CHap

CO_2-emissions per unit of happiness:

A new indicator for sustainable consumption that considers and minimizes rebound effects

Report of Phase 1

Zürich, March 1, 2004

Authors:

Patrick Hofstetter, BAO, Zürich

Toshisuke Ozawa, AIST, Tsukuba

Kayo Sugai, SNTT, Tokyo

Satoshi Toyoda, MRI, Tokyo

Büro für Analyse & Oekologie

Patrick Hofstetter ■ Dr.sc.nat, Dipl.Masch.Ing ETH
Oerlikonerstrasse 45 ■ CH-8057 Zürich
+41 (0)43 288 5363 ■ patrick_hofstetter@yahoo.com

BAO

Acknowledgement

This research was supported by “The promotion project in international research collaboration on global climate change” from the Ministry of Economy, Trade and Industry (METI) of Japan. We thank the sponsor and SNTT for this support. We would also like to thank Dr. A. Inaba from AIST for his leadership and the opportunity for this truly international co-operation.

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

Abstract

Attempts to reduce CO_2-emissions per capita prove to show limited success – if at all. Especially approaches relying primarily on technological progress that increases 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, the methodology needs to model changes in consumption patterns and ultimate utility in order to predict CO_2 emission changes due to the introduction of new technologies or products. Using longitudinal panel data on household activities allows deriving consumption elasticities. These elasticities have been derived for young Japanese women and three examples: automatic cloth dryer purchase, getting a mobile phone, and getting a personal computer. The results confirm that consumption changes in patterns. However, they also show that the used grouping (young Japanese women) and the used sample size (1000) does produce only very few significant changes. Changes in happiness and life satisfaction have been derived from the same data sample. However, these data did not produce statistically significant relationships between change in happiness/life satisfaction and the three examples. In addition to the reasons mentioned above this is also due to the minor relevance of the studied examples. Combining the activity-based calculation of life cycle CO_2 emissions with information on change in consumption patterns and happiness allows identifying consumption activities with lowest CO_2 emissions per unit of happiness. These activities will be likely to escape the efficiency trap and actually deliver lasting reduction in CO_2 emissions per capita. These last steps of the analysis will be executed in FY04 of this project.

Table of contents

1. Introduction

1.1. Motivation

Sustainable production and sustainable consumption are two sides of a coin that is a necessary element of sustainable development. Due to the high relevance of mitigating climate change the Japanese government is exploring many ways to reduce CO_2 emissions. Therefore, the project "The promotion project in international research collaboration on global climate change" focuses on the contribution of a more sustainable consumption to mitigate CO_2 emissions. This is the demand side view that triggers the provisions of goods and services that hitherto is responsible for the emission of greenhouse gases such as CO_2.

While it is well known how to produce goods and services that cause less emissions during production, use and disposal phase it is less clear how easily such products will be adopted and how other lifestyle factors will be affected. These are some of the questions that ask for interdisciplinary and transdisciplinary research methods and a transfer of, e.g., disciplinary knowledge of marketing and behavioral sciences to applications in sustainable consumption.

1.2 Objectives

State-of-the art 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.

2. LCA practitioner measure the utility of products and services often in units such as kg, meters, square meters, or piece and economists often use willingness to pay. However, consumers strive for ultimate utility that can 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 avoid compensational consumption addressed in point 1 above.

Therefore, we suggest here to test a new method to quantitatively assess behavioural aspects of consumption and its consequences on environmental impacts and happiness.

The method shall be demonstrated based on three concrete examples that are candidates for sustainable consumption activities.

1.3 Approach, Procedure and State of the Project

We chose to approach the shortcomings above by developing a new assessment framework (Hofstetter & Madjar 2003) and an empirical test of the framework. The used data set covers a sample of about 1500 young Japanese women that have been followed in a longitudinal panel study. Although the panel data has been collected for different purposes it is very comprehensive and allows to look into both questions: (1) how are consumption activities changing in patterns and (2) how do such changes affect subjective well-being?

We have selected three examples of new activities that fulfil a number of requirements:

- they are typically started as well by young women

- they are covered in the available data set

- they have a potential to cause a change in greenhouse gas emissions

- they are relevant from a time use and/or space use perspective

The following three examples have been selected:

1. Purchasing an automatic cloth dryer
2. Purchasing a personal computer
3. Purchasing a mobile/cellular phone

We assume that these new products will actually be used. Therefore, we call them new activities. Our approach that is described in more detail in section 2 (methods) and the three documents in the appendix consist basically of three modules:

Module CP (consumption patterns)

What other activities are increased or decreased together with each new activity mentioned above? The results to this question are elasticities that tell us how much, e.g., somebody spends more or less on transportation if they start to use a personal computer. This module is called "CP" and reflects that we are looking into the change of Consumption Patterns.

