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CHap for cloth dryer, personal computer, mobile phone, and major life events – an index that measures change in CO_2-emissions and happiness

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0. Overview

This report combines the different modules that have been developed and quantified in Hofstetter et al. (2004) and Ozawa & Hofstetter (2004a-d). The general method is re-iterated and the CHap-index formula discussed and revised. Section 2 gives then the calculation procedure in more details, and section 3 shows the results. A last section looks into the lessons learned.

1. Method

The methodology includes three modules. They are presented together with the calculation process in Figure 1. We selected the purchase and use of an automatic cloth dryer, a mobile phone and a personal computer as activities to demonstrate the method.

- Module CP calculates the change in **c**onsumption **p**atterns if one of the three mentioned goods has been purchased and supposedly put in service. Ozawa & Hofstetter (2004 c,d) provide the relevant data derived from young Japanese women.
- The data for module H has been derived together with the analysis for module CP and reports the change in **h**appiness when the a new good is purchased and used (together with all the other occurring changes in consumption pattern and lifestyle).
- Changing consumption patterns lead to changes in CO_2 emissions during the production and use phase of goods. These changes have been assessed in module C.

The three modules indicated by arrows can be combined in an index that quantifies how much an activity contributes – when considering all simultaneous changes and rebound effects - to an increase in happiness and at what expense in terms of changes in CO_2-emission.

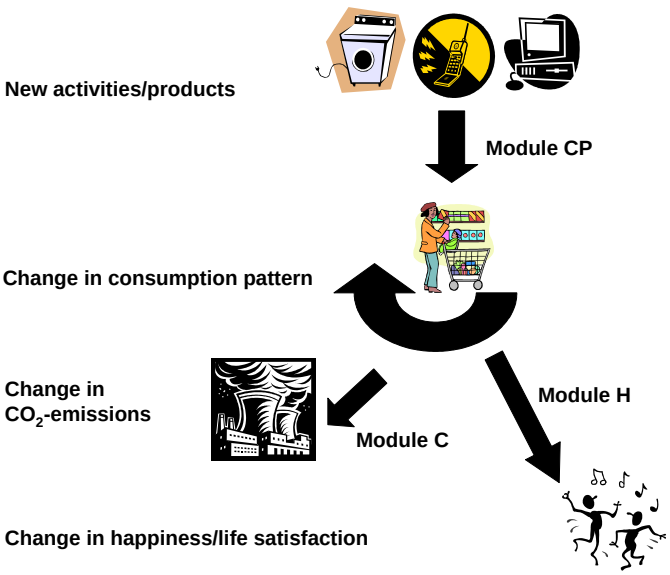


Figure 1: Overview on calculation procedure

This assessment process can be applied to a large set of activities that are suggested to contribute to a more sustainable development. The result could then be a list that ranks those activities either according to their contribution to increase happiness, or according to their changes in CO_2-emission or as a combination of both. This combination of both is the new index introduced here and called *CHap*. Deriving a formula directly from the intention to

increase happiness at minimal additional CO_2-emissions we suggested to calculate *CHap* as follows:

$$CHap_i = \frac{\Delta Happiness_i + 4}{\Delta CO_{2,i}} \qquad [t^{-1}] \qquad (1)$$

Where happiness is measured on a scale from 1 to 5 and CO_2 emissions in tons. The correction value for happiness of 4 makes sure that the nominator falls between 0 and 8. However, this formula has two drawbacks. Firstly, the change in CO_2-emissions may have a positive or negative sign, where large negative numbers are from an environmental point of view most desirable. Therefore, both large positive and all negative CHap would be preferable over small positive values and make the index hard to interpret. Apart from this practical aspect the index would apply an implicit weighting between happiness and CO_2-emissions. Therefore, we suggest the following adapted formula:

$$CHap_i = W * \frac{\Delta Happiness_i}{Happiness_{ref}} - \frac{\Delta CO_{2,i}}{CO_{2,ref}} \qquad [-] \qquad (2)$$

Where happiness is measured on a scale from 1 to 5 and CO_2 emissions in kg. This formula allows that positive happiness and negative CO_2-emission contribute to higher scores of CHap. The normalization or reference values are needed to apply a proper and explicit weighting between change in happiness and CO_2-emissions. For $Happiness_{ref}$ we use here the value "2" because people that feel "average happy" get a score of "3" which makes that *?Happiness* will usually be smaller than 2. For $CO_{2,ref}$ again a person's equivalent per year has been chosen here (10'000 kg CO_2 per year and person[1]). Both normalization factors would need adjustment if larger groups of people or other time slots would be looked at and compared. Further, the weighting factor *W* makes sure that an explicit weight must be given. A weight of *W=1* would mean in our case that an increase in happiness by two units (lifting a person from "average happy" to "very happy") is weighted as equal to a decrease of CO_2-emissions by 10'000 kg/a.

Formula (2) allows, once *W* is set, that all activities can be ordered from the highest CHap to the lowest. Where the top activities have the highest potential to contribute to sustainable consumption and the activities with the lowest scores are likely to have either high CO_2-emissions or a low or negative impact on happiness (or both).

2. The calculation process

Before we analyze the changes in CO_2-emissions and happiness due to consumption activities, we should take the opportunity to get an idea on the total absolute data. This will also allow us to say something about the robustness of our model.

2.1 CO_2-emissions of average Japanese individuals

The per capita emissions of CO_2 within Japan are around 9t CO_2 per capita and year. If one includes CO_2 emissions from import and excludes emissions due to exports one calculates about 10t CO_2 per capita and year (OECD 2003). These data include babies and elderly persons, healthy persons and those in hospitals and it also includes all the emissions that are not easily attributed to individuals like schools, defense, and many other public services. It is therefore interesting to ask what the yearly CO_2-emission looks like for the average young Japanese women covered in the sample. From Table 59 in Ozawa & Hofstetter (2004d) we

[1] As discussed in Section 2.1 this is only a very rough approximation of the average Japanese person and serves to illustrate the method.

use the data on average expenditure per person during September 2000 (column 2 in Table 2-1). In column 3 of Table 2-1 the expenditures of September are extrapolated with a factor 12 to approximate the yearly expenditures. The data on CO_2-intensities can be found in Appendix 1 by Sugai and Toyoda (Tables 3.1-2, 3.2, and 4.3-3) in Hofstetter et al. (2004). They have been derived from an extended input-output analysis of the Japanese economy. The multiplication results in the yearly CO_2-emissions per person (column 5).

Table 2-1: Yearly CO_2-emissions for average person included in the sample (year 2000)

	Expenditure in September 2000	12 month	CO_2 intensity	CO_2 emissions
	1'000yen	1'000yen/a	[t-CO_2/million yen]	kg/a
Food	15.81	189.72	1.96	372
Housing (Rent/Mortgage)	8.3	99.6	0.22	22
Water, Gas, Electricity	4.73	56.76	19.96	1133
Furniture and Household Appliances	1.47	17.64	2.09	37
Clothing and Shoes	3.84	46.08	1.86	86
Medical and Insurance	1.9	22.8	1.51	34
Transportation	4.83	57.96	6.65	385
Communication	3.12	37.44	0.77	29
Education	3.57	42.84	1.05	45
Hobby and Leisure	3.28	39.36	1.74	68
Going out	3.78	45.36	1.81	82
Allowances	6.28	75.36	1.81	136
Total	**60.91**	**730.92**		**2430**

The results in Table 2-1 reveal a number of insights and problems. While the expenditures amount to only 730'000 yen per year[2], the yearly income was stated to be 2'400'000 yen, i.e., only 30% of income was spent directly on the expenditure categories in Table 2-1. The same calculations for 1999 result in total expenditures of 726'000 yen and 2447 kg CO_2/a, and for 1998 expenditures are 656'000 yen and 2112 kg CO_2/a, respectively.
It is very obvious that the expenditures for housing with 100'000 yen per year must be much too low. The resulting emission of 22 kg/a is therefore not truly reflecting the situation. Also, if an average person of the sample is spending only 58'000 yen per year on transportation then we would not complain about a mobility problem in Japan. The total yearly emission estimated here is only 2.4t CO_2 per year, about a quarter of the Japanese average emissions.

