E) = B(F + E) \tag{2}$$

Here we put $B = (I - A^d)^{-1}$. And we define the CO_2 emission coefficient C_i by the following equation.

$$(C_i) = C_i / X_i \tag{3}$$

Here, C_i: CO_2 emission in i-th branch. When each of this emission coefficient C_i is put on the main diagonal, the matrix is expressed as $\overline{C}$ and CO_2 emission column vector C is expressed by the following equation.

$$C = \overline{C}X \tag{4}$$

If the equation (2) is put in the equation (4), we get

$$C = \overline{C}B(F + E) \tag{5}$$

As the equation (5) holds true both in reference year (0) and in comparison year (1), we get

$$C_1 = \overline{C_1} B_1 (F_1 + E_1) \tag{6}$$

$$C_0 = \overline{C_0} B_0 (F_0 + E_0) \tag{7}$$

If we subtract the equation (7) from the equation (6) and simplify, we get

$$\begin{aligned}
\Delta C &= C_1 - C_0 \\
&= \overline{C_1} B_1 (F_1 + E_1) - \overline{C_0} B_0 (F_0 + E_0) \\
&= 1/2 \ (\overline{C_0} B_0 + \overline{C_1} B_1)(F_1 - F_0) \\
&+ 1/2 \ (\overline{C_0} B_0 + \overline{C_1} B_1)(E_1 - E_0) \\
&+ 1/4 \ (\overline{C_0} + \overline{C_1})(B_1 - B_0)(F_0 + E_0 + F_1 + E_1) \\
&+ 1/4 \ (\overline{C_1} - \overline{C_0})(B_0 + B_1)(F_0 + E_0 + F_1 + E_1)
\end{aligned} \tag{8}$$

The first term of the right hand side of this equation is supposed to express the effects of the variation of the domestic final demand; the second term the effects of the variation of the exportation, the third term the effects of the variation of the intermediate input coefficient matrix, the fourth term the influences due to the variation of the emission coefficient. The variation of CO_2 emitted from each branch was decomposed into these 4 factors and their calculated proportions are given in the Table 8 to the Table 11. The variation of CO_2 emitted from each branch in Japan and in Germany is represented for 2 different periods: 1980-1985 and 1985-1990. Here the domestic final demand is divided into the private final consumption, the government final consumption, etc. And when the emission by branch decreased on the whole, the sum total of the proportions for each factor is set to -100%.

First, as is shown in the Table 8 (1980-1985 in Germany), CO_2 emission decreased on the whole. We can see that this change was influenced most by the change of CO_2 emission coefficient. Although the increase of the private final consumption, government final consumption and, above all, the exportation acted toward an increase of the emission, the decrease of the fixed capital formation, change of the intermediate input coefficient and, above all, the fall of the CO_2 emission coefficient acted toward an decrease of the emission. All these effects led the emission to be decreased on the whole.

If we see by branch, the electricity which showed the greatest fall in the

Table 8: Factor Decomposition of the Changes in CO_2 Emission by Branch – Germany; 1980-1985 –

Branch	CO_2 Emission (1000 · CO_2t)			Contribution to the changes in CO_2 emission (%)							
				Changes in domestic final demand					Changes in exports	Changes in intermediate input coefficient	Changes in CO_2 emission coefficient
				Private final consumption	Governmental final consumption	Fixed capital formation		Changes in stocks			
	1980	1985	Changes			Equipment	Construction				
1 Agriculture	8745	8626	–119	136.3	13.3	–0.7	–3.7	278.4	444.3	–457.2	–510.6
2 Forestry and fishery	3154	2406	–748	21.6	1.1	–1.2	–3.0	–10.5	17.2	–26.1	–99.0
3 Electricity	274819	255879	–18940	67.8	6.2	–1.5	–7.7	–7.5	60.9	–29.2	–189.0
4 Gas	1070	244	–826	4.2	0.3	–0.1	–0.5	1.3	3.6	–4.8	–104.0
5 Water	123	115	–8	95.9	7.9	–1.7	–10.1	–2.9	29.7	–80.7	–138.2
6 Coal and cokes	10318	7420	–2898	3.1	0.9	–0.7	–2.2	–3.1	–4.7	–18.9	–74.3
7 Other mining	1044	846	–198	–1.1	0.7	–0.3	–1.6	29.2	–8.3	1.1	–119.8
8 Crude oil and natural gas	1006	1098	92	19.4	3.3	–1.1	–7.1	–68.1	–11.3	–85.5	250.3
9 Chemical products	22033	22784	751	2.1	14.8	–1.5	–18.4	–2.8	486.5	–90.5	–290.1
10 Petroleum products	23581	14227	–9354	–9.5	0.6	–0.2	–1.9	–13.6	5.8	–30.7	–50.6
11 Plastic products	1345	1299	–46	38.4	5.2	2.6	–20.4	–49.4	468.8	9.5	–554.6
12 Rubber products	1338	1156	–182	–0.4	1.9	–5.0	–1.4	–14.4	73.0	–47.0	–106.8
13 Stone and clay products	22945	18578	–4367	0.5	0.8	–0.1	–45.6	–10.1	13.0	–65.1	6.5
14 Ceramic products	1588	1160	–428	10.4	0.4	0.3	–9.7	–18.2	1.7	–20.8	–64.2
15 Glass products	6287	5458	–829	7.2	2.0	–2.2	–7.7	–23.5	100.9	–52.4	–124.2
16 Iron and steel	62692	51436	–11256	2.4	0.5	–3.2	–4.0	–6.1	30.4	–94.7	–25.3
17 Non-ferrous metals	3661	3642	–19	17.3	22.9	38.7	–207.8	–190.5	3008.5	–1738.3	–1050.9
18 Metal products	10211	7548	–2663	2.0	0.6	–3.7	–1.3	–7.8	21.3	–31.7	–79.4
19 General machinery	5487	4508	–979	0.4	0.4	–13.3	–1.5	1.3	33.1	1.1	–121.5
20 Office machine	211	238	27	5.1	1.0	289.9	–0.4	85.4	322.7	–1.4	–602.4
21 Automobile	5444	4834	–610	21.7	1.1	–23.7	–0.8	11.8	134.4	–11.7	–232.8
22 Ship	251	157	–94	0.6	2.3	–1.2	–0.2	–64.5	26.5	10.9	–74.4
23 Aircraft	218	180	–38	1.1	5.9	73.9	–0.2	–2.1	96.8	–56.5	–218.9
24 Electric machinery	4172	3548	–624	–7.7	0.8	19.1	–4.4	–3.5	74.8	0.7	–179.9
25 Precision machinery	534	455	–79	3.6	8.4	–15.7	–0.3	–22.2	56.0	–41.9	–87.9
26 Musical instrument, etc.	204	171	–33	57.2	0.7	–4.8	–0.7	–88.2	0.5	3.7	–68.3
27 Timber	1844	1124	–720	–1.7	0.3	–2.5	–8.5	–15.0	18.9	–9.1	–82.3
28 Wooden products	1654	1431	–223	–44.4	0.5	–23.4	–17.9	–68.8	16.2	–37.0	74.8
29 Pulp and paper	5536	5451	–85	95.0	25.3	5.0	–27.5	–54.5	1351.7	–597.2	–897.9
30 Paper products	1361	1091	–270	6.8	1.5	0.5	–3.3	–7.2	55.1	–28.2	–125.3
31 Printing and publishing	708	675	–33	102.9	10.7	3.8	–8.0	–3.6	123.7	–322.8	–6.8
32 Leather products	374	289	–85	–26.3	0.4	–0.3	–0.3	–19.3	30.7	–24.6	–60.2
33 Textile products	3918	3189	–729	–22.2	0.5	–1.6	–1.2	–2.4	39.8	–13.1	–99.9
34 Wearing apparel	810	596	–214	–19.1	0.3	0.0	–0.1	–27.7	15.3	0.2	–68.8
35 Foodstuffs and feeds	13572	11386	–2186	–2.6	0.9	0.0	–0.2	0.4	21.8	–28.9	–91.4
36 Beverages	3565	3064	–501	21.4	1.1	–0.1	–0.8	–15.5	16.3	–56.3	–66.1
37 Tobacco	156	137	–19	–48.7	0.1	–0.1	–0.3	–3.3	21.6	–14.1	–55.2
38 Construction	8785	7601	–1184	6.3	1.1	0.1	–91.5	–0.3	7.9	–1.4	–22.0
39 Wholesale	9417	9673	256	72.7	10.0	–25.5	–36.0	10.1	321.8	–105.5	–147.6
40 Retail trade	8890	9230	340	31.3	6.0	–5.3	–3.8	–14.5	8.2	5.3	72.8
41 Railway transport	3124	2633	–491	–2.9	1.7	–4.0	–4.9	–13.5	36.2	–30.6	–82.0
42 Maritime transport	3318	3051	–267	0.6	0.6	–0.4	–4.0	4.6	87.2	–67.3	–121.2
43 Post and communication	982	944	–38	253.1	11.6	–3.5	–17.1	–8.3	110.7	215.2	–661.8
44 Other transport services	17807	18950	1143	8.5	4.7	–4.6	–17.0	–18.4	160.5	93.4	–127.1
45 Financial services	872	981	109	83.5	2.2	–0.6	–2.8	–1.1	10.7	33.6	–25.6
46 Insurance	475	535	60	116.0	2.1	–0.4	–4.5	–1.2	16.0	31.8	–59.7
47 Real estate and house rent	243	239	–4	751.7	7.8	–2.6	–6.9	–3.7	49.4	243.6	–1139.3
48 Hotel and restaurant	3220	3001	–219	20.4	2.5	–0.9	–4.3	–3.5	36.3	–42.0	–108.4
49 Research and education	1036	1125	89	104.8	4.6	–0.4	–3.1	–2.0	32.7	90.6	–127.2
50 Health and medical services	1567	1573	6	1069.2	924.0	1.1	–4.9	13.7	45.1	101.6	–2049.9
51 Other market services	3937	4918	981	10.3	1.8	0.5	–2.3	–1.8	22.0	64.4	5.2
52 Public administeration	19809	20297	488	23.7	158.4	–0.2	–2.9	–1.3	14.6	63.2	–155.5
53 Social insurance	389	411	22	0.0	84.7	0.0	0.0	0.0	0.0	0.2	15.2
54 Private non-profit services	2489	2458	–31	474.8	194.9	0.0	–2.0	–1.0	15.5	530.3	–1312.4
55 Total	592339	534066	–58273	24.3	4.6	–1.9	–10.6	–8.7	52.3	–44.7	–115.3

