The fallacy of *ceteris paribus* and real consumers - An attempt to quantify rebound effects.

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Abstract

Sustainable consumption assessment extends the scope of life cycle assessment in at least two respects: First, sustainable consumption looks also into societal and economic consequences of consumption and second, the impact on the consumption pattern becomes relevant above the single product perspective. Two tools have been developed to address this second extension. The first tool is a checklist approach for the design phase of sustainable activities, products and services. It is semi-quantitative in nature and combines results from streamlined life cycle assessment with a rebound factor and an indicator that is supposed to indicate the propensity to consume less, i.e., to escape the consumption treadmill. The second tool is the assessment method we call "CHap". It allows (i) for a more generic functional unit that we call ultimate utility and is approximated by change in happiness and (ii) by allowing for less *ceteris paribus*[1] assumptions. Instead of accepting the assumption that only the product/activity at stake is allowed to change we look into actual changes in consumption patterns that occur at the same time. The CHap approach is demonstrated with data derived from households of young Japanese women using the examples of cloth dryers, personal computers and mobile phones. The results suggest that chosen examples have small impacts on happiness but that considerable changes in other consumption categories occur. Whether these observed changes can be considered to be rebound effects is less than obvious and may need additional information from the consumers. While the usefulness of the CHap approach will depend on the availability of a large quantity of consumption data for the consumer group at stake, the checklist approach is readily available.

1. Introduction

Attempts to reduce CO_2-emissions per capita prove to show limited success – if at all. Especially approaches relying primarily on technological progress that increase the energy efficiency of services have often failed to materialize expected reductions in fossil fuel consumption. Such concepts need to be extended by considering two additional mechanisms: First, existing products or services are not just replaced by the new and more efficient alternative and second, consumers have no intrinsic motivation to reduce energy consumption but to maximize ultimate utility. Therefore, ways to predict changes in consumption patterns and ultimate utility are needed in order to estimate CO_2 emission changes due to the introduction of new technologies or products.

1.1 Objectives

State-of-the art design and assessment methods used for sustainable production have many shortcomings when applied to sustainable consumption. Two shortcomings shall be addressed in this project:

1. Consumers rarely substitute ONE old consumption activity by ONE (and only one) new consumption activity. This yields to rebound effects that may turn the introduction of a new (seemingly) sustainable consumption activity into the reverse (or *vice versa*) (Greening et al. 2000, Binswanger 2001). Such behavioural changes in consumption are usually neglected by assuming *ceteris paribus*.

2. Practitioners of life cycle assessment methods often measure the utility of products and services in units such as kg, meters, square meters, or number of pieces and economists often use willingness to pay or actually paid market prices. However, consumers strive to maximize their

[1] This Latin expression refers to the often used assumption in modelling, where everything else other than those variables that are explicitly allowed or supposed to change remain the same. In environmental product life cycle assessment, this assumption is used for most part of the production and consumption function.

ultimate utility that may better be approximated with measures of quality of life and subjective well-being. We suggest that the acceptability of changes towards sustainable consumption patterns can be improved when ultimate utility increases. This would also reduce compensational consumption addressed in point 1 above.

Understanding the consequences of activities, products, and services not only in terms of environmental life cycle impacts but also in terms of their impact on the change in consumption pattern and the change in utility has been the major objective of this project.

1.2 Approach

Taking the designer perspective we present two tools: one for the early design phase and one for the assessment of goods introduced in the (pilot) market. Both tools consider impacts on happiness, environment, and change in consumption patterns. The checklist approach for the early design phase relies on semi-quantitative assessments that are largely based on four formerly unconnected bodies of knowledge (see Section 2.1). The assessment approach builds on longitudinal panel data that allows one to identify changes in household activities and subjective well-being and was combined with a hybrid method to assess changes in CO_2-emissions (see Section 2.2).