Table 2-2 provides a more comprehensive overview on expenditure for all categories including savings (Table 5 of Ozawa & Hofstetter (2004d)). Indeed taxes and social security are about a quarter of the total income. Stated savings and payments for loans make each about 10% of income. This covers now about 75% of the income. From Table 3 in Ozawa & Hofstetter (2004d) we can guess that the remaining quarter was used to pay back part of the housing loan. All this suggests that Table 2-1 underestimates housing to a large extent. Some of the loan payments may also include car loans which would explain the underestimate in transportation. Also, by neglecting taxes and social security, none of the governmental activities are allocated to individuals.

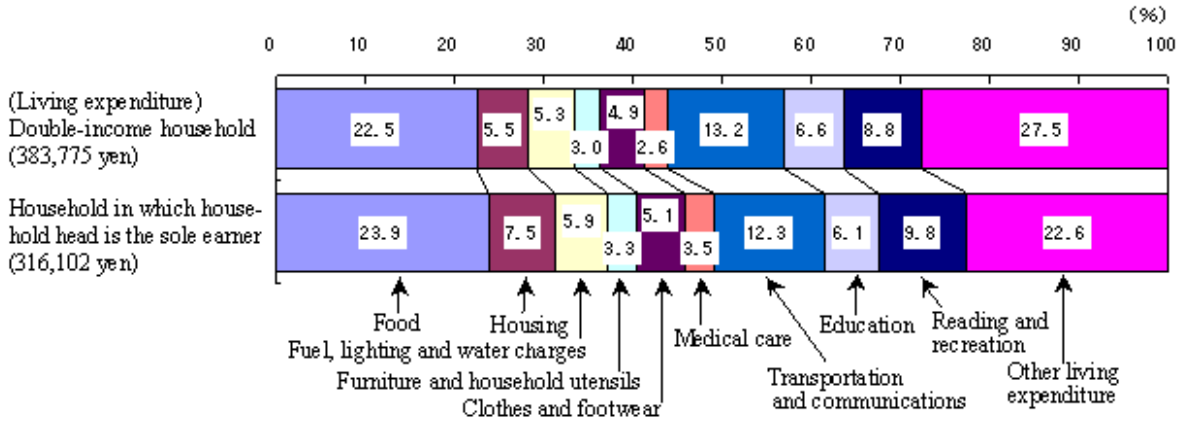
A more representative sample for the whole population is available from the National Survey on Family Expenditure and Income (BS 2000). The average household size is 3.4 persons in 1999 and the living expenditures are about 4 million yen or 1.18 million per person. These expenditures are split according to Figure 2 into expenditure categories. If we compare the results with Table 2-1 we find a reasonable good accordance.

[2] For conversion to USD divide by 100.

Table 2-2: Expenditure of young Japanese women per person and per year (Ozawa & Hofstetter (2004d))

2000	Average value per annum per person (10,000 yen)
Tax and Social Security - Husband	20.39
Tax and Social Security - Wife	17.11
Tax and Social Security - Other family member	21.97
Subtotal tax and social security	*59.47*
Total Household Living Expense	70.10
Total Household Savings	22.44
Total Payment for Loan	26.52
Total	**178.53**

Figure 2: Expense Item Composition of Monthly Average Living Expenditure of Double-Income Households and Households in which Household Head the Sole Earner (Workers' Households) (BS 2000)



From Table 2-3 we see that the included expenditure categories cover 60-70% of the income. However, if the category of "other living expenditure" is excluded this share is down to 45-55%. Although this coverage exceeds the coverage in our JPSC (2004) data, it might be explainable by different reporting methods and socio-demographic groups.

Table 2-3: Trends in Monthly Average Income and Living Expenditure of Double-Income Households and Households in which Household Head is the Sole Earner (Workers' Households) (BS 2000)

Item	1979	1984	1989	1994	1999
Double-income household					
Income (in yen)	320,943	410,252	493,672	599,259	620,567
Real rate of increase (%)	-	5.5	14.4	10.4	2.0
Living expenditure (in yen)	233,792	287,336	334,126	382,149	383,775
Real rate of increase (%)	-	1.5	10.6	4.0	-1.2
Household in which household head is the solo earner					
Income (in yen)	263,787	332,007	386,722	447,962	452,147
Real rate of increase (%)	-	4.0	10.7	5.3	-0.7
Living expenditure (in yen)	206,457	251,729	287,123	321,988	316,102
Real rate of increase (%)	-	0.7	8.5	1.9	-3.3

Notes: 1. Before 1984 the wage and salary income of the householder's spouse consists of the wife's income only.
2. Before 1989 "main business other than wages and salaries" is included in "wage and salary income of household head" and in "wage and salary income of spouse".

Another way to estimate the CO_2-emissions for the purchase and use of household goods and car usage is to look at the stock of durable consumer goods. Column 2 in Table 2-4 provides from Ozawa (2004d) the stock of possessions of an average household sampled in the used survey. The data on CO_2-intensities can be found in Tables 3.1-2, 3.2, and 4.3-3 of Appendix 1 by Sugai and Toyoda in Hofstetter et al. (2004). They have been calculated using average

product prices, an extended input-output analysis of the Japanese economy, and in the case of cloth dryers, personal computers, and mobile phone some additional process data has been used to make the results more specific.

Column 4 in Table 2-4 shows that the stock of durable goods in the average household caused about 9t CO_2-emissions. The average of 1.27 cars is responsible for 70% of these emissions. Considering the average lifetime of these goods (probably more than 10 years) and the number of household members (4.04) reduces the emissions to about 200 kg CO_2 per year and person for the production of durable goods. Column 5 provides rough estimates for the yearly electricity use of such durable goods. Only for personal computers, cloth dryers and mobile phones the numbers are based on Sugai and Toyoda in Hofstetter et al. (2004). If the assumptions made are reasonable, then the use phase for all durable goods except for the air conditioner and car causes about 745 kg CO_2 per year. Per head this is less than 200 kg/a. However, assuming that an average car consumes 8 liter gasoline per 100 kilometer and travels 15'000 km/a results in 3.7 t CO_2/a for the 1.27 cars. This is almost 1t CO_2 per person and stands in a stark contrast to the numbers for transportation presented in Table 2-1. The emissions due to all electric appliances are less than 600 kg CO_2 per person and fit into the numbers given in Table 2-1.

Table 2-4: Average possession data of durable goods for 1999 and 2000 and its associated CO_2-emissions from production and use phase.

	posession	CO_2 intensity	CO_2 emissions	electricity	CO_2-emissions
		possession only	possession only	use phase	use phase
	Mean	t-CO_2/piece	kg	kWh/a	kg/a
Dining Set	0.62	0.272	169	0	0
Cupboard	1.08	0.174	188	0	0
Microwave	0.88	0.052	46	25	7.9
Refrigerator	1.05	0.289	303	450	170
Automatic Dishwasher	0.08	0.197	16	400	11.5
Vacuum Cleaner	1.18	0.067	79	100	43
Laundry Machine	0.92	0.147	135	300	99
Cloths Dryer	0.21	0.135	28	366	27.7
Sewing Machine	0.68	0.192	131	10	2.4
Electric Fan	1.45	0.022	32	100	52
Air Conditioner	1.7	0.277	471	3000	1836
Fan Heater	1.03	0.07	72	200	74
"Kotatsu" Heater	0.81	0.06	49	200	58
TV Set	1.99	0.133	265	100	72
Stereo Sound System	0.65	0.136	88	50	11.7
CD Radio Cassette Recorder	0.78	0.042	33	50	14
VCR	1.4	0.063	88	50	25
Video Camera	0.59	0.273	161	5	1
Telephone	1.8	0.033	59	10	6.5
Bicycle	1.89	0.051	96	0	0
Car	1.27	4.913	6240		3657
TV Game	1.24	0.026	32	50	22.3
Word Processor	0.41	0.176	72	50	7.4
Personal Computer	0.56	0.375	210	117	23.6
FAX	0.42	0.089	37	100	15.1
Mobile Phone	1.26	0.018	23	0.247	0.1
Total			**9123**		**6238**

These initial calculations show that the available panel data from JPSC (2004) are reasonable and within the range of what can be explained based on the more representative national surveys. However, it also shows that the expenditure categories are not very detailed and that only about one quarter of the income is covered by the detailed expenditure categories. The

way the expenditure categories are reported suggests that expenditure and CO_2-emissions are underestimated when looking solely at the expenditure category. Luckily, it was found that the emissions from cars can easily be calculated from the information on car possession.