CO_2 emission owes its drop most to the decline of the CO_2 emission coefficient as with the overall change. However in the iron and steel, 2nd branch in the decrease of the emission, the situation is somewhat different. In this branch the decrease of CO_2 emission is due to the change of the intermediate input coefficient rather than the decline of the CO_2 emission coefficient. Although many branches decreased their CO_2 emission owing to the change of the CO_2 emission coefficient or the intermediate input coefficient, some branches showed its increase to the contrary. We can see, for example, the branch of other transport showing the greatest increase owes its increase to the growth of exportation and the branch of other market services to a change of the intermediate input coefficient, thus increasing a lot CO_2 emission.

We can see the same phenomena from the Table 9, for the Japanese situation of the corresponding period (1980-1985), that there was the decline of CO_2 emission coefficient which influenced most on the overall decrease and that the reduction of construction investment acted negatively as in Germany. However the situation is a little different in that the growth of the private final consumption acted more positively than the exportation and that the increase of the equipment investment was also a positive factor.

By branch, unlike Germany, it was not electricity but stone and clay products that decreased the emission the most. For its decrease, the change of the intermediate input coefficient and the decline of the CO_2 emission coefficient played almost the same role. The second branch which showed a significant decrease was iron and steel. The cause is attributed solely to a change of the intermediate input coefficient. The growth of the private final consumption, the exportation and CO_2 emission coefficient acted positively. However a technological change to save iron and steel to be use, exceeding this increase, brought about a decrease on the whole.

Significant differences from Germany in this period are that the change of CO_2 emission in the electricity was not a decrease but an increase and that, on the other hand, the CO_2 emission in other market services decreased to the contrary. First, regarding with electricity, the change of the intermediate input coefficient and the decline of CO_2 emission coefficient acted negatively. But the growth of the private final consumption, the equipment investment, and the exportation offset it and acted positively for an increase of CO_2 as a result. And unlike Germany, the other market services decreased CO_2 owing to a decline of CO_2 emission coefficient, which was

Table 9: Factor Decomposition of the Changes in CO_2 Emission by Branch – Japan; 1980-1985 –

Branch	CO_2 Emission ($1000 \cdot CO_2t$)			Contribution to the changes in CO_2 emission (%)							
				Changes in domestic final demand					Changes in exports	Changes in intermediate input coefficient	Changes in CO_2 emission coefficient
				Private final consumption	Governmental final consumption	Fixed capital formation		Changes in stocks			
	1980	1985	Changes			Equipment	Construction				
1 Agriculture	7305	6083	−1222	66.6	0.6	−0.1	−0.3	31.7	1.0	−46.7	−152.8
2 Forestry and fishery	16636	12964	−3672	9.6	0.6	3.9	−1.7	3.9	5.9	−24.3	−97.9
3 Electricity	235925	239542	3617	896.8	46.9	221.7	−24.1	−1.8	284.8	−779.2	−545.2
4 Gas	1725	1151	−574	76.1	1.3	4.0	−0.6	0.1	6.6	−16.8	−170.8
5 Water	291	533	242	28.2	1.8	2.7	−0.3	0.1	3.5	5.4	58.7
6 Coal and cokes	14796	12123	−2673	24.0	1.5	23.7	−3.3	8.0	15.5	−46.7	−122.7
7 Other mining	1054	771	−283	44.1	0.9	26.3	−1.5	75.1	38.6	20.8	−304.3
8 Crude oil and natural gas	190	241	51	27.4	2.8	11.8	−1.5	−78.3	17.4	42.9	77.6
9 Chemical products	33698	40057	6359	78.3	3.9	20.1	−1.3	−1.6	43.8	3.1	−46.3
10 Petroleum products	33933	35875	1942	149.7	10.8	40.5	−7.8	10.9	59.8	−396.9	233.0
11 Plastic products	3251	1586	−1665	145.2	0.2	2.4	−0.3	6.7	96.6	2071.1	−2422.1
12 Rubber products	1799	862	−937	14.2	0.5	4.7	−1.2	0.1	20.5	−9.1	−129.6
13 Stone and clay products	91846	65720	−26126	12.1	0.4	3.0	−5.5	−2.4	2.6	−52.5	−57.8
14 Ceramic products	2103	1531	−572	16.5	0.7	6.2	−2.4	−4.5	17.2	−1.3	−132.4
15 Glass products	4397	5035	638	55.2	2.2	26.0	−3.8	5.8	74.7	15.0	−75.1
16 Iron and steel	153407	137646	−15761	20.0	1.5	46.0	−7.0	13.2	14.8	−292.8	104.4
17 Non-ferrous metals	8946	5669	−3277	10.3	0.5	21.4	−0.8	−6.1	24.5	−41.4	−108.5
18 Metal products	22858	19405	−3453	9.6	1.2	25.2	−6.2	−2.5	43.3	74.9	−245.4
19 General machinery	4961	3583	−1378	5.3	0.6	63.9	−0.5	−6.0	22.0	−58.3	−127.0
20 Office machine	618	503	−115	27.4	0.3	499.4	7.4	−3.8	364.7	52.5	−1047.9
21 Automobile	4031	5312	1281	25.7	0.5	−1.3	−5.4	0.1	70.8	56.5	−46.9
22 Ship	506	349	−157	0.8	1.1	20.9	−0.8	−38.1	50.3	24.7	−159.1
23 Aircraft	263	150	−113	2.7	7.9	121.9	−0.1	−21.1	−28.4	95.2	−278.1
24 Electric machinery	7447	4772	−2675	18.5	0.4	36.9	1.6	−0.4	58.5	15.5	−231.0
25 Precision machinery	826	427	−399	4.1	0.2	14.6	−0.2	1.3	16.3	−4.1	−132.2
26 Musical instrument, etc.	4584	2564	−2020	8.0	0.8	11.4	−0.6	1.7	9.6	−125.1	−5.8
27 Timber	728	206	−522	3.5	0.2	2.4	−1.5	−1.5	1.4	−21.9	−82.7
28 Wooden products	1174	444	−730	9.8	0.4	9.9	−1.6	−2.2	3.3	−31.0	−88.7
29 Pulp and paper	14584	17198	2614	69.6	4.3	18.7	−2.1	−10.8	36.7	−57.7	41.3
30 Paper products	470	1188	718	13.0	0.5	3.7	−0.3	0.6	4.1	3.8	74.7
31 Printing and publishing	506	715	209	28.1	3.2	7.8	−0.7	−0.2	11.7	5.5	44.7
32 Leather products	173	232	59	15.3	0.4	3.9	−0.2	0.0	9.1	−16.9	88.5
33 Textile products	7648	6730	−918	−18.2	1.5	13.9	0.1	−5.4	−5.6	−111.9	25.6
34 Wearing apparel	1101	1507	406	70.0	0.6	8.9	−0.2	2.1	5.1	7.1	6.4
35 Foodstuffs and feeds	9798	9646	−152	1353.6	5.6	15.4	−2.0	117.2	14.2	423.6	−2027.6
36 Beverages	2242	2415	173	53.7	1.7	6.9	−0.8	11.8	7.9	−19.1	37.9
37 Tobacco	355	225	−130	6.8	0.1	0.7	−0.1	−13.9	1.2	3.5	−98.2
38 Construction	18048	21229	3181	5.6	0.6	1.0	−13.1	0.1	1.3	2.7	101.9
39 Wholesale	12879	16809	3930	21.2	1.0	29.2	−1.7	1.7	26.3	−32.8	55.2
40 Retail trade	22757	19629	−3128	140.8	1.0	−7.5	−3.8	0.6	5.3	−72.7	−163.6
41 Railway transport	2532	2450	−82	195.2	20.7	54.0	−6.1	2.5	51.8	−318.8	−99.3
42 Maritime transport	38726	34383	−4343	10.0	1.1	8.8	−1.9	0.3	−17.2	−5.3	−95.8
43 Post and communication	1043	796	−247	117.3	2.4	11.5	−1.0	0.3	13.8	5.7	−249.9
44 Other transport services	30978	39218	8240	13.0	1.7	9.8	−1.8	1.1	18.5	28.2	29.5
45 Financial services	437	376	−61	183.3	2.6	20.7	−2.1	0.1	22.1	30.3	−356.9
46 Insurance	280	210	−70	129.9	0.4	2.4	−0.5	0.3	2.6	36.7	−271.8
47 Real estate and house rent	809	1287	478	22.2	0.2	1.3	−0.2	0.1	1.6	−1.0	75.8
48 Hotel and restaurant	9104	10320	1216	61.0	2.4	10.6	−1.2	1.3	19.6	−5.9	12.1
49 Research and education	7913	9911	1998	91.2	1.5	13.6	−0.9	0.3	20.1	36.1	−61.9
50 Health and medical services	4380	5516	1136	141.0	0.1	0.3	0.0	0.1	0.3	2.9	−44.6
51 Other market services	36468	31194	−5274	85.8	5.3	23.9	−2.6	2.9	35.6	−39.0	−211.9
52 Public administeration	16450	16487	37	1433.0	5040.2	29.5	−4.0	3.1	57.4	127.1	−6586.4
53 Social insurance	511	788	277	−2.1	10.6	0.0	0.0	0.0	0.0	0.0	91.6
54 Private non-profit services	4608	6226	1618	63.8	0.3	3.3	−0.3	−0.1	4.7	3.4	24.8
55 Total	904099	861814	−42285	180.1	12.9	67.4	−12.4	5.5	75.8	−164.7	−264.5