1.3 Underlying hypotheses and evidence from literature

In Hofstetter & Madjar (2003) we introduced the idea of limiting factors [2] and drivers of consumption. Drivers can be understood at the top level where we see individuals maximizing their ultimate utility. On a level lower basic needs and their satisfiers can be understood as well as drivers to consumption. We suggest that the better a consumption activity both fulfils basic needs and maximizes utility the lower the propensity to get into a tread mill. In a tread mill consumption does not really satisfy and triggers more consumption. This means that our new tools base on the hypotheses that:

a) The better an activity, product, or service satisfies basic needs and maximizes ultimate utility, the lower the propensity for more (material) consumption. In other words: There is a saturation for the willingness to increase utility and therefore also a saturation in consumption.

b) Maximizing ultimate utility is possible without increased material consumption or even with less than average consumption.

Although we did carefully review the literature there is only limited evidence to support those two hypotheses. Sure, there is enough evidence that non-materialistic people can have very high levels of happiness or that some countries with low GDP per capita score high on happiness. However, we know little what happens when these people attempt to change their happiness and/or consumption level. Some of this evidence will be presented here. Extended reviews in Hofstetter & Madjar (2003) and Madjar & Hofstetter (2004b) do provide enough support to justify work that builds on these hypotheses because there is as well no good evidence against these assumptions.

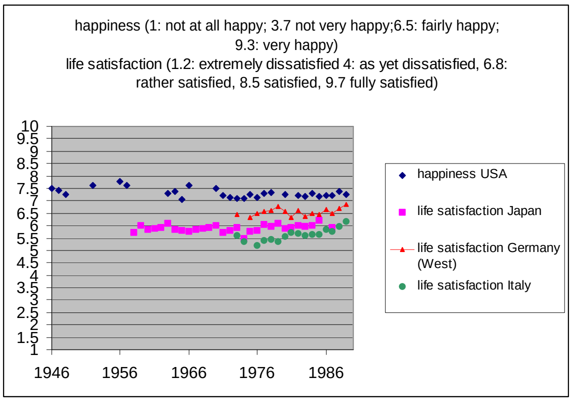

Figure 1: Happiness and life sections over time in four different nations (Veenhoven 1993). The scales have been transformed and the difference in values between nations has no meaning here.

Frey & Stutzer (2002) show that although income per capita in Japan rose between 1958 to 1991 from less than 3000 US$ to about 15'000 US$ the life

[2] such as money, time, space, skills, information, and other scarce resources

satisfaction was more or less stable over this time (life satisfaction was between 2.5 and 2.8 rated on a 4-point scale, Figure 1 shows the result transformed to a scale from 0-10). The same applies to happiness levels in the USA and life satisfaction levels in Germany and Italy. This suggests that there is no correlation between GDP per capita and subjective well-being which is a necessary condition for hypothesis (b).

Kasser (2002) analyzed the influence of making progress towards materialistic and non-materialistic goals and showed that making progress in materialistic goals did not enhance the well being level (high materialistic line) while achieving non-materialistic goals enhances the well-being level (see Figure 2). However, not achieving non-materialistic goals lowers the well-being level while not achieving materialistic goals hardly affects well-being. These are important findings and support at least hypothesis (b).

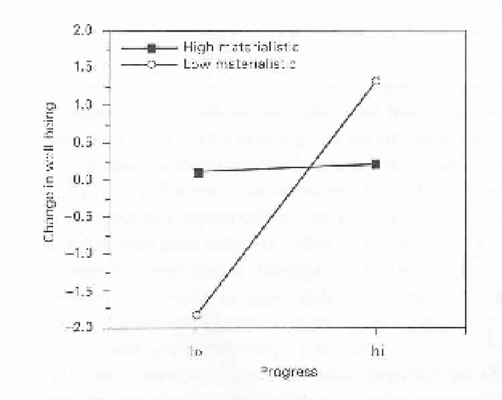

Figure 2: Changes in well-being as a function of the progress in materialistic and non-materialistic goals (Kasser 2002)

Diener & Oishi (2000) showed that those valuing love higher than money have a much higher life satisfaction than those who give priority to money (the higher the importance of love is, the higher is also the life satisfaction level (see Figure 3). They used data from 7'167 students in 41 countries. Therefore, this outcome is not biased by cultural factors. There is a positive correlation between love and life satisfaction but a negative correlation between money and life satisfaction. Therefore, this excludes "money" as measure for ultimate utility and would support hypothesis (a) with subjective well-being as utility measure.