The embedded uncertainties of the illustrated calculation procedure for CO_2-emissions together with the observed expenditure to income gap should make clear that all calculation in this report can best be characterized as first estimates. Interpretations based on these results should be made with respect to these data weaknesses.

2.2 Change in consumption patterns (Module CP)

In Hofstetter et al. (2004:115ff) the calculation of consumption elasticities has been provided. The term elasticities is borrowed from economics where elasticity is used to describe the change in demand (or supply) due to changes in prices. Here we are interested in change of demand due to changes in activities/product acquisition. The idea to calculate elasticities using panel data was inspired by Gershuny (2002) who used a similar approach to tackle with changes in time consumption.

The elasticity coefficients have been calculated as follows:

$$e = \frac{\text{Change of variable for adopters (NY) - Change of variable for non - adopters (NN)}}{\text{Change of variable for non - adopters (NN)}} = \frac{NY - NN}{NN} \quad (3)$$

For this report we use the more recent data provided in Ozawa & Hofstetter (2004c,d). An example will be given in Table 2-5 below and an overview on all results in Table 3-1 and 3-2.

2.3 Change in CO_2-emissions due to changes in consumption patterns (linking Module CP and C)

In order to calculate the resulting CO_2-emissions from changes in induced consumption we use the following general formula:

$$CO_2\text{-emissions} = e*NN*I = (NY-NN)*I \quad (4)$$

Where I is the CO_2-intensity of the variable at stake.

The data on CO_2-intensities can be found in Appendix 1 by Sugai & Toyoda in Hofstetter et al. (2004). Data are taken from Table 3.1-2, 3.2, and 4.3-3. The data on the change in consumption is taken from Ozawa & Hofstetter (2004c,d). Table 2-5 illustrates the procedure for the average of all households that purchased within a year a cloth dryer compared to those that did not (Table 9 in Ozawa & Hofstetter 2004d). In Column 2 and 3 we report that 906 households did not possess a cloth dryer in 1998 and did neither so in 1999 (NN). Only 29 households did purchase a cloth dryer in this period (Columns 4 & 5). These first columns give the mean data per household and the standard deviation (SD). In this example only the difference in household expenditure for food between NN and NY are significant (shaded row). Column 6 does not only display the difference between columns 2 and 4 but also extrapolated the monthly expenditure to a full year. Column 7 shows the applied emission

intensities *I* and column 8 delivers the changes in CO_2-emissions between households that purchase a cloth dryer and those that don't. The row "Total" adds up all column totals where appropriate. The row with "significant changes only" restates in this example only the CO_2-emission due to food. And the last row does include the shaded cells in Column 8 assuming that the three non-shaded expenditure categories might adequately be covered in Table 2-6.

Before we turn to the next step in the calculation we would like to mention a few first insights that will be discussed in Section 3:

- Should we look at significant changes only or is the grand total the relevant number?
- Do we need to consider also changes in family size? And if so, how?
- How is it explainable, that, e.g., the expenditure for food increases so much if the family size actually got smaller?
- Is it reasonable to assume that all observed changes have a causal relationship with the purchase and use of a cloth dryer?

Table 2-5: Demonstration example for the calculation of CO_2-emissions based on change in expenditure data linked to the purchase of a cloth dryer between September 1998 and September 1999 (grey row indicates statistically significant of at least $p<0.1$)

	NN		NY		NY-NN		
	N =906		N =29		12 month	CO_2 intensity	CO_2 emissions
	Mean [1000 yen]	SD	Mean [1000 yen]	SD	Mean [1000 yen]	[t-CO_2 / million yen]	kg/a
Food	4.91	28.21	15.17	25.27	123.12	1.96	241
Housing (Rent/Mortgage)	1.75	43.69	-0.45	32.66	-26.4	0.22	-6
Water, Gas, Electricity	0.97	9.01	2.76	9.58	21.48	19.96	429
Furniture and Household Appliances	-1.31	13.92	1.07	8.96	28.56	2.09	60
Clothing and Shoes	0.26	17.85	0.69	16.38	5.16	1.86	10
Medical and Insurance	-0.46	20.36	-1.48	14.29	-12.24	1.51	-18
Transportation	9.98	59.66	11.86	24.73	22.56	6.65	150
Communication	3.18	8.31	1.93	10.12	-15	0.77	-12
Education	1.95	23.55	-1.93	11.61	-46.56	1.05	-49
Hobby and Leisure	-0.41	25.75	-0.28	28.7	1.56	1.74	3
Going out	-1.18	18.41	-1.76	19.81	-6.96	1.81	-13
Allowances	-0.38	24.83	-2.38	24.3	-24	1.81	-43
Total	**19.26**		**25.2**		**71.28**		**751**
significant changes only							**241**
Changes not covered elsewhere							**700**

In a next step we look, similar to Table 2-4, into the changes in consumer goods (see Table 2-6). Column 6 quantifies by how much a household that purchased a cloth dryer within a year also added additional durable goods compared to those households that did not buy a cloth dryer. Columns 8 and 10 quantify the CO_2-emissions attributed to the production and use phase, respectively. Simultaneous to the cloth dryer there has been observed a significant increase (shaded cells) in dining sets, automatic dishwasher, electric fan, air conditioner, CD Radio Cassette Recorder, Bicycle, and FAX machine. The story behind this change could be that the kitchen was remodeled because a cloth dryer needed to be fitted in. Because of the opportunity of a total reorganization the family decides to put in as well a new dishwasher and dining set. The waste heat from running the dryer and dishwasher made it necessary to add fans and air-conditioners in the kitchen. In the time saved from not washing dishes or hanging clothes, the family listens more often to CDs and goes for a bicycle ride. In order to

afford all these purchases, one family member started to work from home and needed the fax machine.

Table 2-6: Demonstration example for the calculation of CO_2-emissions based on change in durable goods linked to the purchase of a cloth dryer between September 1998 and September 1999 (grey row indicates statistically significant of at least $p<0.1$)

	NN		NY		NY-NN	CO_2 intensity	CO_2 emissions	electricity	CO_2-emissions
	N = 2351		N = 84			possession only	possession only	use phase	use phase
	Mean	SD	Mean	SD	Mean	t-CO_2/piece	kg/a	kWh/a	kg/a
Dining Set	0.04	0.4	0.17	0.47	0.13	0.272	35	0	0
Cupboard	0	0.48	0.14	0.64	0.14	0.174	24	0	0
Microwave	0.02	0.31	0.1	0.41	0.08	0.052	4	25	0.72
Refrigerator	0.02	0.38	0.03	0.33	0.01	0.289	3	450	1.62
Automatic Dishwasher	0	0.19	0.07	0.26	0.07	0.197	14	400	10.08
Vacuum Cleaner	0.05	0.52	0.21	0.56	0.16	0.067	11	100	5.76
Laundry Machine	0.02	0.33	0.07	0.46	0.05	0.147	7	300	5.4
Cloths Dryer	0	0	1	0	1	0.135	135	366	131.76
Sewing Machine	0.02	0.36	-0.03	0.19	-0.05	0.192	-10	10	-0.18
Electric Fan	0.04	0.68	0.28	0.7	0.24	0.022	5	100	8.64
Air Conditioner	0.07	0.74	0.41	1.02	0.34	0.277	94	3000	367.2
Fan Heater	0.02	0.63	0.03	0.68	0.01	0.07	1	200	0.72
“Kotatsu” Heater	-0.03	0.52	0	0.65	0.03	0.06	2	200	2.16
TV Set	0.09	0.71	0.45	0.87	0.36	0.133	48	100	12.96
Stereo Sound System	0.01	0.49	-0.07	0.46	-0.08	0.136	-11	50	-1.44
CD Radio Cassette Recorder	0.01	0.51	0.24	0.58	0.23	0.042	10	50	4.14
VCR	-0.01	0.63	0.03	0.73	0.04	0.063	3	50	0.72
Video Camera	0.04	0.29	-0.03	0.33	-0.07	0.273	-19	5	-0.126
Telephone	0.03	0.87	0.21	1.01	0.18	0.033	6	10	0.648
Bicycle	0.06	0.83	0.45	1.06	0.39	0.051	20	0	0
Car	0.02	0.51	0.17	0.38	0.15	4.913	737		432
TV Game	0.12	0.66	0.14	0.52	0.02	0.026	1	50	0.36
Word Processor	-0.01	0.38	0	0.46	0.01	0.176	2	50	0.18
Personal Computer	0.12	0.44	0.03	0.73	-0.09	0.375	-34	117	-3.79
FAX	0.06	0.36	0.21	0.56	0.15	0.089	13	100	5.4
Mobile Phone	0.18	0.6	0.31	0.54	0.13	0.018	2	0.247	0.011
Total							**1103**		**985**
significant changes only							**239**		**408**

2.4 Change in happiness

We calculate change in happiness with the same method that already allowed us to calculate changes in consumption patterns. However, we are not only listing the change in happiness but also change in life satisfaction and change in living standard. As discussed in Ozawa & Hofstetter (2004d) the change in living standard does not tell us much because in Japanese culture people do not strive for a maximum living standard. However, apart from our main interest in the change of happiness we may also look at the change in life satisfaction that may be more directly linked to the purchase and possession of durable goods.