the most significant factor. Among other branches, the other transport increased the emission as in Germany. It is because an growth of domestic final demands and exportation and changes in the intermediate input coefficient and CO_2 emission coefficient contributed each to the increase for about 20 to 30%.

Looking at the situation of the latter half of the 1980's in Germany in the Table 10, we can see that the decrease of CO_2 emission continued because of the change of the intermediate input coefficient and, above all, the drop of CO_2 emission coefficient as during the first half of the 1980's. However, contrary to the first half, equipment investment and construction investment increased, acting positively to the emission of CO_2. Unlike the first half of the 1980's, it was not electricity but iron and steel that decreased emission of CO_2 the most. It was solely due to a change of the intermediate input coefficient. The second branch in decrease of CO_2 emission was public administration. The main reason is the decline of CO_2 emission coefficient. It is a unique characteristic compared with the first half of the 1980's and Japan.

Among others, electricity decreased its CO_2 emission by a change of the intermediate input coefficient and a decline of the CO_2 emission coefficient, chemical products, stone and clay products, glass products, etc., by a drop of CO_2 emission coefficient. Coal/cokes also decreased its emission due to mainly a change of the intermediate input coefficient. In the tendency of decrease on the whole, the other transport, the other market services and the wholesales/retail trade increased CO_2 emission. In case of the other transport and the wholesale and retail trade, an increase of the private final consumption gave a great influence, an increase of exportation acting positively. However the other market services increased CO_2 emission by the influence of a change of the intermediate input coefficient. This is a tendency which continued since the first half of the 1980's and is also one of the differences from Japan.

Lastly we will consider the latter half of the 1980's of Japan with the Table 11. This is the only period when there was an increase of CO_2 emission on the whole, compared with Germany and the first half of the 1980's of Japan. We can understand that the increase was caused because the CO_2 emission coefficient went up and the private final consumption and the construction investment acted positively to a similar degree. In particular, the influence of the construction investment was significant.

Table 10: Factor Decomposition of the Changes in CO_2 Emission by Branch – Germany; 1985-1990 –