Diener and Seligman (2004) discussed the causal way of happiness and materialism and suggested that although most studies concluded that materialism tend to decrease happiness it could also be that unhappiness could drive people to focus on extrinsic goals such as material wealth. Further they state that "longitudinal data indicate that part of the typical correlation between income and well-being is due to well-being causing higher incomes rather than the other way round". If this is true then it would be interesting to analyze what influence enhancing subjective well-being will have on materialism and consumption? Income is rather highly correlated with consumption. Will this possibly higher consumption be sustainable? Would this lead again to a negative effect (rebound effect) on happiness? This is why we suggest in Section 4 to falsify our hypotheses with additional analysis.

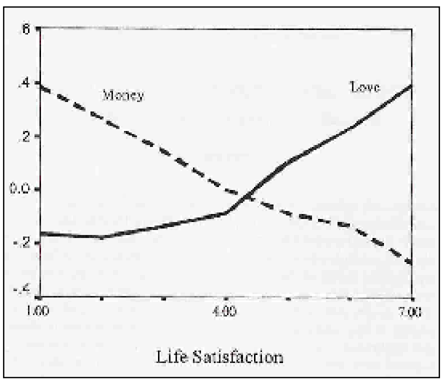

Figure 3: Relation between life satisfaction and love respectively money (Diener and Oishi 2000)

Based on the review in Hofstetter & Madjar (2003) we concluded that "happiness" might be a good indicator for ultimate utility. As long as no cross-cultural comparisons or generalizations are made, happiness is a good and simple self-reported measure of subjective well-being. Although both the checklist approach and the CHap method focus on happiness as a measure for ultimate utility our results sometimes also report life satisfaction and standard of living.

Section 2 provides short descriptions of the applied methods for both tools and Section 3 provides illustrations through examples. Section 4 offers a discussion of the results and conclusions from this work.

2. Methods

We propose two new tools for the sustainable consumption toolbox: First a checklist approach to support design for sustainable consumption [3] and second, a method to quantitatively assess behavioural aspects of consumption and its consequences on CO_2-emissions and happiness. The checklist-approach serves for the early design stages for sustainable activities, products, services (APS) when not all parameters are known and support is needed to come up with more sustainable alternatives. The quantitative assessment method is only applicable for APS that are at least partly introduced in the market for at least a year. It may serve to screen a large number of established APS and rank them according to the newly developed CHap index.

2.1 Design for sustainable consumption: The checklist approach

The semi-quantitative checklist approach combines four so far separated fields of importance to sustainable consumption:

i) The work on basic needs and satisfiers by Max-Neef (1991) is re-interpreted and operationalized.

ii) Happiness-enhancers have been compiled .

iii) Six limiting factors that have been proposed to cause rebound effects are combined to a rebound factor.

iv) A streamlined life cycle assessment is used to quantify potential life cycle impacts of APS.

Max-Neef (1991) suggested that there are nine universal basic needs (subsistence, protection, affection, understanding, participation, leisure/idleness, creation, identity, freedom) plus transcendence, which is not yet universal. He also gives a total of 129 satisfiers, i.e., factors that support the satisfaction of these needs when we look at the existential categories of “being” and “doing”. Although “subsistence” is considered to be the most basic need neither Max-Neef nor we did apply a hierarchy to these needs. We also assumed that all satisfiers are equally important. Therefore, an activity, product or service (APS) that covers several satisfiers and needs would be preferable over APS that focus on one need only. The assumption is that the better basic needs are satisfied through APS, the less individuals would be prone to consume more.