The results are given in Table 3-1 for a large number of different samples. A detailed discussion is also provided in Ozawa & Hofstetter (2004d).

3. Results

Tables 3-1 and 3-2 summarize the major results applying the methods described in Sections 1 and 2 on the Japanese panel data. Before we start to discuss these results in more detail we explain the result tables.

Table 3-1:
The description of the sample groups includes the considered years and, where stated, the sub-group that has been selected. In the last two columns we give the number of households that were in the samples and column 3 indicates where the respective detailed data set can be found in Ozawa & Hofstetter (2004c,d). The three columns on change in happiness, life satisfaction, and living standard need to be looked at with care. Only the very few numbers in italic letters depict statistical significant changes.

Table 3-2
The assessed activities and sample specifications are identical to Table 3-1. Columns 3-10 follow the calculation procedure in Tables 2-5 and 2-6. In order to guess the total emissions we used two different assumptions. First, we add those induced changes in CO_2 emissions due to changes in expenditure not concerning durable household goods with the emissions due to the purchase of durable household goods and the estimated emissions for their use phase. This means that we did not spread the CO_2-emissions from durable good production over several years because we assume that they will average out and because we wanted to give weight to the purchasing decision. This also means that there is some double counting. Some emissions from the use phase of durable goods are likely to be already considered in the estimate based on the expenditure information. Second, we only added those emissions that showed statistically significant changes at $p<0.1$.

In order to discuss whether the change in family size needs to be considered and how large the contribution would be, we multiplied the change in household size by the average emission of one household member. From Tables 2-1 and 2-4 we add the 2430 kg/Person with a tenth of the production of durable goods plus the usage phase and adjust by 4.03 to calculate the per capita emission. This results in 4200 kg CO_2 per capita and year. For this adjustment it would not make sense to use the national average of 10t CO_2 per capita and year because we have shown earlier that we are covering only a sub-set of all direct and indirect emissions. The calculated adjustment for change in number of family members means that this change in terms of kg CO_2 per household would be expected if the change in family size would be the only change. This is a first approximation only, because, e.g., for the case where we compared families that got a baby with those that did not will obviously show an increase by about one person. However, a newborn baby will probably cause less than the average additional emission of 4200 kg CO_2. Starting to live in a house, getting married, and starting to use a cloth dryer between 1998 and 1999 are the cases where larger and statistical significant changes in number of family members occurred. The column “percentage from total change” does provide the percentage increase or decrease of the column “Total change in emissions” if the change in family members is included.

Finally, we calculated for each case the CHap index using equation (2) of Section 1. However, while we assumed in equation (2) that the ?CO_2 is caused by one person, we are dealing here with households that have 4.01 to 4.04 household members. Therefore, we divide the change in CO_2-emissions by four. Further, we assume that W=1, i.e., 2 units of happiness are equally important as 10 t of CO_2 emissions, and choose the “Total change in emissions” (divided by four) as the best estimate for net emission change.

Table 3-1: Results for three case examples and major life events using different sampling methods (italic = statistical significant change in subjective well-being p<0.1)

Assessed activity	Considered sample group	Data from	Change in happiness -	Change in Life Satisfaction -	Change in Living Standard -	Change in number of Family Members person/houshold	Adjustment for change in number of family members kg CO_2 per year	Percentage from total change %	Cases NN -	Cases NY -
using a mobile phone	1998-1999	D5, Table 11	-0.007	0.093	0.002	-0.06	-252	48%	215	124
using a mobile phone	1999-2000	D5, Table 14	-0.050	0.062	0.068	-0.03	-126	9%	129	119
using a mobile phone	1998-1999, 1999-2000	D5, Table 47	-0.043	0.078	0.023	-0.04	-168	20%	344	243
using a mobile phone	1998-1999, 1999-2000, not got married	D5, Table 51b	-0.054	0.092	0.025	-0.04	-168	51%	339	232
using a mobile phone	1998-1999, 1999-2000, not got married, not gave birth, not moved to own house, not enrolled	D5, Table 54	0.044	0.078	-0.044	-0.04	-168	-10%	45	20
using a personal computer	1998-1999	D5, Table 10	-0.064	-0.133	0.034	-0.01	-42	3%	689	135
using a personal computer	1999-2000	D5, Table 13	0.102	0.088	0.103	0.010	42	-8%	555	162
using a personal computer	1998-1999, 1999-2000	D5, Table 46	0.006	-0.03	*0.066*	-0.003	-13	1%	1244	297
using a personal computer	1998-1999, 1999-2000, not got married	D5, Table 50b	-0.012	-0.029	*0.084*	0.02	84	-14%	1220	273
using a personal computer	1998-1999, 1999-2000, not got married, not started new lesson/learning, not became chairperson, not got full-time position	D5, Table 53	0.033	0.086	0.190	0.05	210	5%	183	23
using a cloth dryer	1998-1999	D5, Table 9	-0.115	-0.054	-0.042	*-0.25*	-1050	38%	906	29
using a cloth dryer	1999-2000	D5, Table 12	0.017	0.075	0.043	0.137	575	-122%	902	32
using a cloth dryer	1998-1999, 1999-2000	D5, Table 45	-0.048	0.01	0.002	-0.05	-210	206%	1808	61
using a cloth dryer	1998-1999, eliminating cases with major events	D5, Table 30	-0.139	-0.11	-0.009	*-0.17*	-714	49%	738	23
using a cloth dryer	1999-2000, eliminating cases with major events	D5, Table 33	0.134	*0.351*	-0.037	0.05	210	-13%	663	23
using a cloth dryer	1998-1999, 1999-2000, not got married	D5, Table 49b	-0.045	0.01	0.034	-0.02	-84	17%	1758	58
using a cloth dryer	1998-1999, 1999-2000, not got married, not gave birth, not moved to own house, not enrolled	D5, Table 52	-0.019	0.365	-0.057	-0.048	-201.6	-6%	656	14
Getting married	1998-1999, 1999-2000	D3, Table A-1	*0.24*	0.066	-0.061	*-0.33*	-1386	15%	2231	57
Having a baby	1998-1999, 1999-2000	D3, Table A-2	-0.036	-0.091	*0.101*	*1.06*	4452	2182%	2034	149
Starting new lesson or learning	1998-1999, 1999-2000	D3, Table A-4	0.048	*-0.226*	-0.057	0.01	42	-8%	1967	64
Taking leadership of a committee	1998-1999, 1999-2000	D3, Table A-5	-0.001	-0.045	-0.013	-0.02	-84	-18%	1768	235
Started living in a house	1998-1999, 1999-2000	D3, Table A-9	0.017	0.047	*0.173*	*0.79*	3318	-79%	948	65

Table 3-2: Results for three case examples and major life events using different sampling methods (continued), (CHap with W=1)