Branch	CO_2 Emission (1000 · CO_2t)			Contribution to the changes in CO_2 emission (%)							
				Changes in domestic final demand							
				Private final consumption	Governmental final consumption	Fixed capital formation		Changes in stocks	Changes in exports	Changes in intermediate input coefficient	Changes in CO_2 emission coefficient
						Equipment	Construction				
	1980	1985	Changes								
1 Agriculture	8626	7870	–756	76.5	2.6	1.3	0.9	–36.3	71.7	–78.6	–138.1
2 Forestry and fishery	2406	2325	–81	238.1	11.8	28.5	68.3	719.0	182.5	600.4	–1948.5
3 Electricity	255879	254159	–1720	926.1	82.6	182.4	83.9	41.7	605.0	–939.3	–1082.5
4 Gas	244	453	209	12.7	0.8	1.4	0.9	–2.9	7.9	–4.4	83.6
5 Water	115	117	2	628.1	43.0	49.6	43.2	3.6	160.4	215.4	–1043.3
6 Coal and cokes	7420	6089	–1331	0.8	2.1	7.5	4.3	–2.7	–21.7	–178.6	88.3
7 Other mining	846	821	–25	111.6	7.1	24.3	14.7	–4.0	12.8	–546.1	279.7
8 Crude oil and natural gas	1098	1063	–35	289.2	12.7	24.3	18.8	–81.8	89.6	–595.9	143.1
9 Chemical products	22784	21706	–1078	99.8	14.8	14.9	11.6	–22.2	265.6	5.3	–489.9
10 Petroleum products	14227	13244	–983	229.4	4.9	8.5	11.9	13.2	64.2	–177.8	–254.2
11 Plastic products	1299	1535	236	27.2	1.3	15.6	5.0	1.7	100.9	48.8	–100.5
12 Rubber products	1156	964	–192	73.4	1.9	15.9	1.3	–45.7	61.5	–17.6	–190.6
13 Stone and clay products	18578	17103	–1475	23.9	2.9	5.2	106.2	20.2	27.4	42.0	–327.8
14 Ceramic products	1160	1224	64	–56.1	2.7	8.7	47.4	119.0	82.3	–95.1	–8.9
15 Glass products	5458	4192	–1266	13.7	1.5	7.1	3.3	3.5	35.6	2.8	–167.6
16 Iron and steel	51436	46987	–4449	19.9	1.4	33.5	12.5	14.0	25.8	–219.9	12.9
17 Non-ferrous metals	3642	3133	–509	10.7	1.0	18.3	1.4	21.8	92.9	35.8	–281.9
18 Metal products	7548	7236	–312	61.4	5.2	136.0	56.0	14.2	203.7	94.9	–671.4
19 General machinery	4508	4040	–468	6.3	0.8	96.6	1.6	–0.8	74.3	–15.8	–263.0
20 Office machine	238	190	–48	3.6	0.7	94.0	0.3	–37.0	43.9	66.7	–272.2
21 Automobile	4834	3970	–864	27.9	0.6	37.6	0.4	3.9	57.6	–8.9	–219.2
22 Ship	157	145	–12	22.6	16.4	18.2	2.1	43.3	166.1	–272.4	–96.4
23 Aircraft	180	188	8	52.1	26.6	–274.6	3.2	32.9	204.6	667.9	–612.6
24 Electric machinery	3548	3299	–249	36.0	2.3	79.6	10.1	24.5	183.7	118.8	–554.9
25 Precision machinery	455	406	–49	72.8	20.5	13.5	0.7	–51.1	35.2	55.7	–247.4
26 Musical instrument, etc.	171	164	–7	647.6	4.3	6.7	3.2	–219.5	142.9	61.6	–746.7
27 Timber	1124	1092	–32	172.3	6.1	100.2	115.4	289.7	273.1	–363.9	–693.0
28 Wooden products	1431	1441	10	1456.4	15.5	915.3	197.6	–636.6	492.5	527.1	–2867.7
29 Pulp and paper	5451	6153	702	34.0	4.1	6.5	3.4	6.8	108.8	12.8	–76.5
30 Paper products	1091	1165	74	101.8	6.9	13.7	10.4	43.8	176.2	100.4	–353.0
31 Printing and publishing	675	744	69	67.0	6.8	12.2	4.8	4.5	78.8	59.8	–134.0
32 Leather products	289	216	–73	–134.0	0.7	1.1	0.3	48.9	13.5	31.9	–62.3
33 Textile products	3189	2818	–371	–107.2	1.3	1.4	1.7	73.8	35.4	55.8	–162.3
34 Wearing apparel	596	482	–114	–32.8	0.7	0.3	0.2	32.2	16.0	4.3	–120.7
35 Foodstuffs and feeds	11386	10536	–850	140.7	2.6	1.4	0.8	–23.8	98.3	–9.6	–310.5
36 Beverages	3064	2793	–271	119.4	2.5	3.0	1.5	–50.3	62.3	–32.2	–206.0
37 Tobacco	137	130	–7	–18.9	0.5	1.4	0.9	–52.4	81.8	47.7	–160.9
38 Construction	7601	7374	–227	67.6	7.0	6.0	410.1	0.4	0.7	17.0	–608.7
39 Wholesale	9673	10679	1006	102.6	3.7	0.5	9.0	–5.8	43.6	12.5	–66.0
40 Retail trade	9230	9871	641	214.2	6.2	3.2	1.9	28.3	4.6	22.0	–180.5
41 Railway transport	2633	1966	–667	34.7	1.2	5.6	2.8	1.9	32.6	–61.2	–117.5
42 Maritime transport	3051	2699	–352	16.6	0.6	1.9	2.3	–3.9	–60.8	2.9	–59.6
43 Post and communication	944	1155	211	129.1	2.8	4.3	3.2	0.6	18.8	2.1	–60.9
44 Other transport services	18950	25127	6177	63.8	1.4	6.0	3.2	2.1	31.7	–2.8	–5.3
45 Financial services	981	1044	63	742.3	5.6	6.9	5.6	0.9	21.6	–331.7	–351.1
46 Insurance	535	555	20	664.8	8.5	12.0	13.8	2.1	47.0	77.6	–725.7
47 Real estate and house rent	239	218	–21	176.1	2.5	2.3	1.8	1.1	10.3	97.7	–391.8
48 Hotel and restaurant	3001	2776	–225	45.9	3.4	10.8	4.3	1.3	44.9	35.0	–245.6
49 Research and education	1125	1056	–69	42.9	8.6	11.2	5.8	0.5	81.8	115.9	–366.6
50 Health and medical services	1573	1453	–120	24.3	81.3	0.5	0.5	–0.3	2.1	70.0	–278.4
51 Other market services	4918	7102	2184	21.5	1.6	5.0	2.9	0.2	11.0	57.4	0.4
52 Public administeration	20297	17895	–2402	25.2	36.5	0.8	2.9	0.0	2.8	–9.5	–158.7
53 Social insurance	411	462	51	0.0	74.4	0.0	0.0	0.0	0.0	0.0	25.6
54 Private non-profit services	2458	2353	–105	540.1	85.3	1.1	2.3	0.4	3.7	140.3	–873.2
55 Total	534066	523978	–10088	332.4	32.7	75.7	57.3	23.6	242.7	–276.5	–587.9

Table 11: Factor Decomposition of the Changes in CO_2 Emission by Branch – Japan; 1985-1990 –

Branch	CO_2 Emission (1000 · CO_2t)			Contribution to the changes in CO_2 emission (%)							
				Changes in domestic final demand					Changes in exports	Changes in intermediate input coefficient	Changes in CO_2 emission coefficient
				Private final consumption	Governmental final consumption	Fixed capital formation		Changes in stocks			
	1980	1985	Changes			Equipment	Construction				
1 Agriculture	6083	7162	1079	27.9	1.3	4.7	5.2	−16.0	−0.3	−43.2	120.4
2 Forestry and fishery	12964	17057	4093	−8.9	0.8	3.5	20.5	3.3	−2.4	−45.8	129.0
3 Electricity	239542	309515	69973	54.4	2.7	17.4	18.6	1.0	0.7	12.2	−7.1
4 Gas	1151	1135	−16	1879.6	32.2	132.6	179.1	3.6	34.6	−341.4	−2020.3
5 Water	533	415	−118	40.1	4.5	9.3	12.3	0.2	1.9	−19.1	−149.2
6 Coal and cokes	12123	14381	2258	32.9	1.9	43.5	73.0	9.3	−88.1	10.2	17.3
7 Other mining	771	641	−130	−8.2	1.9	36.5	33.3	−5.2	−26.3	−506.7	374.7
8 Crude oil and natural gas	241	34	−207	13.9	0.5	3.3	4.3	13.8	0.5	−39.7	−96.7
9 Chemical products	40057	47008	6951	61.7	4.3	19.3	20.4	2.7	31.8	43.9	−84.3
10 Petroleum products	35875	23288	−12587	42.0	1.4	8.4	15.3	4.6	2.4	−47.0	−127.1
11 Plastic products	1586	2155	569	17.8	1.1	21.4	22.6	1.1	9.7	24.3	2.0
12 Rubber products	862	1740	878	18.2	0.4	9.0	6.7	−0.2	6.0	10.0	49.8
13 Stone and clay products	65720	73661	7941	20.3	1.2	12.5	264.1	8.2	2.0	−134.4	−74.0
14 Ceramic products	1531	1895	364	13.0	1.1	15.3	63.7	6.0	−15.8	10.2	6.4
15 Glass products	5035	4944	−91	415.2	15.9	338.1	396.4	−45.7	110.4	−207.6	−1122.7
16 Iron and steel	137646	142380	4734	103.6	6.7	285.9	364.9	−6.0	−851.5	−2897.2	3093.6
17 Non-ferrous metals	5669	6380	711	42.4	2.2	95.4	70.4	45.5	−52.2	−766.0	662.3
18 Metal products	19405	19214	−191	408.7	25.6	1340.1	1334.4	176.9	594.1	3664.5	−7644.4
19 General machinery	3583	5154	1571	7.6	0.6	38.6	3.3	1.5	5.6	15.5	27.4
20 Office machine	503	522	19	174.1	0.8	898.3	28.9	56.7	1133.2	786.1	−2978.1
21 Automobile	5312	5397	85	977.1	7.9	537.2	182.8	17.4	26.9	198.9	−1848.1
22 Ship	349	318	−31	9.6	6.4	−105.5	3.7	59.2	−337.2	−18.8	282.7
23 Aircraft	150	143	−7	52.8	97.9	−132.1	15.3	97.8	280.5	397.5	−909.7
24 Electric machinery	4772	5140	368	144.3	1.9	237.4	24.2	−5.0	7.6	−63.8	−246.7
25 Precision machinery	427	680	253	9.1	0.3	30.5	2.9	−2.2	3.6	−10.6	66.3
26 Musical instrument, etc.	2564	3037	473	38.5	3.0	28.0	26.9	2.7	3.4	9.5	−12.0
27 Timber	206	888	682	1.7	0.2	1.4	19.6	0.5	0.0	−18.6	95.2
28 Wooden products	444	687	243	3.6	0.7	9.8	32.5	7.2	1.3	−25.2	70.2
29 Pulp and paper	17198	15993	−1205	107.6	9.1	61.9	75.7	−6.1	32.9	31.1	−412.2
30 Paper products	1188	1036	−152	83.9	3.1	35.7	27.5	−0.4	12.3	9.2	−271.4
31 Printing and publishing	715	1119	404	20.9	2.3	10.5	8.0	1.6	2.7	20.8	33.2
32 Leather products	232	302	70	14.5	0.6	6.5	4.7	9.5	−14.1	8.2	70.2
33 Textile products	6730	4725	−2005	20.6	0.4	6.7	6.6	−3.3	−9.8	−16.0	−105.3
34 Wearing apparel	1507	1340	−167	92.0	1.6	19.0	10.8	12.6	−7.1	−1.8	−227.1
35 Foodstuffs and feeds	9646	12221	2575	−7.3	1.1	2.2	2.2	−4.0	−0.3	−18.8	125.0
36 Beverages	2415	2916	501	139.8	0.8	5.5	5.1	−1.9	0.7	16.9	−66.8
37 Tobacco	225	243	18	−142.7	0.7	7.0	5.9	35.9	6.3	−84.7	271.6
38 Construction	21229	31481	10252	2.9	0.2	0.8	90.2	0.0	0.1	−1.7	7.5
39 Wholesale	16809	16975	166	1732.7	26.9	1602.5	514.0	−10.8	−143.5	1243.2	−4864.9
40 Retail trade	19629	17252	−2377	81.9	0.9	13.6	8.7	0.0	1.1	−17.3	−189.0
41 Railway transport	2450	1483	−967	26.7	1.1	6.7	5.3	0.0	0.5	−3.9	−136.4
42 Maritime transport	34383	34657	274	675.7	18.8	338.2	446.6	16.9	−366.4	458.6	−1488.4
43 Post and communication	796	1018	222	49.1	2.9	18.1	15.9	0.4	10.9	463.8	−461.0
44 Other transport services	39218	63134	23916	36.5	0.8	9.4	12.4	0.0	5.9	10.1	25.0
45 Financial services	376	778	402	25.1	0.7	6.4	6.2	0.2	5.8	−1.1	56.9
46 Insurance	210	468	258	12.2	0.1	1.4	2.4	0.0	−0.1	−10.3	94.2
47 Real estate and house rent	1287	3466	2179	22.3	0.1	1.5	1.1	0.0	0.2	1.7	73.2
48 Hotel and restaurant	10320	8395	−1925	74.2	1.5	13.1	11.8	0.3	5.7	−41.5	−165.0
49 Research and education	9911	13853	3942	−105.6	1.1	21.1	9.7	0.7	8.0	1.7	163.4
50 Health and medical services	5516	6218	702	15.3	0.1	1.0	0.9	0.0	0.1	−11.6	94.2
51 Other market services	31194	26970	−4224	159.9	5.2	46.8	42.2	1.0	6.6	−204.8	−157.0
52 Public administeration	16487	20286	3799	5.8	52.5	0.5	0.6	0.0	−0.2	−4.7	45.6
53 Social insurance	788	523	−265	−11.8	37.5	0.0	0.0	0.0	0.0	0.0	−125.7
54 Private non-profit services	6226	4049	−2177	57.9	0.2	2.4	2.7	0.1	0.3	−34.7	−128.9
55 Total	861814	985900	124086	67.3	4.8	38.0	64.5	2.1	−29.7	−119.1	72.0