The second building block assumes that only happy people will feel less pressure to consume more with the idea that this would make them happier. As stated before, this assumption needs more evidence. However, we are convinced that offering APS that increase happiness offer the needed basis for sustainable development. Table 2-1 offers a list of happiness enhancing activities that have been collected from psychologists, psychiatrists, anthropologists and other scientists (see, e.g., Fordyce (1993), Wiesemann (2003), Myers (2004), Varughese (2004), and Monthier (2004)). This unique list that builds on Hofstetter & Madjar (2003) and Madjar & Hofstetter (2004b) has been analyzed using elements of Vester’s (2000) paper computer to identify this factors that are likely to play a very active role in stimulating or buffering other factors (Hofstetter & Madjar 2005). These insights on the relative influence on each other has led to a preliminary weighting of the happiness enhancers.

[3] Whenever we claim throughout this paper to develop tools for sustainable consumption we focus on the environmental and sometimes CO_2-dimension only.

	Happiness enhancers	weight
A	keep busy and active	1
B	become an outgoing social personality creating networks	1.5
C	meaningful work that engages your skills	1.5
D	lower expectations & aspirations	1
E	positive, optimistic thinking for present and future	1
F	become present oriented	1
G	healthy personality (food, sleep, movements)	1.5
H	skill engaging leisure activities	1.5
I	be yourself	1
J	prioritize close relationships	1
K	nurture spiritual (religious) self	1.5
L	focus beyond self	1
M	don't equate happiness with money	1
N	Take control of your life, get organized	1
O	Enhance self-esteem	1.5
P	act extraverted	1.5
Q	have sex with a person you love	2
R	prioritize happiness, act happily	2.5
S	be grateful	1
T	give love a high value in life	1
U	set achievable important non-materialistic goals	2.5
V	be open for new experiences / changes in believes	1

Table 2-1: List of happiness enhancers and a preliminary relative weighting of importance (Hofstetter & Madjar 2005)

Hofstetter & Madjar (2003) identified six major limiting factors to consumption: money, time, space, skills, information, other limiting resources. These six factors are quantitatively modelled and combined to a rebound factor that indicates the tendency of a APS to stimulate or allow for additional (material) consumption. The underlying assumption is that rebound effects have the power to significantly alter the total environmental impacts due to the adoption of a new APS and need to be considered when making recommendations for sustainable consumption (see Section 4).

The following 10-step checklist to design for sustainable consumption builds on these building blocks:

1. Brainstorm on activities, products and services (APS) based on needs, satisfiers, and happiness enhancers (see Hofstetter & Madjar 2005).
2. Identify for each APS the covered needs and satisfiers. Add the number of covered satisfiers and multiply this number by the number of basic needs that are (partly) covered by these satisfiers.
3. Apply the list of happiness enhancers (Table 2-1) to the potentially new APS and make a list of factors that are completely satisfied (3 points), good contribution (2 points), and weak contribution (1 point).
4. Multiply the number of evaluation points from step 2 and 3 with each other. Rank the APS according to the total points and select the top scorers for next steps.
5. Identify for each new APS one to three most similar established APS that might be substituted by APS for sustainable consumption. This should not just be based on intuition but by looking at the basic needs that are most directly satisfied.
6. Adjust the number and repetitions of activities, products, or services to approximately match the size, amount or extent of the new APS described in step 1.
7. Repeat steps 2 and 3 to the identified established APS.
8. Guesstimate for each selected potentially new and existing APS the life cycle costs, hours completely absorbed by APS, dwelling space, and other resources. Further, the share of people without sufficient skills and information should be estimated.
9. Perform a streamlined LCA to get a first estimate on environmental life cycle impacts of all APS under consideration.
10. Use Table 3-1 to evaluate the new APS according to its potential for sustainable consumption and its competitiveness against established APS.

A similar checklist was also developed for improving existing APS and more details are available in Hofstetter & Madjar (2005).

2.2 CHap: An index to assess and rank sustainable consumption activities, products, and services

The methodology includes three modules (Figure 4). 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 using a hybrid approach.

The three modules indicated by arrows can be combined to the index *CHap* 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.