Module C (CO_2-emissions)

What CO_2-emissions are directly caused by each new activity and those activities that are affected by the lifestyle change? This module "C" stands for the consequences in CO_2 emissions and uses a hybrid approach developed within the field of life cycle assessment.

Module H (Happiness)

How is the subjective well-being changing based on the new activities? This is measured here with life satisfaction and happiness and will be supplemented by insights and results from other projects.

Reports on module CP and C can be found in the appendix. A first set of results on module H is included in the report on module CP.

This project consists of three steps. The pre-study reports the general framework and positions the work within the available literature. The report was published in Hofstetter & Madjar 2003. Phase 1 of the main study will be concluded with this report that refines the framework by suggesting an assessment method with an application. This includes working papers for module C and CP, first results for module H, and a first evaluation of the elasticity calculations. Phase 2 of the main study will be performed in fiscal year 2004 and link the three modules, assess and evaluate the three examples, critically discuss the new assessment method including its relevance for policy making.

1.4 Related research

The suggested approach borrows and combines methods that have been developed in empirical social sciences, time use research, quality of life and subjective well-being research and life cycle assessment. However, there are only few initiatives that shall be mentioned here because they capture sub-questions that are relevant for our research project.

Yamana & Seto (2003) look as well at consumption patterns rather than single activities and assess CO_2 emissions of different lifestyles. Preliminary results suggest relevant differences in CO_2 emissions between different lifestyles. Their project is targeted to test the social receptivity of sustainable lifestyles. Based on collected survey data they defined lifestyle groups and respective consumption patterns. The survey has no longitudinal panel architecture. Therefore, the project looks into hypothetical lifestyle changes. This is different to our approach that looks at actual changes in consumption patterns. Another difference is that Yamana & Seto (2003) look in a different way to ultimate utility than we do. They look into the social receptivity of the change while we look into the change in life satisfaction and happiness. Therefore, the two projects will provide interesting complementary insights on similar questions.

Social scientists are concerned about the role of increased information technology in our lives and are interested to learn more about its impact. In Hofstetter & Madjar (2003) we discussed in some detail the longitudinal panel data that has been used in Gershuny (2002). Gershuny used this data to look into the change of time use patterns when people start to use the internet. E-living is a European research project that looks into very similar questions but considers a large array of information technologies and looks not only into changing time patterns but also assesses the change in quality of life (Anderson 2004). This study uses 2-wave panel data that has been collected in 6 European countries. In section 3.2 we compare some preliminary results of e-living with our results.

These are just few examples on related activities. It seems that especially in the environmental and sustainability assessment of new information technology researchers start to think in similar terms as has been proposed and developed in our project (see, e.g., Hertwich 2003). Therefore, it will be necessary to make the insights of this project widely available to direct future research activities.

1.5 Structure of the report

This report describes the used method in Section 2 and includes some insights on how to link the single elements. Section 3 briefly discusses preliminary results based on the working papers in the appendix before Section 4 provides an outlook to phase 2 and beyond.

The working papers attached in the appendix from AIST and SNTT include all relevant data and are the basis for phase 2.

2. Methods

2.1 Overview

The project title and the goals stated in the previous section suggest that the method needs to be able to assess both, changes in CO_2-emissions and happiness/life satisfaction. In addition, these changes are not assessed on a macro or national level but on an activity/product level. This implies that the model needs a high resolution on the micro level and should at the same time be able to deal with the complex web of links that is responsible for indirect effects. The method should be able to reflect behavioural responses that go far beyond those usually considered in general equilibrium models on the macro level or simplistic assumption made in micro level tools, e.g., the functional unit definition in Life Cycle Assessment. In short, a method is needed that is able to deal with rebound effects on the micro level.

For this reason, a new method has been suggested in Hofstetter & Madjar (2003) and is further developed here. The method is descriptive in the sense that observed behaviour is used to derive causal relationships between activities. We call those elasticities, because of their similarity to economic elasticities used in computable general equilibrium models. However, the derived elasticities are not used within a full blown computable general equilibrium model. Instead, we calculate the first iteration of changes in the demand function and assume a parallel development of the supply. The supply side is then analyzed using a hybrid model as often used within LCA. Finally, the change in happiness/life satisfaction is as well assessed analyzing observed data. Later this data will be supplemented by additional insights from the literature.