Assessed activity	Considered sample group	Change in expen-diture 10'000 Yen/a	Induced Change in CO_2 due to change in expenditure kg CO_2/a	stat. Sign. kg CO_2/a	Induced Change in CO_2 due to change in expenditure not concerning durable household goods kg CO_2/a	Change in emissions due to purchase of durable house-hold goods kg CO_2/a	stat. Sign. kg CO_2/a	Estimated change in emissions due to use of changed composition of durable household goods kg CO_2/a	stat. Sign. kg CO_2/a	Total Change in emissions kg CO_2/a	stat. sig. kg CO_2/a	Change in number of Family Members person/household	Adjustment for change in number of family kg CO_2 per year	Percentage change due to change in family members %	CHap -
using a mobile phone	1998-1999	57	339	571	281	167	15	76	-13	524	573	-0.06	-252	48%	-0.017
using a mobile phone	1999-2000	102	439	132	518	582	541	335	269	1435	942	-0.03	-126	9%	-0.061
using a mobile phone	1998-1999, 1999-2000	46	279	127	277	366	353	209	171	852	651	-0.04	-168	20%	-0.043
using a mobile phone	1998-1999, 1999-2000, not got married	-16	47	87	52	187	23	90	-6	329	104	-0.04	-168	51%	-0.035
using a mobile phone	1998-1999, 1999-2000, not got married, not gave birth, not moved to own house, not enrolled	-584	-2661	-73	-2653	515	-56	497	-26	-1641	-155	-0.04	-168	-10%	0.063
using a personal computer	1998-1999	116	-1	197	95	1036	971	481	365	1612	1533	-0.01	-42	3%	-0.072
using a personal computer	1999-2000	-34.8	-222	21	-290	579	395	269	176	558	592	0.010	42	-8%	0.037
using a personal computer	1998-1999, 1999-2000	27	-189	53	-182	783	769	360	358	961	1180	-0.003	-13	1%	-0.021
using a personal computer	1998-1999, 1999-2000, not got married	-76	-597	-335	-559	796	778	374	367	611	810	0.02	84	-14%	-0.021
using a personal computer	1998-1999, 1999-2000, not got married, not started new lesson/learning, not became chairperson, not got full-time position	-563	-4229	-4181	-4302	121	-34	2	-12	-4179	-4227	0.05	210	5%	0.121
using a cloth dryer	1998-1999	71	751	241	700	1103	239	985	408	2788	888	*-0.25*	-1050	38%	-0.127
using a cloth dryer	1999-2000	-291	-1967	-2404	-2075	1171	549	1377	993	473	-862	0.137	575	-122%	-0.003
using a cloth dryer	1998-1999, 1999-2000	-122	-692	-1288	-773	247	116	628	258	102	-914	-0.05	-210	206%	-0.027
using a cloth dryer	1998-1999, eliminating cases with major events	-87	6	0	36	671	64	738	326	1445	390	*-0.17*	-714	49%	-0.106
using a cloth dryer	1999-2000, eliminating cases with major events	-6	-1191	224	-1272	1334	652	1573	1143	1635	2019	0.05	210	-13%	0.026
using a cloth dryer	1998-1999, 1999-2000, not got married	-182	-1298	-1379	-1398	859	319	1042	677	503	-383	-0.02	-84	17%	-0.035
using a cloth dryer	1998-1999, 1999-2000, not got married, not gave birth, not moved to own house, not enrolled	-655	-5559	-5342	-5717	1438	1258	1104	953	-3175	-3131	-0.048	-201.6	-6%	0.070
Getting married	1998-1999, 1999-2000	953	4154	3672	4396	3003	2956	1742	1749	9141	8377	*-0.33*	-1386	15%	-0.109
Having a baby	1998-1999, 1999-2000	-93	-75	0	-67	-69	38	-68	11	-204	49	*1.06*	4452	2182%	-0.013
Starting new lesson or learning	1998-1999, 1999-2000	159	-185	0	-392	526	134	376	21	510	155	0.01	42	-8%	0.011
Taking leadership of a committee	1998-1999, 1999-2000	-77	-22	11	-127	-177	12	-157	-5	-461	18	-0.02	-84	-18%	0.011
Started living in a house	1998-1999, 1999-2000	-175	1361	55	1255	1227	1151	1743	1736	4225	2942	*0.79*	3318	-79%	-0.097

When selecting the most relevant samples to discuss the three case studies mobile phone, personal computer, and cloth dryer one would prefer the samples that do exclude major life events affecting happiness or consumption patterns. Therefore, we give more details for these three samples in Table 3-3 through Table 3-8.

Table 3-3: CO_2-emissions based on change in expenditure data linked to the purchase of a mobile phone, combined sample for 1998-1999 and 1999-2000, including those that not got married, not gave birth, not moved to own house, and not enrolled (grey row indicates statistically significant of at least p<0.1).

	NN		NY		NY-NN		
	N =45		N =20		12 month	CO_2 intensity	CO_2 emissions
	Mean [1000 yen]	SD	Mean [1000 yen]	SD	Mean [1000 yen]	[t-CO_2 / million yen]	kg/a
Food	9.07	44.04	-6.75	24.73	-189.80	1.96	-372
Housing (Rent/Mortgage)	0.16	7.78	-0.70	7.14	-10.27	0.22	-2
Water, Gas, Electricity	-0.87	8.26	0.00	4.13	10.40	19.96	208
Furniture and Household Appliances	1.04	7.24	0.15	5.99	-10.73	2.09	-22
Clothing and Shoes	-0.42	15.62	0.30	9.51	8.67	1.86	16
Medical and Insurance	1.62	11.25	-0.05	9.13	-20.07	1.51	-30
Transportation	31.96	148.88	0.80	6.89	-373.87	6.65	-2486
Communication	0.33	5.88	2.60	6.44	27.20	0.77	21
Education	4.58	12.64	-1.25	6.21	-69.93	1.05	-73
Hobby and Leisure	0.60	21.81	0.30	10.40	-3.60	1.74	-6
Going out	-0.62	10.40	-3.70	20.55	-36.93	1.81	-67
Allowances	-3.24	19.09	3.85	13.18	85.13	1.81	154
Total	**44.2**		**-4.45**		**-583.8**		**-2661**
significant changes only					**-70**		**-73**
Changes not covered elsewhere							**-2653**

The result interpretation given here needs to take into account the very low number of cases for both, non-adopters and adopters of mobile phones. Further, mobile phones have already in 1998 been widely used in Japan. Therefore, we are looking at a group of laggards. It is interesting to note that the adopting households have a slight decrease in expenditures while the non-adopters have a huge increase. The difference of 580'000 yen can be considered to be huge.

Food and transportation are consumed much less which results in a steep decrease of estimated CO_2-emissions by 2.7 tons (see in Table 3-3). However, only the decline in education is statistically significant. Although the communication expenditures increase slightly (as expected) it is hard to believe that the adoption of a mobile phone allowed substituting as much transportation as suggested. Indeed, Table 3-4 shows that adopters did add more cars than non-adopters did (though not statistically significant). The impact of purchasing a mobile phone and reducing the number of dining sets, vacuum cleaner, and cloth dryers suggests that some of the young women in the sample left their previous households, probably moving together with other younger people that earn less money (=> lower household expenditure) and that tend to communicate by mobile phone. If this is true, then the cause of the observed change in the consumption pattern would be the moving out from, e.g., the parents home.

As indicated in Table 3-1 the group of phone adopters reports slightly higher happiness and life satisfaction but lower standard of living. This might be explained by the suggested story above.

Table 3-4: CO_2-emissions based on change in durable goods linked to the purchase of a mobile phone, combined sample for 1998-1999 and 1999-2000, including those that not got married, not gave birth, not moved to own house, and not enrolled (grey row indicates statistically significant of at least p<0.1).