If we see by branch, we know that the construction, the stone and clay products, coal/cokes, etc. increased the emission owing to a growth of the construction investment. However, the electricity which increased the CO_2 emission the most owes its increase to the growth of the private final consumption rather than the construction investment. Though the decline of the CO_2 emission coefficient acted a little negatively, the expansion of the domestic final demand because of the economic boom offset it and acted largely positively. And the other transport is the second branch in CO_2 emission because the influence of the expansion of the domestic final demand such as the private final consumption, etc., was great and there was no negative factor. In the increasing tendency as a whole, contrary to the situation in Germany, CO_2 emission from the branch of petroleum products decreased significantly. This can be explained by the negative effect owing to the decline of CO_2 emission coefficient which offset and exceeded the positive effect due to the expansion of the domestic final demands. For the same reason, the retail trade and the non-market services decreased CO_2 emission. And the other market services was the second branch in the decrease of CO_2 emission, having a negative effect due to a change of the intermediate input coefficient.

When we analyze the variations of CO_2 emission for consideration over 2 divided periods in Japan and Germany, we find that we can divide the 1980's in Japan into 2 distinctive periods regarding the CO_2 emission due to the Japanese extraordinary economic boom in the latter half of the 1980's, while in Germany the key tendency remained unchanged. We can find a great difference between these two countries in that in Japan the CO_2 emission coefficient went up on the whole with the economic boom, whereas in Germany there was a steady decreasing tendency of CO_2 emission in spite of the increasing tendency of the domestic final demands. However it is to be noted that the both countries had a steady tendency of CO_2 increase in the other transport, especially in the land transport, for reason of not merely the domestic final demands but other factors.

6. Decomposition of Factors for the Differences in CO_2 Emission between Japan and Germany

In the previous section, we have seen tendencies of CO_2 emission in Japan and Germany. In this section we will consider causes of differences of CO_2

emission between Japan and Germany through factor decomposition analysis. We use the following expressions for the analysis, in application of the formula (8) of the preceding section.

$$\begin{aligned}\Delta C &= C_J - C_G \\ &= \overline{C_J} B_J (F_J + E_J) - \overline{C_G} B_G (F_G + E_G) \\ &= 1/2\ (\overline{C_G} B_G + \overline{C_J} B_J)(F_J - F_G) \\ &+ 1/2\ (\overline{C_G} B_G + \overline{C_J} B_J)(E_J - E_G) \\ &+ 1/4\ (\overline{C_G} + \overline{C_J})(B_J - B_G)(F_G + E_G + F_J + E_J) \\ &+ 1/4\ (\overline{C_J} - \overline{C_G})(B_G + B_J)(F_G + E_G + F_J + E_J) \end{aligned} \quad (9)$$

(Here, the suffix J or G means the vector/the matrix of Japan or of Germany)

We can understand from these expressions that we need to unify the currency units. Here the calculation was made converting Yen into D-Mark by the exchange rate[18]. And the result of the analysis is considered around the year 1990.

We can see from the Table 12 that CO_2 emitted directly or indirectly from the production in Japan, excluding CO_2 emitted directly at the private final consumption, is very different from Germany on the whole, if not doubled. 55% of this difference can be explained by a considerable difference in the private final consumption. And 30.2% is attributable to the difference in the construction investment. In this way the overall difference can be explained by the difference of the domestic final demands reflecting also the difference of the population. The other factors are to be offset mutually. The exportation gives 17% negative effect in the difference of the emission. This means that Germany has more emission in the exportation, acting toward diminishing the overall difference. What is to be noted is the CO_2 emission coefficient. 6.3% is a small value on the whole but acts toward increasing the difference. That is, the CO_2 emission coefficient is smaller in Germany, contributing to the difference of emission between Japan and Germany. However, comparing the analysis results for 1980 and 1985 mentioned in the note, we see that this coefficient was higher in the past in Germany and reversed in 1990. This was the change occurring only in CO_2 emission coefficient while the other sources such as the domestic final demands and the exportation had kept almost the same tendency as in the 1980's.

Seen by branch, the iron and steel show the biggest difference. We can see

Table: 12 Factor Decomposition of the Differences in CO_2 Emission between Germany and Japan (1990)