The three modules and the calculation process are presented in Figure 2.1. We selected the new use of an automatic cloth dryer, a mobile phone and a personal computer as activities to demonstrate the method. The three modules indicated by arrows will be described in the following subsections. If this assessment process would be applied to a large set of activities that include all those activities that are suggested to contribute to a more sustainable development one could calculate the following indicator:

$$CHap_i = \frac{\Delta Happiness_i + 4}{\Delta CO_{2,i}} * 10000 \qquad [t^{-1}] \qquad (1)$$

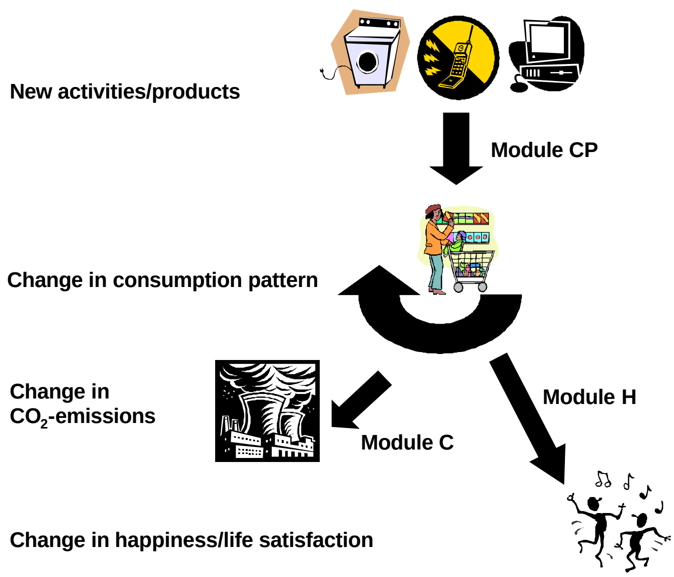

Figure 2.1: Overview on calculation procedure

Where happiness is measured on a scale from 1 to 5 and CO_2 emissions in kg. The correction value for happiness of 4 makes sure that the nominator falls between 0 and 8. The correction factor of 1000 makes sure that CHap takes values that are not too small. The activities could then be ordered from the lowest Chap to the highest. Where the top activities[1] have the highest potential to contribute to sustainable consumption and the activities with the highest scores are likely to have either high CO_2-emissions or a low or negative impact on happiness (or both).

Further information on the single steps and methods used can be found in the following sub-sections. This report covers only module CP and C and some aspects of module H (see appendix). However, the linkage of these modules and the assessment of the three cases will be covered by the final report of phase 2 (FY 04/05).

2.2 Consumption elasticities for changing consumption patterns

The method used is common in empirical social sciences and epidemiology where the analysis of longitudinal panel data is often used. The data is based on individuals that are followed over a certain time and where data is collected at least twice. In our case we rely on panel data that has been collected by The Institute for Research on Household Economics and is called 'Japanese Panel Survey of Consumers (JPSC)'[2]. This data that was derived from Japanese women is collected since 1993 and includes two groups. Women with 24-34 years of age in 1993 form group A, and group B includes women with 24-28 year of age in 1998. The data includes a large number of variables on socio economic data, family events, time-use data, consumption data and data on happiness and life satisfaction.

We selected the latest three years of data that was available when we started the analysis (1997-1999). By comparing the data for each individual for 1997 with 1998 and 1998 with 1999 one can identify the changes on an individual level. For each of the three case studies we sorted the data into four strata. Women that did not have a PC and did not buy a PC are classified as “No No” or “NN”, adopters are labelled “NY”, people that already had a PC and kept it are labelled “YY”, and those that got rid of a PC without replacing it are labelled “YN”. In a next step one can observe how these for groups differ in other aspects that the possession of the goods we are focusing on. By dividing the scores of NY with NN one can calculate the elasticity of all other variables for the case of adopting a specified new activity.

For the analysis in phase 2 we have included information on household expenditure and its change and differences of possessions of other goods. In order to learn more about the data additional analysis is provided in Appendix 2, such as time use data and the correlation with socio-economic data. Data preparation, data cleaning, and the assumptions made for the analysis are provided in the working paper on module CP (see Appendix 2).

Although the method is well established and superior in terms of giving insights on causal consequences there are a number of caveats that need to be considered. Firstly, there is a vast amount of independent variables (measured and unmeasured) that differ from individual to individual. Some are genetically determined, others due to upraising, education, luck and (conscious) decisions. This makes that no individual is exactly comparable to another. Considering all independent variables is impractical and selecting only few a delicate task. In order to identify (significant) trends one needs a large number of individuals and a good idea

[1] These are the activities with low CHap values. This is because a happiness value of 1 stands for ‘very happy’ and 5 for ‘unhappy’.
[2] see http://www.kakeiken.or.jp .

on what independent variables should be controlled for. Therefore, the interpretation needs to take into account that a common but not considered independent variable may be responsible for the observed effect that was mistaken as a causal effect of a considered independent variable. Further, even weak relationships may be relevant because adding more individuals and independent variables is likely to increase the effect and its statistic significance.