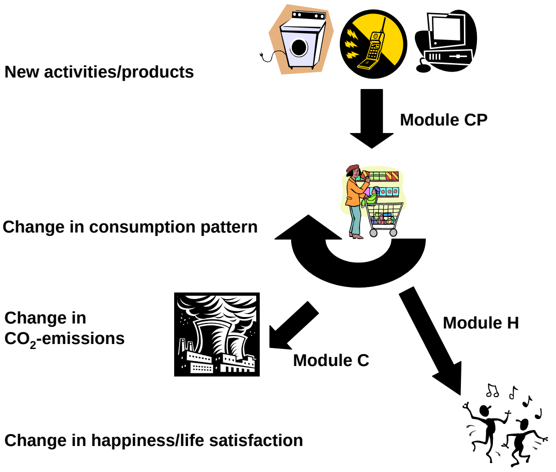

Figure 4: Overview on calculation procedure for CHap

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*:

$$\text{CHap}_i = W * \frac{\Delta Happiness_i}{Happiness_{ref}} - \frac{\Delta CO_{2,i}}{\text{CO}_{2,\text{ref}}} \qquad [-] \qquad (1)$$

Where happiness is measured on a scale from 1 to 5 and CO_2 emissions in kg. This formula allows that increased happiness and reduced CO_2-emissions contribute to higher scores of *CHap*. 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). 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).

Consumption elasticities are one of the new elements of this method. 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:

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

$$= \frac{NY - NN}{NN} \qquad (2)$$

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

$$CO_2\text{-emissions} = e*NN*I = (NY-NN)*I \qquad (3)$$

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). It is derived from input-output analysis using an extended input-output table for the Japanese economy. Process analysis and literature data was used for the three examples mobile phone, personal computer, and cloth dryer. The data on the change in consumption is taken from Ozawa & Hofstetter (2004c,d). For change in happiness we looked at the difference in change between the non-adopter group (NN) and the adopter group (NY). For a more detailed description of the method and assumptions we refer to Hofstetter & Ozawa (2005) and Ozawa & Hofstetter (2004c,d).

3. Results

3.1 Illustration example "gardening" for the checklist-approach

An old Chinese saying suggests that gardening may make people happy all life. Therefore, this looks like a perfect activity to illustrate the checklist for sustainable consumption. Here we show only the resulting evaluation Table 3-1. In Hofstetter & Madjar (2005) we assumed that having a dog, using a weekend house for maintenance work and walking, or starting yoga classes may be competing alternatives to gardening. We used desktop assumptions to fill in the table and would like to highlight only few issues here:

- In terms of need satisfaction and enhancing happiness the activities gardening, having a dog and starting yoga classes score rather similar. Only the weekend house scores much lower.
- The tendency to cause rebound effects has two sides to the coin. High costs, time and space demand etc. are good to avoid or reduce additional consumption. However, it also may make an activity, product or service less likely to be picked up by consumers. Also, the suggested evaluation procedure leaves much room for interpretation. Therefore, full transparency needs to be kept at the design and evaluation stage.
- We approximate in this example environmental impacts by primary energy demand guessed based on the assumed yearly costs. For the gardening we assumed a berry, fruit, salad and vegetable garden that would substitute for some of the household demand to be produced, stored, and transported elsewhere. Therefore, a net negative impact results.

Table 3-1: Evaluation table for sustainable consumption checklist, example "gardening" (Hofstetter & Madjar 2005)