Branch	CO_2 Emission (1000 · CO_2t)			Contribution to the differences in CO_2 emission (%)							
				Differences in domestic final demand					Differences in exports	Differences in intermediate input coefficient	Differences in CO_2 emission coefficient
				Private final consumption	Governmental final consumption	Fixed capital formation		Changes in stocks			
	Japan	Germany	Difference			Equipment	Construction				
1 Agriculture	7162	7870	−708	972.7	−7.8	54.6	18.0	−4.1	−151.6	175.8	−1157.6
2 Forestry and fishery	17057	2325	14732	33.4	−0.7	1.2	7.4	−3.1	−5.9	30.1	37.6
3 Electricity	309515	254159	55356	216.8	−0.5	39.8	51.1	3.4	−34.7	34.3	−210.1
4 Gas	1135	453	682	39.2	−0.7	4.0	7.1	−0.1	−5.9	−61.5	117.8
5 Water	415	117	298	81.5	−1.3	4.0	7.4	0.3	−2.6	−3.0	13.7
6 Coal and cokes	14381	6089	8292	22.5	0.2	11.7	31.0	5.0	−29.4	−33.3	92.3
7 Other mining	641	821	−180	44.3	−1.6	31.3	46.2	−3.2	−316.3	−468.9	568.1
8 Crude oil and natural gas	34	1063	−1029	17.3	0.2	3.0	6.1	2.3	−9.5	−55.1	−64.5
9 Chemical products	47008	21706	25302	43.8	−1.7	8.5	11.5	2.3	−38.8	28.6	45.9
10 Petroleum products	23288	13244	10044	36.5	−0.2	9.3	24.8	6.0	−10.8	30.2	4.1
11 Plastic products	2155	1535	620	60.7	−0.3	36.2	61.3	3.3	−54.3	79.7	−86.7
12 Rubber products	1740	964	776	36.8	−0.3	18.6	12.5	11.3	−2.3	84.8	−61.4
13 Stone and clay products	73661	17103	56558	4.7	0.1	1.8	69.5	0.8	−4.6	−20.0	47.7
14 Ceramic products	1895	1224	671	17.8	−1.3	10.3	93.4	4.5	−7.0	75.0	−92.7
15 Glass products	4944	4192	752	139.2	−4.7	57.1	100.5	15.1	−99.7	62.1	−169.6
16 Iron and steel	142380	46987	95393	8.9	0.2	13.5	19.8	1.1	−36.5	−6.9	99.8
17 Non-ferrous metals	6380	3133	3247	17.1	0.1	20.5	20.2	3.4	−72.6	−37.8	149.1
18 Metal products	19214	7236	11978	10.5	0.3	18.0	22.4	2.8	−1.4	60.8	−13.5
19 General machinery	5154	4040	1114	26.4	0.1	144.9	28.8	11.2	−82.5	77.5	−106.4
20 Office machine	522	190	332	15.9	0.0	94.5	3.3	5.7	87.8	41.8	−149.1
21 Automobile	5397	3970	1427	50.1	0.2	40.9	14.7	−1.3	0.8	135.5	−140.9
22 Ship	318	145	173	5.0	3.9	48.6	2.0	12.9	77.2	15.6	−65.1
23 Aircraft	143	188	−45	46.2	30.8	57.4	7.2	−8.7	−218.8	−143.5	129.4
24 Electric machinery	5140	3299	1841	51.7	0.4	81.4	14.0	1.1	14.4	31.6	−94.5
25 Precision machinery	680	406	274	47.6	−15.8	69.7	5.5	13.8	31.1	−29.3	−22.6
26 Musical instrument, etc.	3037	164	2873	17.2	−0.3	9.7	5.7	2.5	3.8	33.0	28.3
27 Timber	888	1092	−204	−3.9	−0.9	20.4	318.3	−26.4	−84.6	409.1	−731.9
28 Wooden products	687	1441	−754	−31.7	−0.3	7.3	49.2	10.0	−17.9	2.1	−118.8
29 Pulp and paper	15993	6153	9840	36.3	−0.8	8.9	12.3	−0.1	−22.5	78.6	−12.6
30 Paper products	1036	1165	−129	264.8	−7.4	74.5	97.1	−9.7	−162.8	61.6	−418.1
31 Printing and publishing	1119	744	375	129.7	−1.8	23.1	20.0	3.2	−15.4	127.7	−186.4
32 Leather products	302	216	86	198.5	−2.0	7.4	8.8	−27.1	−66.3	23.5	−42.8
33 Textile products	4725	2818	1907	118.3	−0.4	14.1	9.4	−10.2	−32.3	37.8	−36.7
34 Wearing apparel	1340	482	858	84.9.0	−0.2	5.8	2.4	3.6	−11.6	12.0	3.1
35 Foodstuffs and feeds	12221	10536	1685	473.0	−3.3	7.5	7.7	5.0	−91.2	−17.6	−281.1
36 Beverages	2916	2793	123	2659.3	−15.5	51.2	52.9	71.2	−122.0	−12.3	−2584.9
37 Tobacco	243	130	113	63.0	−0.1	1.5	1.4	0.9	−14.3	−13.1	60.7
38 Construction	31481	7374	24107	3.0	0.1	0.5	90.1	0.0	−0.5	−2.1	8.8
39 Wholesale	16975	10679	6296	90.1	−1.2	74.8	31.5	2.4	−5.0	31.8	−124.3
40 Retail trade	17252	9871	7381	127.6	−2.8	10.7	4.6	0.1	−0.3	15.4	−55.2
41 Railway transport	1483	1966	−483	541.0	0.7	14.0	37.7	1.4	−65.5	170.2	−799.5
42 Maritime transport	34657	2699	31958	8.0	0.0	2.5	4.7	0.3	22.8	15.9	45.9
43 Post and communication	1018	1155	−137	236.2	−4.6	61.2	89.8	4.2	−17.4	927.7	−1397.1
44 Other transport services	63134	25127	38007	57.6	−0.2	10.3	14.3	0.7	−7.8	13.5	11.7
45 Financial services	778	1044	−266	98.4	−4.6	19.7	29.1	1.1	45.0	72.8	−361.5
46 Insurance	468	555	−87	495.9	−1.7	19.4	43.6	1.1	−4.7	−107.8	−545.8
47 Real estate and house rent	3466	218	3248	28.2	−0.1	1.4	1.3	0.1	−0.3	−3.4	72.9
48 Hotel and restaurant	8395	2776	5619	86.2	−0.2	4.6	4.9	0.2	0.0	17.9	−13.6
49 Research and education	13853	1056	12797	4.8	0.0	8.4	4.4	0.5	−2.4	24.5	59.7
50 Health and medical services	6218	1453	4765	85.6	−9.4	0.2	0.2	0.0	−0.1	−23.6	47.1
51 Other market services	26970	7102	19868	46.9	−0.5	8.8	11.4	0.4	−0.1	−16.2	49.3
52 Public administeration	20286	17895	2391	86.6	192.0	3.9	4.9	0.3	−3.6	−95.0	−89.0
53 Social insurance	523	462	61	49.8	−2802.6	0.0	0.0	0.0	0.0	−1.8	2854.6
54 Private non-profit services	4049	2353	1696	180.6	−12.9	1.0	1.6	0.1	0.3	−44.5	−26.2
55 Total	985900	523978	461922	55.0	0.2	13.9	30.2	1.3	−17.0	10.0	6.3
Note) Contribution to the differences in 1980 and 1985											
Total in 1980	904098	592339	311759	57.3%	−2.0%	9.1%	38.0%	0.0%	−7.9%	24.2%	−18.8%
Total in 1985	861814	534066	327748	65.8%	−0.9%	12.7%	30.9%	2.4%	−7.4%	18.4%	−22.0%

that unlike the overall difference mainly attributable to the difference in the domestic final demands, this difference comes mainly from the difference of the CO_2 emission coefficient. And the stone and clay products show the second biggest difference. The major factor of this difference lies in the difference of the construction investment, the CO_2 emission coefficient augmenting the difference. However, as for the electricity showing the 3rd biggest difference, the situation is different. This difference is attributable to the difference in the private final consumption and the construction investment, the difference of the CO_2 emission coefficient giving a large negative effect. That is, the CO_2 emission coefficient of Germany is higher than that of Japan, acting toward diminishing the difference. Among the branches showing a great difference of the CO_2 emission between Japan and Germany, only the difference of the CO_2 emission coefficient of the electricity acts negatively. In other words, in the other branches, the CO_2 emission coefficient of Japan is higher than that of Germany. The reason for such a high CO_2 emission coefficient in the electricity of Germany is, as we have seen, due to the difference of energies used. That is, the electricity in Germany still depends largely on coal or brown coal.

The branches showing the 4th or 5th greatest difference are transport related branches such as the other transport or the maritime transport. However, within the same transport related branches, there is a difference of the situation. The difference between the two countries in the emission of the CO_2 by the maritime transport is mainly due to the differences of the CO_2 emission coefficient and the exportation. That is, unlike Germany, the exportation of Japan, which is an island country, depends overwhelmingly on the maritime transport. On the other hand, the difference of the emission from the other transport is attributable to the difference of the domestic final demands for more than 80%. Above all, the difference in the private final consumption is great.

When we consider the branches of great difference between Japan and Germany, we can see that the difference comes primarily from the difference in the CO_2 emission coefficient or the domestic final demands except for the electricity.

7. Substitution of Emission due to the Importation

It is well known that the exportation influences greatly on the domestic environment through the production for it. In this study as well, as the Table 7 shows, there are even branches which emit more CO_2 in the production for exportation than in the production to satisfy the domestic final demands. Whereas in the importation, the production for it is replaced in the exporting country and the emission of CO_2 is also replaced there. Of course, it comes to the same thing as there is emission somewhere on the planet. However at least in the importing country, the emission of CO_2 is replaced. How about establishing a balance from the point of view of the CO_2 emission as result of the exportation and the importation[19]. Let us here examine a kind of trade balance based on CO_2, not payment of money or quantity of goods. Since both Japan and Germany are trade giants, it may serve as one of the interesting indexes.