	NN		NY		NY-NN	CO_2 intensity	CO_2 emissions	electricity	CO_2-emissions
	N = 45		N =20			possession only	possession only	use phase	use phase
	Mean	SD	Mean	SD	Mean	t-CO2/piece	kg/a	kWh/a	kg/a
Dining Set	0.11	0.38	-0.05	0.22	-0.16	0.272	-44	0	0
Cupboard	-0.04	0.30	0.05	0.39	0.09	0.174	16	0	0
Microwave	0.02	0.15	-0.05	0.22	-0.07	0.052	-4	25	-1
Refrigerator	-0.02	0.34	-0.05	0.22	-0.03	0.289	-8	450	-5
Automatic Dishwasher	-0.04	0.21	0.00	0.00	0.04	0.197	9	400	6
Vacuum Cleaner	0.13	0.34	-0.05	0.51	-0.18	0.067	-12	100	-7
Laundry Machine	0.02	0.15	-0.05	0.22	-0.07	0.147	-11	300	-8
Cloths Dryer	0.04	0.21	-0.10	0.45	-0.14	0.135	-20	366	-19
Sewing Machine	0.04	0.30	0.05	0.22	0.01	0.192	1	10	0
Electric Fan	0.04	0.42	0.05	0.39	0.01	0.022	0	100	0
Air Conditioner	-0.11	0.96	0.10	0.55	0.21	0.277	58	3000	228
Fan Heater	0.04	0.30	0.10	0.31	0.06	0.07	4	200	4
“Kotatsu” Heater	-0.09	0.36	-0.05	0.22	0.04	0.06	2	200	3
TV Set	0.02	0.40	0.15	0.49	0.13	0.133	17	100	5
Stereo Sound System	0.02	0.15	-0.05	0.22	-0.07	0.136	-10	50	-1
CD Radio Cassette Recorder	0.04	0.37	0.20	0.41	0.16	0.042	7	50	3
VCR	0.04	0.42	0.15	0.37	0.11	0.063	7	50	2
Video Camera	0.00	0.21	0.05	0.22	0.05	0.273	14	5	0
Telephone	0.11	0.53	0.30	0.73	0.19	0.033	6	10	1
Bicycle	-0.02	0.75	0.25	0.79	0.27	0.051	14	0	0
Car	0.00	0.00	0.10	0.45	0.10	4.913	491		288
TV Game	0.11	0.49	0.15	0.75	0.04	0.026	1	50	1
Word Processor	0.00	0.37	0.10	0.55	0.10	0.176	18	50	2
Personal Computer	0.13	0.55	-0.05	0.22	-0.18	0.375	-69	117	-8
FAX	-0.02	0.15	0.05	0.22	0.07	0.089	6	100	3
Mobile Phone	0.00	0.00	1.10	0.31	1.10	0.018	20	0.247	0
Total							**515**		**497**
significant changes only							**-56**		**-26**

Table 3-5: CO_2-emissions based on change in expenditure data linked to the purchase of a personal computer, combined sample for 1998-1999 and 1999-2000, including those that not got married, not started new lesson/learning, not became chairperson, and not got full-time position (grey row indicates statistically significant of at least p<0.1).

	NN		NY		NY-NN		
	N =183		N =23		12 month	CO_2 intensity	CO_2 emissions
	Mean [1000 yen]	SD	Mean [1000 yen]	SD	Mean [1000 yen]	[t-CO_2 / million yen]	kg/a
Food	1.92	25.24	-9.78	24.56	-140.47	1.96	-275
Housing (Rent/Mortgage)	-0.65	12.52	4.04	13.04	56.33	0.22	12
Water, Gas, Electricity	0.81	8.83	-0.35	6.95	-13.88	19.96	-277
Furniture and Household Appliances	0.14	8.72	-0.26	12.94	-4.84	2.09	-10
Clothing and Shoes	-0.90	13.43	2.96	10.62	46.23	1.86	86
Medical and Insurance	0.44	10.88	-4.09	11.83	-54.29	1.51	-82
Transportation	8.64	75.28	-39.43	207.78	-576.89	6.65	-3836
Communication	2.25	7.43	3.52	9.64	15.31	0.77	12
Education	1.04	21.64	7.00	22.69	71.48	1.05	75
Hobby and Leisure	-1.85	17.87	1.57	37.48	40.95	1.74	71
Going out	0.26	12.69	-2.17	11.15	-29.17	1.81	-53
Allowances	-1.03	23.55	1.17	12.11	26.48	1.81	48
Total	**11**		**-36**		**-563**		**-4229**
significant changes only					**-715**		**-4181**
Changes not covered elsewhere							**-4302**

Table 3-6: CO_2-emissions based on change in durable goods linked to the purchase of a personal computer, combined sample for 1998-1999 and 1999-2000, including those that not got married, not started new lesson/learning, not became chairperson, and not got full-time position (grey row indicates statistically significant of at least p<0.1).

	NN		NY		NY-NN	CO_2 intensity	CO_2 emissions	electricity	CO_2-emissions
	N = 183		N =23			possession only	possession only	use phase	use phase
	Mean	SD	Mean	SD	Mean	t-CO_2/piece	kg/a	kWh/a	kg/a
Dining Set	0.01	0.37	0.00	0.00	-0.01	0.272	-1	0	0
Cupboard	-0.04	0.40	-0.04	0.47	-0.01	0.174	-1	0	0
Microwave	0.01	0.27	0.00	0.00	-0.01	0.052	0	25	0
Refrigerator	-0.01	0.39	0.00	0.30	0.01	0.289	2	450	1
Automatic Dishwasher	0.01	0.18	-0.09	0.29	-0.10	0.197	-19	400	-14
Vacuum Cleaner	0.04	0.43	0.13	0.63	0.09	0.067	6	100	3
Laundry Machine	-0.01	0.31	0.00	0.00	0.01	0.147	1	300	1
Cloths Dryer	-0.02	0.16	0.00	0.00	0.02	0.135	2	366	2
Sewing Machine	0.02	0.38	0.04	0.37	0.02	0.192	4	10	0
Electric Fan	0.07	0.79	0.13	0.55	0.06	0.022	1	100	2
Air Conditioner	0.03	0.57	0.13	0.92	0.10	0.277	27	3000	105
Fan Heater	0.02	0.64	0.13	0.76	0.11	0.07	8	200	8
“Kotatsu” Heater	-0.05	0.42	-0.13	0.46	-0.08	0.06	-5	200	-5
TV Set	0.01	0.65	0.09	0.67	0.08	0.133	10	100	3
Stereo Sound System	0.02	0.50	0.04	0.64	0.03	0.136	4	50	0
CD Radio Cassette Recorder	0.03	0.51	0.00	0.52	-0.03	0.042	-1	50	0
VCR	-0.01	0.64	-0.17	0.72	-0.16	0.063	-10	50	-3
Video Camera	0.03	0.24	-0.04	0.37	-0.07	0.273	-19	5	0
Telephone	-0.03	0.80	0.13	0.81	0.16	0.033	5	10	1
Bicycle	0.07	0.75	-0.09	0.67	-0.15	0.051	-8	0	0
Car	0.01	0.41	-0.04	0.21	-0.05	4.913	-240		-141
TV Game	0.18	0.75	-0.04	0.64	-0.22	0.026	-6	50	-4
Word Processor	0.02	0.31	-0.13	0.34	-0.15	0.176	-27	50	-3
Personal Computer	0.00	0.00	1.00	0.00	1.00	0.375	375	117	42
FAX	0.00	0.31	0.13	0.46	0.13	0.089	12	100	5
Mobile Phone	0.22	0.60	0.39	0.84	0.17	0.018	3	0.247	0
Total							**121**		**2**
significant changes only							**-34**		**-12**

The higher number of cases increases the number of statistically significant changes. Adopters of personal computers reduce their expenditures by more than 400’000 yen. Since non-adopters increase their expenditures, the gap gets even bigger. One could speculate that computer adopters need to save the money they spent to purchase the computer. The largest decrease can be observed on transportation and food. Some of the adopters may have started to work or study from home instead of commuting and eating out. This would also explain the increase in housing costs. Thanks to the internet access it is easily possible to save on medical and other insurance. In this example, the data on durable goods in Table 3-6 confirms the reduced transportation activity. Also, the significant increase in fax purchases supports our story above. A decline in word processors makes sense because personal computers substitute them. Only the decline in dishwashers is less obvious and might be due to budget constraints. The personal computer scores positive on all measures of subjective well-being, which is also supported by Madjar & Hofstetter (2004a). The very large savings in CO_2-emissions and the positive sign for happiness results in the highest CHap within the three examples.

Table 3-7: CO_2-emissions based on change in expenditure data linked to the purchase of a cloth dryer, combined sample for 1998-1999 and 1999-2000, including those that not got married, not gave birth, not moved to own house, and not enrolled (grey row indicates statistically significant of at least p<0.1).