Activities, products, services		Gardening	Dog	Weekend House	Yoga	Remarks
Number of covered satisfiers	S	79	64	44	54	
Number of covered needs	N	8	9	8	10	
Score	S*N	632	567	352	540	
Score from happiness enhancers	H	22.5	23.5	10	24	
Total score	H*S*N	14'220	13'536	3'520	12'960	higher means better potential for SC
Life Cycle Costs	Euro/a	200	2000	15000	600	
Ratio competing alternatives to gardening	C	1	10	75	3	Ratio >1 is better for avoiding rebound effects and worse for acceptability
Hours 100% absorbed	h	150	600	160	125	
Ratio competing alternatives to gardening	T	1	4	1.07	0.83	Ratio >1 is better for avoiding rebound effects
Occupied dwelling space	m^2	200	5	1	2	
Ratio competing alternatives to gardening	D	1	0.025	0.005	0.01	Ratio >1 is better for avoiding rebound effects
Other scarce resources		0	0	0	0	
Ratio competing alternatives to gardening	R	1	1	1	1	Ratio >1 is better for avoiding rebound effects and potentially worse for LCA
Share of people without required skills	%	10	20	10	30	
Ratio competing alternatives to gardening	L	1	2	1	3	Ratio >1 is better for avoiding rebound effects and worse for market potential
Share of people without required information	%	50	75	50	30	
Ratio competing alternatives to gardening	I	1	1.5	1	0.6	Ratio >1 is better for avoiding rebound effects and worse for market potential
Score for rebound effect	C*T*D*R*L*I	1	3	0.4	0.04	Ratio >1 means better for avoiding rebound effects
Environmental impacts analyzed by streamlined LCA	Primary energy kWh/a	-200	2000	15000	300	
Rank order happiness and satisfaction score	H*S*N	1	1	4	1	Highest score gives rank no.1 (only difference > 20% justifies different rank)
Rank order rebound effect		2	1	3	4	Highest ratio gives rank no. 1 (only difference > 20% justifies different rank)
Rank order impacts		2	6	8	4	Lowest Eco-Points gives rank no.1 (double weight rank order points, only difference > 20% justifies different rank)
Total rank order points		5	8	15	9	Just sum the three previous rows, lowest sum is best.

Weighting environmental impacts twice results in the final ranking in a comfortable "victory" of gardening followed by having a dog and taking yoga classes. In a real life application the designer could now select the most promising alternatives, make a business plan, and then make the final choice for the activity, product, or service to be offered.

3.2 CHap for cloth dryer, personal computer and mobile phones

In order to apply equations (1) and (3), we rely on the impressing Japanese Panel Survey of Consumers (JPSC) provided by the Institute for Research on Household Economics (IRHE) of Japan. Co-author Toshisuke Ozawa is approved user of the data and performed the statistical analysis using the three most recent years 1998-2000 for households of almost 1500 young women. Although the initial number of households seems large and even after combining the two samples from 1998-1999 and 1999-2000 we still were faced with very few remaining cases for adopters after excluding cases with major life events that affect our analysis. Therefore, the explanatory power of the used data and analysis remains limited. Table 3-2 illustrates how a selection of 10 major events affect happiness and the purchase of durable goods. Only getting married did positively impact happiness in a statistically significant manner. However, there are many life events that correlate well with buying the three example products.

Table 3-2: Events that affect happiness and the possession of three technologies (Ozawa & Hofstetter 2004d) (Significant different at $p<0.05$ between NN and NY (+: increase; -: decrease))

	Got married	Gave birth to a child	Husband moved out for business reason	Started a new hobby	Took responsibility as a chairperson of an organization	Entrance exam and enrollment	Working	Have a full-time position	Living in a detached single family house	Living in an own condominium or house
Happiness	+									
Cloths Dryer				-					+	
Personal Computer	+			+	+			+		
Mobile Phone	+	-				+				+

Among the multiple results in Ozawa & Hofstetter (2004a-d) and Hofstetter & Ozawa (2005) we will present here a very small selection only. Table 3-3 gives an impression how a ranking list of sustainable activities, products and services could look like. We give here the CHap values derived from equations (1) and (3) and using a number of assumptions:

1. The calculated CO_2-emissions include statistically significant and non-significant changes in the whole consumption pattern within one year of adopting the new APS.
2. The results combine the two samples 1998-99 and 1999-00 and they also adjust for changes in family size by correcting with a per capita emissions value.
3. All changes in this year are attributed to the listed APS only.
4. The CHap for cloth dryers, personal computers, and mobile phones are the values after excluding all households that did show other life events that affect happiness in a major way.