Here we define the CO_2 based trade balance as follows.

$$\overline{C}(I-A^d)^{-1}(M-E)$$

(As for the symbols, refer to the section 5. M is imports column vector)

The results of the calculation are shown in the Table 13 and Table 14, divided between Japan and Germany. The left hand side of the table shows CO_2 emitted really from the exportation. The middle of the table shows a level of the CO_2 emission supposed if the production were made inside the country without importation. It is an imaginary figure (imputed quantity) representing the quantity of the CO_2 emitted outside the country because of the importation[20]. Lastly, the right hand side of the table shows differences of subtraction of the actual CO_2 emission by the exportation from the imputed CO_2 emitted outside the country because of the importation[21].

On the whole Japan and Germany both show a similar tendency. The total CO_2 emission by the exportation decreased in 10 years. The CO_2 emission replaced by the importation decreased over the year 1985 but increased significantly afterward, with a positive balance in 1990. It means that there was a gain from the point of CO_2 emission. Until 1985 Japan had more exports than imports, giving a considerable negative balance. However after 1985 the imports increased rapidly and the balanced turned positive,

Table 13: CO_2 Trade Balance in Germany

(unit: 1000 · CO_2t)

	Emission by Export			Substitution by Import			CO_2 Trade Balance		
	1980	1985	1990	1980	1985	1990	1980	1985	1990
1 Agriculture	1252	1592	1845	5693	5626	5885	4441	4034	4040
2 Forestry and fishery	645	544	499	2051	1317	1025	1405	773	525
3 Electricity	61019	60074	60099	61371	55589	59380	352	-4484	-719
4 Gas	231	56	100	203	46	91	-28	-10	-9
5 Water	19	19	20	18	16	20	-1	-3	0
6 Coal and cokes	4982	3417	2571	2843	2253	2264	-2138	-1165	-307
7 Other mining	678	545	523	2434	1773	1954	1756	1228	1431
8 Crude oil and natural gas	321	336	311	8264	6867	8459	7944	6532	8148
9 Chemical products	12424	14326	14008	8926	9916	11209	-3499	-4410	-2798
10 Petroleum products	4615	3330	2950	10462	8645	7839	5846	5315	4888
11 Plastic products	573	676	806	386	400	574	-187	-276	-232
12 Rubber products	690	683	579	558	522	513	-133	-161	-66
13 Stone and clay products	3485	3909	3362	3717	3567	3283	232	-342	-78
14 Ceramic products	655	530	567	683	463	627	28	-67	60
15 Glass products	2407	2673	2127	2119	2045	1941	-288	-628	-186
16 Iron and steel	40444	36719	32194	24233	21713	25309	-16210	-15006	-6884
17 Non-ferrous metals	2374	2613	2218	3003	2902	2808	629	289	590
18 Metal products	3944	3290	3054	2110	1608	2021	-1834	-1682	-1033
19 General machinery	3208	2821	2375	1005	838	973	-2204	-1983	-1402
20 Office machine	111	117	86	195	191	183	83	74	97
21 Automobile	2616	2683	2132	896	798	986	-1720	-1885	-1145
22 Ship	68	71	72	43	39	25	-25	-32	-46
23 Aircraft	112	104	104	121	118	145	9	14	40
24 Electric machinery	1794	1743	1640	1148	1138	1346	-645	-605	-294
25 Precision machinery	178	194	165	130	136	160	-48	-58	-5
26 Musical instrument, etc.	82	73	63	119	77	96	37	3	32
27 Timber	451	389	351	1128	582	614	677	194	263
28 Wooden products	204	251	259	201	214	279	-4	-37	20
29 Pulp and paper	2416	2989	3414	4478	4272	5310	2062	1283	1896
30 Paper products	392	405	443	321	270	338	-71	-136	-105
31 Printing and publishing	140	162	205	99	96	144	-41	-66	-61
32 Leather products	72	82	83	303	263	283	231	182	200
33 Textile products	1659	1593	1471	2742	2384	2753	1083	791	1282
34 Wearing apparel	124	129	117	316	282	344	192	153	227
35 Foodstuffs and feeds	1879	1945	2314	2970	2700	2743	1091	755	428
36 Beverages	269	277	373	684	557	567	415	280	195
37 Tobacco	9	12	16	7	12	18	-2	0	1
38 Construction	206	296	271	170	181	222	-37	-115	-49
39 Wholesale	2559	3173	3461	1622	1676	2265	-937	-1498	-1196
40 Retail trade	100	133	163	89	106	142	-11	-27	-21
41 Railway transport	981	972	763	520	443	346	-461	-529	-417
42 Maritime transport	2858	2683	2339	1373	1366	1252	-1485	-1316	-1087
43 Post and communications	144	163	179	117	133	173	-27	-30	-6
44 Other transport services	5760	7416	9219	3872	4172	6014	-1888	-3245	-3205
45 Financial services	60	69	71	78	78	71	18	9	-1
46 Insurance	37	48	49	34	37	41	-3	-11	-7
47 Real estate and house rent	7	10	12	5	6	9	-3	-4	-3
48 Hotel and restaurant	416	431	472	352	314	403	-64	-117	-70
49 Research and education	150	180	212	114	123	170	-36	-56	-42
50 Health and medical services	8	10	12	22	18	20	14	8	7
51 Other market services	815	1208	1819	738	1014	1735	-78	-195	-84
52 Public administeration	328	396	343	424	352	346	96	-44	3
53 Social insurance	0	0	0	0	0	0	0	0	0
54 Private non-profit services	21	23	19	23	20	20	2	-3	0
55 Total	170993	168579	162922	165531	150273	165739	-5462	-18306	2816

Table 14: CO_2 Trade Balance in Japan

(unit: 1000 · CO_2t)

	Emission by Export			Substitution by Import			CO_2 Trade Balance		
	1980	1985	1990	1980	1985	1990	1980	1985	1990
1 Agriculture	215	162	140	1571	1208	1908	1357	1046	1768
2 Forestry and fishery	661	622	559	8210	7476	7301	7549	6854	6742
3 Electricity	33702	34429	32364	35332	25124	32043	1630	-9305	-321
4 Gas	118	65	47	58	30	38	-60	-35	-9
5 Water	20	36	23	18	25	26	-2	-11	3
6 Coal and cokes	5554	4047	2367	6701	5987	7422	1147	1940	5055
7 Other mining	508	230	204	14039	5152	10772	13531	4922	10568
8 Crude oil and natural gas	25	38	3	13965	11632	2355	13940	11594	2352
9 Chemical products	7871	9922	10392	5365	5743	8535	-2506	-4179	-1857
10 Petroleum products	5200	5136	2516	7322	7641	7012	2123	2505	4496
11 Plastic products	130	363	446	546	123	233	415	-240	-213
12 Rubber products	728	342	590	129	42	229	-599	-300	-361
13 Stone and clay products	5445	4374	4266	2319	1742	4622	-3126	-2632	356
14 Ceramic products	595	472	414	100	57	150	-496	-415	-264
15 Glass products	847	1365	1176	347	379	680	-501	-986	-496
16 Iron and steel	63421	55672	30501	8785	8231	17013	-54636	-47441	-13488
17 Non-ferrous metals	3109	2135	1549	3971	2951	7273	862	816	5724
18 Metal products	4465	4921	4071	958	709	1376	-3507	-4212	-2695
19 General machinery	1458	965	1176	274	140	375	-1184	-825	-801
20 Office machine	196	193	220	61	26	56	-135	-167	-164
21 Automobile	1639	2597	2056	128	143	286	-1511	-2454	-1770
22 Ship	267	223	165	56	22	20	-211	-201	-145
23 Aircraft	81	10	22	497	133	125	417	123	103
24 Electric machinery	2594	1945	1556	466	212	301	-2128	-1733	-1255
25 Precision machinery	344	180	248	88	39	100	-256	-141	-148
26 Musical instrument, etc.	956	511	494	596	307	828	-360	-204	334
27 Timber	35	12	34	98	28	274	63	16	240
28 Wooden products	78	28	34	61	19	56	-17	-9	22
29 Pulp and paper	2217	3056	2529	2939	2953	3367	721	-103	838
30 Paper products	69	183	132	54	107	154	-15	-76	22
31 Printing and publishing	51	83	116	42	47	97	-9	-36	-19
32 Leather products	23	32	26	14	16	144	-8	-16	118
33 Textile products	1649	1459	818	848	926	1358	-801	-533	540
34 Wearing apparel	48	67	40	86	96	229	38	29	189
35 Foodstuffs and feeds	273	242	243	1038	889	2077	765	647	1834
36 Beverages	61	67	62	182	167	321	121	100	259
37 Tobacco	3	3	3	12	10	31	9	7	28
38 Construction	104	173	195	87	98	162	-17	-75	-33
39 Wholesale	1956	3135	1983	906	1018	1023	-1051	-2117	-960
40 Retail trade	573	342	242	502	251	256	-70	-91	14
41 Railway transport	145	166	79	121	85	83	-25	-81	4
42 Maritime transport	28298	24866	21289	8926	8137	9474	-19372	-16729	-11815
43 Post and communications	111	67	112	78	39	106	-32	-28	-6
44 Other transport services	3481	5535	8372	2420	3263	7532	-1061	-2272	-840
45 Financial services	98	65	116	76	59	148	-21	-6	32
46 Insurance	14	11	14	10	7	16	-4	-4	2
47 Real estate and house rent	19	36	88	16	21	72	-3	-15	-16
48 Hotel and restaurant	470	662	442	745	736	1068	275	74	626
49 Research and education	737	1164	3058	549	488	1533	-189	-676	-1525
50 Health and medical services	9	15	11	11	11	13	1	-4	2
51 Other market services	4817	4427	2519	4488	2654	2410	-329	-1773	-109
52 Public administeration	61	82	33	53	45	33	-8	-37	0
53 Social insurance	0	0	0	0	0	0	0	0	0
54 Private non-profit services	140	218	47	100	128	41	-40	-90	-6
55 Total	185690	177149	140204	136363	107573	143156	-49327	-69576	2952