	NN		NY		NY-NN		
	N =656		N =14		12 month	CO_2 intensity	CO_2 emissions
	Mean [1000 yen]	SD	Mean [1000 yen]	SD	Mean [1000 yen]	[t-CO_2 / million yen]	kg/a
Food	1.52	28.38	-8.57	50.54	-121.15	1.96	-237
Housing (Rent/Mortgage)	1.68	21.17	-2.21	10.18	-46.77	0.22	-10
Water, Gas, Electricity	0.96	9.30	-0.07	7.23	-12.40	19.96	-248
Furniture and Household Appliances	-0.17	11.54	0.50	12.96	8.01	2.09	17
Clothing and Shoes	1.17	15.33	8.21	17.39	84.49	1.86	157
Medical and Insurance	-0.05	20.60	-3.50	18.84	-41.43	1.51	-63
Transportation	6.40	89.05	-65.93	199.08	-867.94	6.65	-5772
Communication	2.38	8.77	2.29	8.31	-1.14	0.77	-1
Education	1.70	15.34	3.79	18.56	25.03	1.05	26
Hobby and Leisure	0.28	28.62	7.07	33.07	81.47	1.74	142
Going out	0.30	19.71	7.50	31.36	86.40	1.81	156
Allowances	0.21	24.23	12.79	36.05	150.87	1.81	273
Total	**16**	**863**	**-38**	**-4696**	**-655**		**-5559**
significant changes only					**-633**		**-5342**
Changes not covered elsewhere							**-5717**

The number of cloth dryer adopters is very small. Nevertheless, a surprising number of significant changes was identified in Tables 3-7 and 3-8. Again, the total expenses of the adopter-group is smaller than for non-adopters. And again the reduction in transportation expenses is the major source of reduced expenditure. However, this is in contrast to the increased number of cars and is likely to be an artefact. The increase in expenditures for clothing and shoes is interesting and is likely causally related with the cloth dryer.

The number of significant changes in durable goods is very large and all changes indicate an increase in number of goods. Although the refrigerator may have been replaced together with installing a cloth dryer and made it necessary to equip the room with an air conditioner, it is hard to make up a story for all the other items. Obviously, purchasing of a cloth dryer goes together with a substantial increase in other durable goods. Whether this is causal or not remains open.

Despite a huge increase in life satisfaction the happiness and even the living standard was reported to decrease. This may support the hypotheses that life satisafaction is closer related to durable goods. Again, this example of cloth dryer is heavily affected by the low number of adopters.

A further indication of the lacking robustness of these results can be seen in Tables 3-1 and 3-2. For instance, the results for 1998-1999 versus 1999-2000 look very differently and would suggest sometimes opposite conclusions. Also, the results by excluding those that got married look very different from those that exclude in to getting married, giving birth, moving to an own house, and enrolling to a school. This suggests that other life happenings are dominating the results. From this we need to ask, whether the life happenings reported by the young women are sufficient or whether additional events would need to be considered, such as falling in love, having a friend with certain hobbies, etc.

Table 3-8: CO_2-emissions based on change in durable goods linked to the purchase of a cloth dryer, combined sample for 1998-1999 and 1999-2000, including those that not got married, not gave birth, not moved to own house, and not enrolled (grey row indicates statistically significant of at least $p<0.1$).

	NN		NY		NY-NN	CO_2 intensity	CO_2 emissions	electricity	CO_2-emissions
	N = 656		N =14			possession only	possession only	use phase	use phase
	Mean	SD	Mean	SD	Mean	t-CO_2/piece	kg/a	kWh/a	kg/a
Dining Set	0.01	0.32	0.07	0.27	0.06	0.272	17	0	0
Cupboard	-0.02	0.33	-0.07	0.27	-0.05	0.174	-10	0	0
Microwave	0.00	0.24	0.07	0.27	0.07	0.052	3	25	1
Refrigerator	0.00	0.22	0.14	0.36	0.15	0.289	42	450	24
Automatic Dishwasher	0.00	0.19	0.00	0.00	0.00	0.197	0	400	0
Vacuum Cleaner	0.01	0.37	0.36	0.63	0.34	0.067	23	100	12
Laundry Machine	0.00	0.21	0.07	0.27	0.07	0.147	10	300	7
Cloths Dryer	0.00	0.00	1.00	0.00	1.00	0.135	135	366	132
Sewing Machine	0.02	0.32	0.07	0.47	0.05	0.192	10	10	0
Electric Fan	0.04	0.46	0.14	0.53	0.11	0.022	2	100	4
Air Conditioner	0.02	0.52	0.29	1.27	0.27	0.277	74	3000	290
Fan Heater	0.01	0.44	0.57	1.09	0.56	0.07	39	200	40
“Kotatsu” Heater	-0.02	0.35	0.07	0.27	0.09	0.06	5	200	6
TV Set	0.04	0.45	0.43	0.65	0.39	0.133	51	100	14
Stereo Sound System	0.02	0.43	0.14	0.53	0.13	0.136	17	50	2
CD Radio Cassette Recorder	0.03	0.50	-0.07	0.47	-0.10	0.042	-4	50	-2
VCR	0.00	0.55	0.43	1.16	0.43	0.063	27	50	8
Video Camera	0.03	0.29	0.00	0.00	-0.03	0.273	-8	5	0
Telephone	0.03	0.64	0.57	0.94	0.54	0.033	18	10	2
Bicycle	0.10	0.76	0.21	1.12	0.12	0.051	6	0	0
Car	0.02	0.36	0.21	0.70	0.19	4.913	955		560
TV Game	0.09	0.68	0.00	0.96	-0.09	0.026	-2	50	-2
Word Processor	-0.01	0.34	0.14	0.53	0.16	0.176	28	50	3
Personal Computer	0.11	0.44	0.07	0.47	-0.04	0.375	-13	117	-1
FAX	0.04	0.31	0.14	0.53	0.10	0.089	9	100	4
Mobile Phone	0.19	0.61	0.29	0.73	0.10	0.018	2	0.247	0
Total							**1438**		**1104**
significant changes only							**1258**		**953**

In order to learn more about the sensitivity of the CHap index we provide two more calculations: (1) by considering only those emissions that turned out to be statistically significant and (2) by correcting for the number of family members using the number for an average family member. Table 3-9 displays the results including a sub-set of sample alternatives and ranking the CHap for the three different calculation procedures. Although the CHap shows several changes due to the calculation procedure, the ranking remains robust with one exception. This is the case of having a baby that was already discussed above. Since the adjustment makes sense in order to consider the effect of family size we prioritize the results in columns 7 and 8. To restrict the analysis to significant changes only does not seriously alter the results and such a number would be inappropriately sensitive to additional households added to the analysis.

Looking again at Table 3-1 and 3-2 and focusing this time at the selected life altering events suggests that from a CO_2 point of view both getting married and moving to an own house may cause large increases in CO_2 emissions, while having a baby, and taking the leadership of a committee reduces emissions. One would have expected that the latter will score high on CHap. However, the derived change in happiness has been slightly negative, which is contrary to our expectations and might need additional interviews to understand this outcome.

Let us make a final remark to "getting married", the consistent rank order number 14. Getting married was the only activity that showed a statistically significant increase in happiness. Therefore, one could argue that this is the only activity where we are able to calculate a CHap with reasonable certainty. For the case of getting married it might be wrong to allocate all expenses and additional durable goods to the year of marrying only, if one expects that *being* married increases happiness as well. Therefore, activities that may need investments that pay in terms of increased happiness over more than one year would need an adjusted methodology.

Table 3-9: Comparing CHap and rank order for three different calculation procedures

Assessed activity	Considered sample group	Chap with total emissions	Rank order	Chap with stat. significant emissions only	Rank order	Chap with total emissions plus adjustment for change in family members	Rank order
		-	-	-	-	-	-
using a mobile phone	1998-1999, 1999-2000	-0.043	12	-0.038	12	-0.047	13
using a mobile phone	1998-1999, 1999-2000, not got married	-0.035	11	-0.030	11	-0.039	12
using a mobile phone	1998-1999, 1999-2000, not got married, not gave birth, not moved to own house, not enrolled	0.063	3	0.026	3	0.059	4
using a personal computer	1998-1999, 1999-2000	-0.021	7	-0.027	10	-0.021	9
using a personal computer	1998-1999, 1999-2000, not got married	-0.021	7	-0.026	9	-0.019	8
using a personal computer	1998-1999, 1999-2000, not got married, not started new lesson/learning, not became chairperson, not got full-time position	0.121	1	0.122	1	0.126	1
using a cloth dryer	1998-1999, 1999-2000	-0.027	9	-0.001	5	-0.032	10
using a cloth dryer	1998-1999, 1999-2000, not got married	-0.035	10	-0.013	7	-0.037	11
using a cloth dryer	1998-1999, 1999-2000, not got married, not gave birth, not moved to own house, not enrolled	0.070	2	0.069	2	0.065	3
Getting married	1998-1999, 1999-2000	-0.109	14	-0.089	14	-0.143	14
Having a baby	1998-1999, 1999-2000	-0.013	6	-0.019	8	0.098	2
Starting new lesson or learning	1998-1999, 1999-2000	0.011	4	0.020	4	0.012	5
Taking leadership of a committee	1998-1999, 1999-2000	0.011	4	-0.001	5	0.009	6
Started living in a house	1998-1999, 1999-2000	-0.097	13	-0.065	13	-0.014	7

4. Discussion and Conclusions

What did we get?