Assessed activity	CHap	Rank
Using a personal computer	0.126	1
Having a baby	0.098	2
Using a cloth dryer	0.065	3
Using a mobile phone	0.059	4
Starting new lesson or learning	0.012	5
Taking leadership of a committee	0.009	6
Started living in a house	-0.014	7
Getting married	-0.143	8

Table 3-3: Comparing CHap with adjustment for change in family size for three durable goods and five life events.

The high ranking of having a baby is not the consequence of a happier family. On the contrary, the happiness actually decreases according to our analysis. However, the CO_2-correction for the additional person in the family results in a large negative change in emissions. In the case of getting married happiness increases but CO_2 emissions increase as well, especially if all the added durable goods and other expenditures are counted in one year only (while the happiness increase supposedly sustains).

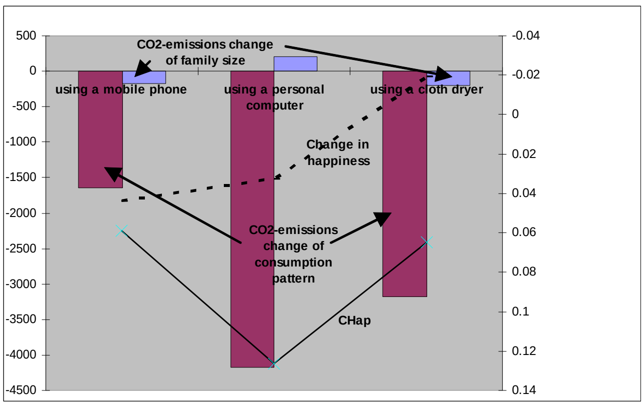

Figure 5: CHap and its constituting factors for three durable goods, correcting for major life events. (left y-axis: CO_2-Emissions in kg per household per year; right y-axis: change in happiness and CHap [-])

The very good ranks for the three durable goods need some further insights. Figure 5 provides the change in happiness -derived from the household sample- which is positive for mobile phones and personal computers but negative for cloth dryer (all not statistically significant). The darker bars indicate changes in CO_2 emissions per household between considering adopter and non-adopter households. This does not only include the actual change due to the production and use of the consumer good under consideration but covers as well all other deviations within the year of adoption. We can see that these bars are all heavily negative and this would not change if the CO_2-emissions due to changes in family size (light bars) would be considered. We should keep in mind that production and use of one year of a mobile phone, personal computer, and cloth dryer cause 18, 420, and 270 kg CO_2 respectively. This is 10% or less of what Figure 5 shows and *positive* not *negative*! This would imply a negative rebound effect of a factor of 10 or higher. The shown results are completely dominated by dramatic reductions in expenditure for transportation. This reduction can not be explained by avoiding trips by smart use of mobile phone and computer. We rather suspect that there are three bias at work:

i) After eliminating all cases with major affecting life events we end up with a very small number of adopters and sometimes non-adopters which makes the results arbitrary.
ii) Our method automatically assumes that the adoption is the cause for a change in consumption pattern. However, due to the nature of the analyzed APS, it is more likely that other changes in lifestyle are responsible for the observed change in impacts.
iii) The expenditure data for transportation -this is the data that proves to dominate the results- accounts for an average person in our sample in 2000 only 57’000 yen (570 USD) per year or 3.2% of income per capita. This amount does not account for car loans. Even if this would be included the total amount looks low. This means that the available data may not be sufficient to properly calculate CO_2-changes that account for all lifestyle and consumption changes.

These findings apply as well to the results shown in Table 3-3.

4. Discussion and conclusions

Much has been achieved in bringing together so far isolated fields relevant to sustainable consumption. The two new tools, one for design, the other for assessment, include both an assessment of environmental impacts. However, they also provide two different proposals on how to consider (the propensity for) rebound effects and (the potential for) utility maximization. The latter being a measure to predict the likelihood that the sustainable consumption activity indeed brings the expected satisfaction and may reduce the demand for additional (material) consumption. It is exactly this last purpose that remains so far a hypothesis awaiting further empirical evidence.