exceeding Germany in 1990.
In Germany, when seen by branch, the following branches are in the considerable black in the CO_2 balance: crude petroleum and natural gas, petroleum products, agriculture, pulp and paper, other mining, fiber and textile products, etc. Many of these branches are found in the domain of raw materials or primary products, reflecting the trade structure. On the other hand, the industrial branches such as iron and steel, chemical products, machinery, automobile, metal products, etc., have more exportation than importation, which gives a deficit tendency in the balance. However there are many branches which show a decreasing tendency in the deficit as iron and steel. In the branches of services, the other transport, the maritime transport, the wholesale, etc., show a great deficit.
In Japan as well, the branches such as the other mining, the forestry/fishery, the petroleum products, the coal/cokes, the agriculture, the foods, etc., show a considerable surplus in the CO_2 balance. The tendency is almost the same as Germany on the whole, though the order is different. On the other hand, the following branches show a great deficit: the iron and steel, the maritime transport, the metal products, the chemical products, the automobile, the electric machinery, the research and education, etc. The branches of the iron and steel and the maritime transport show a remarkable deficit compared with Germany. However the situation is rapidly improving, contributing significantly to the overall tendency of the CO_2 balance.

8. Conclusion

We have seen comparisons of the CO_2 emission structure between Japan and Germany through the input-output analysis. At last, we will summarize this study and point out the tasks for the future.

(1) The total quantity of CO_2 emission is greater in Japan which has a larger population. However, as for the quantity of CO_2 emitted directly from the private final consumption within the final demand, Germany emits more than Japan. The reason is, as was already considered in the section 3, that Germany uses more energy except for the petroleum and the liquidated gas, in its absolute quantity, than Japan. It will be necessary as our future task to conduct an international comparative analysis taking also the climate and the life style, etc into consideration[22].

(2) Though electricity is clean energy at the stage of the final consumption, CO_2 is emitted at the stage of its production. Owing to the energy type, Germany produces more CO_2 and the efficiency is not so good. The quantity of CO_2 emitted from the generation of the electricity occupies a fairly large proportion in the total. Consequently it will be necessary to continue the study including the tendency of the demand for electricity, substituting energies, propagation of energy saving electric appliances in the households, etc.

(3) In Germany, except for the direct emission at the final consumption stage, the total amount of CO_2 emitted from each branch decreased in the latter half of the 1980's contrary to Japan. It is significantly due to the decline of CO_2 emission coefficient. As a result, unlike the period up to 1985, the difference of CO_2 emission between Japan and Germany at the stage of the intermediate input/demands can be explained in 1990 not only by the difference of the domestic final demands but also by the difference of CO_2 emission coefficient. As a task for the future, it will be further necessary to analyze the tendency of the 1990's afterward. Especially after the 90's, the economic activities were at a slump on the whole both in Japan and in Germany, which must have contributed negatively to the CO_2 emission. It is necessary to analyze influences due to changes of CO_2 emission coefficient or intermediate input structures, distinguishing from the trend of domestic demand.

(4) The quantity of the CO_2 emission induced by the production for exportation in Japan and in Germany is great since both countries are export giants. Indeed, the emission of certain branches by exportation exceeds that by domestic final demands. However the increase of the volume of the imports during the latter half of 1980's promoted substitution of the products and replacement of the CO_2 emission, turning the CO_2 balance positive in 1990. As our task in the future, it will be necessary to study not only the impact of the trade of a certain country on its country's environment but the impact from a global point of view using, for example, an international input-output table. It is because the expansion of importation may invite a destruction of the environment in the developing countries even if it can contribute to the world economy by creating demands. The problem of the global warming itself is, of course, not a regional problem but rather a global problem.

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Notes

1) The financial support by the Ministry of Education, Science and Culture for the fiscal year 1999 is greatfully acknowledged. The author also thanks the University of Kansai for giving him a chance to research exclusively in the latter half of the 1999th year.

2) Murayama (1999) treats a connection of frequent unusual weather with the global warming.

3) Of course many different comparisons have been made so far. However there has been no comparison between Japan and Germany based upon input-output analysis.

4) The quantity of the CO_2 emission of Germany in this figure covers all Germany. That is, it includes the emission of the former East Germany before the Reunification. It is surprising to be able to see a decreasing tendency there. On the other hand, it is to be noted that the emission level of Germany was higher than that of Japan up to 1989, in spite of a larger population of Japan.

5) Moriguchi, Y. & Nishioka, S. (1990) also try a simple international comparison, using the OECD statistics.

6) As for the method of this adjustment/compilation, refer to Yoshinaga (1996).

7) As for the estimation method of the original CO_2 emission by the input-output table, refer to Moriguchi, Y., Kondo, Y. & Shimizu, H. (1993), Yoshioka, K., Hayami, H., Ikeda, A., and Suga, M. (1992).

8) Since such an adjustment is difficult, there are fewer international comparisons by input-output analysis. Proops, L. R., Faber, M. and Wagenhals, G. (1992) is a comparison between Japan and Germany. It is very helpful.

9) To obtain a stable intermediate input coefficient, Japanese method is supposed to be better. However this method is adopted only in Japan. It is one example to show that an advancement may become an obstacle for international comparisons.

10) If all of this is integrated to the branch of transport, just the transport excluding the households accounts for over 10% of the total emission in Japan. A simple comparison between Japan and Germany without adjusting the self-transportation was Yoshinaga (1996)'s study, which clearly was not a sufficient one. In this paper, the author referred to the intermediate input values of each branch from the branch of self-transportation to allot CO_2 emitted by the self-transportation to each branch.

11) The data of Germany for 1995 were not available at the time of writing this paper. However with CO_2 data, it is impossible to establish the input-output table in the real prices since the deflators for the 1990 prices have not yet been prepared and published.

12) This depends also on the degree of the electrification. It is equally related to the fact that Japan has more passengers transport kilometers by rail road (persons · kms) while Germany has more freight transport kilometers (tons · kms). Refer to "Overseas Transport Statistics", etc., by Ministry of Transport.

13) Only the major ones comparable between Japan and Germany are picked up.

14) For example, in 1995, the number of diesel cars in Japan was 4,864,928 (10.7% of the total passenger cars) while in Germany it was 5,544,551 (13.7% of the total passenger

cars). In trucks, the difference is still greater. For details, refer to "Overseas Transport Statistics" by Ministry of Transport, etc.

15) As an analysis which integrates CO_2 emitted in the generation of electricity for the household use into the household emitted CO_2, there is a study of Stahmer (1996).
16) This is a result calculated by the formula (5) in the section 5.
17) This emission includes naturally CO_2 emitted in the generation of electricity for private final consumption calculated in the Table 5.
18) In 1990, the exchange rate was 1 DM = 89.6127447Yen. It may be also necessary to consider a conversion by purchasing power parity.
19) As for Japan, there are similar analyses such as Moriguchi, Y., Kondo, Y. & Shimizu, H. (1995). However they have not obtained CO_2 balance.
20) This is what is called imputation calculation. It is different from CO_2 emitted really by the production in foreign countries for exportation to Japan.
21) It is to be noted that the trade balance here is the opposite of the usual balance.
22) References here are: Aoyagi, M., Moriguchi, Y., Kondo, Y., & Shimizu, H. (1995), Suga, M. (1997), Stahmer, C. und Mitarbeiter (1996), etc.

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