Figure 3 summarizes once more the quantitative results derived from the empirical analysis. We shall recall that the data covers the households of young Japanese women, and that we were looking into the purchase and assumed use of a mobile phone, personal computer, and cloth dryer. This selection was data driven. There was not a hypothesis that these three activities would have large influence on the happiness level of the young women nor did we assume that the purchase of these goods would cause a large number of induced changes in the consumption pattern. However, the three goods do have an impact on available time and allow to organize life differently, especially if the personal computer is connected to the internet. Therefore, we assumed that these examples could serve to demonstrate the approach. Realizing that major life events would dominate the changes in happiness and consumption patterns, we did clear the data set from those households that reported such events.

Although we did expect some changes in CO_2-emissions, the calculated reductions displayed in Figure 3 exceed the expectations in two ways:

- First, we assumed that those activities that save time may cause a rebound effect which leads to a net increase in emissions.

- Second, even if we divide the emission-bars by the number of family members the net decrease amounts to 400 kg (mobile phone), 800 kg (cloth dryer), and 1000 kg (personal computer). Considering that we covered about 4200 kg CO_2-emissions from about 10'000 kg CO_2 per average Japanese inhabitant the above savings would be between 10% and almost 25%.

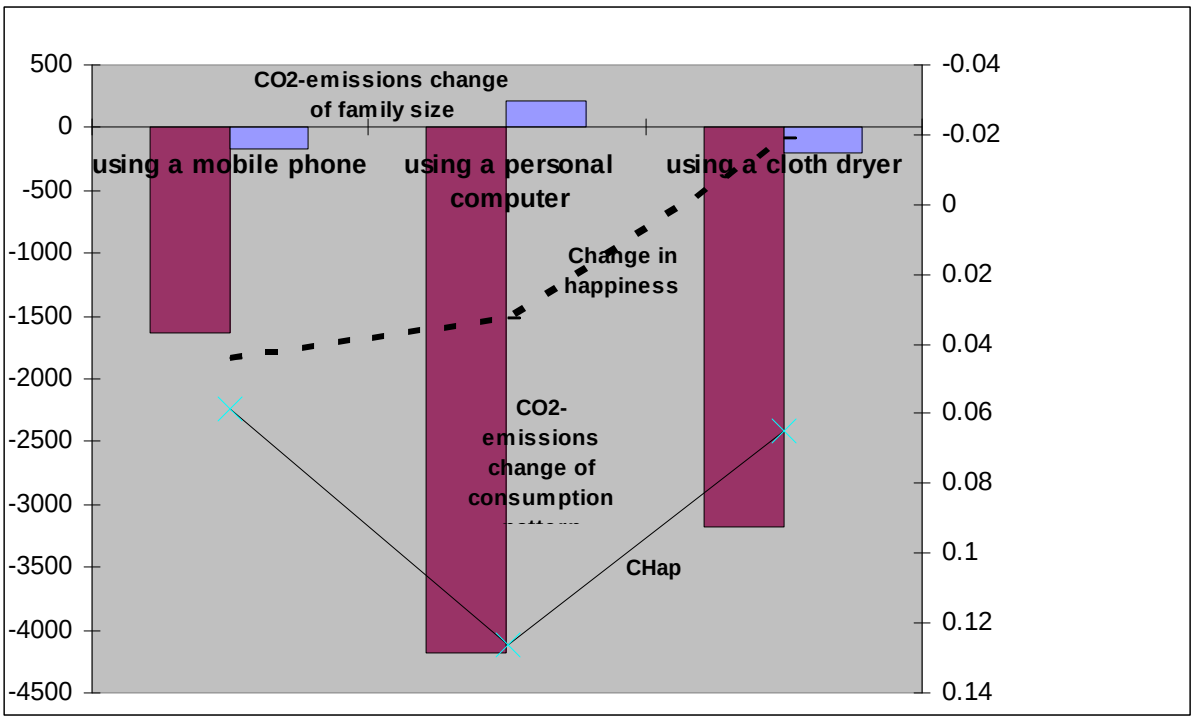


Figure 3: CHap and its constituting factors for three durable goods, correcting for major life events. (left y-axis: CO_2-Emissions in kg per household per year; right y-axis: change in happiness and CHap [-])

What are the caveat?

Some of the caveat have been mentioned above. However, a major caveat seems to apply to the question of causality. Although we did use panel data and did not just rely on correlation analysis as most other empirical analyses, this may not be good enough for activities that are hardly the true cause for major changes in consumption patterns.

Realizing how fast the large sample of more than 1000 households of young women melts if unaffected sub-groups are needed, the method may need to become more sophisticated by correcting for other independent factors rather than just excluding households that show other major changes. Although the chosen approach is rather transparent, it would require a much larger sample to take account of all relevant factors while still securing a sub-sample size that allows to detect statistically significant signals.

The obtained results for the three examples are also questionable because we found a reduction in household expenditure for all three examples. Especially the reduction in expenses in food and transportation looks suspicious. Sure, one can easily safe on eating out expenses in order to compensate for a luxury cloth dryer. But how is it possible that such substantial savings in transportation could be made? Or to say it bluntly: Would the purchase of a mobile phone causally lead to the reduction of 2.5 tons CO_2 per household as suggested in Table 3-3, then NGOs and governments may consider to give away mobile phones for free being a very cost-efficient way to reduce traffic.
We also need to be aware that our CO_2-calculations relied on only a small share of the household income that was spent on the available expenditure categories. Shifts in housing

and other loan-related consumption has not been included. Therefore, our results do only apply if all these shifts cancelled within the sub-samples.

Further, we did have household data for consumption but not for happiness. Also, not all decisions are taken by the same person in a household. Therefore, what see in the change on happiness in one person and change in consumption of a household may be only weakly correlated (because the husband gets the full happiness from the personal computer or the balcony that is now no more used for drying clothes.

Surprisingly enough, the choice whether only statistically significant changes in emissions are included or not did not change the ranking of the analyzed cases. Although the number of subjects in the sub-samples was small the data was surprisingly robust at least with respect to the CHap rank order.

How to proceed?
The presented analysis did succeed in demonstrating the approach. However, it becomes obvious that the used panel data is insufficient

- for analyzing more promising examples of sustainable consumption
- for allowing a reliable quantification that withstands careful review with respect to causality and statistical significance.

In order to justify the additional efforts needed for more reliable data to calculate CHap we need to clarify, whether there is empirical evidence, that

1. people that got happier in the course of several years indeed were able to do so without increased material consumption (CO_2-emissions)
2. at least some people that followed a number of recommended sustainable consumption activities managed to get both, more happy and less carbon-intensive?

Only if we can falsify the underlying hypothesis that striving for more happiness can reduce environmental impacts in a convincing empirical analysis we should proceed in collecting more relevant panel data that is analyzed with more sophisticated methods. Point 1 seems to be more relevant in this respects and might be evaluated with the available JPSC data set.

Before these questions are clarified we should realize that although we demonstrated on how to calculate CHap for three examples and five major life events, the conceptual basis of the index is most relevant. Our careful evaluations in Hofstetter & Madjar (2003), Hofstetter et al. (2004), and in Madjar & Hofstetter (2004b) make clear that the approach of striving for happiness enhancing activities that have low environmental impacts is convincing and can readily be applied.

For the time being we suggest to:

(i) list probable consequences of suggested sustainable consumption activities and assess there impact. E.g., if a cloth dryer indeed makes it necessary that an additional air-conditioner is mounted, both, the use of the cloth dryer and the air-conditioner need to be considered,

(ii) use the check-list in Hofstetter & Madjar (2005) to decide on the likelihood that an activity increases happiness, satisfaction, and reduces rebound effects, and

(iii) go ahead and promote the analyzed activity as sustainable consumption activity[3] if both tests are satisfactory.

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This report may or may not reflect the policy and opinion of the commissioners.

[3] We use here the term sustainable consumption although we are primarily looking at the environmental performance. The catalogue may be expanded to also evaluate the societal, social and economic performance.

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