Checklist approach

The developed checklists for designing new or improving existing activities, products, or services allow to estimate need satisfaction, potential for happiness enhancement, propensity for rebound effects, and environmental impacts at reasonable costs and offer a proposal on how to condensate the information to indicators on different aggregation levels. This offers maximum transparency and may stimulate further improvements towards more sustainable consumption.

The whole checklist approach has the quality and purpose of a streamlined evaluation before all design, production and marketing parameters are fixed or even known. In addition to the major untested assumption already mentioned, there are a number of caveat that apply to the operationalization by the checklists. We do not know what limiting factors have the largest quantitative impact on the environmental impacts of consumption patterns. We do know they are relevant and we made further progress in quantifying all rebound effects together (Hofstetter & Ozawa 2005) but we have no factor analysis that indicates the relative importance of the single factors. We have accepted that all satisfiers listed by Max-Neef (1991) are equally important and that although subsistence is the most basic of all needs it should get equal weight to each others. The checklists did also assume a weighting of the factors that enhance happiness. The most critical and active factors from the happiness enhancing programs have been identified and deserve most attention when activities, products, and services are designed for sustainable consumption. However, the relative weighting remains a first subjective guess and we do not empirically know what happiness enhancing factors contribute most (and under what conditions). Further, we accepted that all six limiting factors have a multiplicative effect on rebound effects without having any empirical basis to support this assumption.

As a next step, applications and experiences will be needed to refine the tool and also get a better understanding on the importance of pseudo satisfiers, synergic satisfiers, and inhibiting satisfiers. Such insights may even help to prioritize activities, products, and services that should undergo a re-design procedure for more sustainable consumption.

CHap

Some of the caveat have been mentioned before. 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. The survey is filled in only once a year and for the month of September only. This may not be frequently enough to detect immediate and short term impacts on consumption in a causal way. However, this also means that mid and long term impacts may remain undetectable because there are too many other relevant things happening during a full year.

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 Figure 5, then NGOs and governments may consider to give away mobile phones for free being a very cost-efficient way to reduce traffic. The rebound factor of more than -10 would indeed be very promising for any sustainable consumption APS. In addition to the reasons mentioned, the CO_2-calculations relied on a small share of the household income that was spent on the available expenditure categories. Shifts in housing and other loan-related consumption (e.g., cars) has not been included. Therefore, our results would only apply if all these shifts had cancelled within the sub-samples.

Unfortunately, we did have household data for consumption but data on happiness only for one household member, the young women. Also, not all decisions are taken by the same person in a household. Therefore, what we see in the change on happiness in one person and the observed change in consumption of a complete household with typically four persons may be only weakly correlated (because the husband gets the full happiness from the personal computer).

These observations make it obvious that the used panel data is insufficient:

1) for analyzing more promising examples of sustainable consumption, and
2) 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

3) at least some people that got happier in the course of several years indeed were able to do so without increased material consumption or CO_2-emissions, and

4) 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 3 seems to be more relevant in this respects and might be evaluated with the available JPSC data set.

For the time being where the mentioned work above still needs to be done we suggest to:

- Use the checklist approach to predict the likelihood that an activity increases happiness, satisfaction, and reduces rebound effects and environmental impacts. This approach can be used for both designing new and improving existing activities, products, and services.
- List probable consequences of suggested sustainable consumption activities and assess there impact. E.g., if a personal computer indeed requires to buy a printer, equip the house with broadband access, buy an office chair, and buy a carpet that withstands the rolls of an office chair then we should analyze, the use of the personal computer as well as all the other usually induced purchases. It could also be that the heating demand will increase because PC owners tend to sit long hours with little movements requiring higher room temperatures to feel comfortable. In order to brainstorm on possible consequences and their probability one might use focus groups or survey techniques.
- Go ahead and promote the analyzed activity as sustainable consumption activity if both tests are satisfactory.

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