2.3 CO_2-emissions

As indicated above, we know for each case study what additional household good has been purchased, what other changes in the allocation of the household budget have been made in the same year and how somebody differs in terms of household good purchases from individuals that did not buy the case study good in the first place.

In order to show the consequences on CO_2-emissions three sets of data are needed:

1. Life cycle emissions for the three case study goods, i.e., PC, mobile phone and automatic cloth dryer [kg].
2. Emission intensities [kg CO_2/yen] for the household expenditure categories differentiated in the panel data.
3. Production emissions [kg CO_2/good] for all other monitored household goods.

The used methods to calculate are described in Appendix 1 and have the purpose of getting estimates rather than detailed assessments of the CO_2-emissions. In short, the following methods have been used:

ad 1: Here the most detailed analysis was done by combining data from assessments that have been previously done by others (literature data), own calculations of the production step using Japanese Input-Output tables that have been extended by data on sector emissions of CO_2, and additional calculations for the use phase (electricity consumption times CO_2 emissions per kWh). The disposal phase was neglected due to its small relevance for the chosen examples.

ad 2: We used Japanese Input-Output tables that have been extended by data on sector emissions of CO_2 to calculate sector emission intensities. Some sectors needed to be aggregated in order to fit for our categories given in the panel data.

ad 3: From the panel data it was possible to derive the average purchasing price per good. This price and the sector intensities were used to estimate production emissions.

The authors are aware that these results are only indicative of the true emissions because a number of simplifying assumptions are made:

- we assumed that the imported goods cause the same CO_2-emissions per yen as the same sector within Japan
- depreciation of capital goods was not included
- it was assumed that the studied products have the average CO_2-intensity of the respective sector
- no difference was made between producer CO_2-intensities and consumer CO_2-intensities
- we included only CO_2-emissions from fossil energy combustion

These assumptions may in total under- or overestimate the true emissions, because the biases go both ways. An even more striking assumption[3] was made when we decided to estimate the

[3] This is meant from a modelling point of view, because the remainder model is consequential in its nature.

average CO_2 emission per good or spent Yen. It would be more sensible to look into the changes in CO_2 emissions of one additional good purchased or Yen spent. However, the consequential analysis of emissions is still in its infancy and was beyond the scope of this project.

2.4 Change in happiness and life satisfaction

The goal of this module is to quantify the change in happiness when the three new activities are adopted including all behavioural changes. Happiness is selected as acceptability indicator or ultimate utility indicator because happiness is a relevant driver in people's (consumption) behaviour. In addition, the importance of happiness as utility indicator in economics is growing. Recent economic research focuses on what economists can learn from happiness research (Hofstetter & Madjar 2003).
The meaning and importance of happiness in people's life is not the same in all cultures. Therefore, it is important that the chosen data set of JPSC includes happiness data for the same group. Where other indicators close to happiness like life satisfaction or "flow[4]" exist, these indicators can be used in addition to happiness as indicator to measure the outcome of changes in consumption behaviour.

The project will pursue three separate tracks to understand and quantify the impact of activities on subjective well-being:

1. The longitudinal panel data from JPSC includes two measures of subjective well-being: happiness and life satisfaction. Analogous to the method described in section 2.2 the change in happiness and life satisfaction was determined (for details see Appendix 2).
2. A literature search will focus on how other studies assessed the subjective well-being related to the use of PC, mobile phone, and automatic cloth dryer.
3. In order to get some rules of dump we will study the characteristics behind activities that are likely to increase subjective well-being.

In this report we will quantify track 1 and discuss its results in section 3.2. Track 2 and 3 will be explored in FY04. Although we prefer to use happiness as an indicator for ultimate utility we also analyze life satisfaction in track 1. The happiness data in the survey is usually collected as the very last question of a question booklet of more than 50 pages. Therefore, the answer to this last happiness question is likely to be biased by the tedious task of answering all previous questions. Depending on a persons nature one may be extremely happy that the task is finally finished or rather sad after having spent such a long time with tiring questions. The relation to the life in general may be weakened. The question of life satisfaction is doing a better job in referring to the life in general and not the moment of filling in the questionnaire.

2.5 Linking the three elements

Each of the three modules described above will lead to interesting results and insights itself. However, linking module CP with module C will allow assessing the net change in CO_2-emissions due to the adoption of a new activity (or product in our case). This net change corrects for direct and indirect rebound effects and will give us additional information on the

[4] State of total involvement with a certain activity that requires complete concentration. To be in a flow state during a certain activity can be a driver to perform this activity more often.

relevance of these rebound effects. Module H allows quantifying the change in happiness. Therefore, equation (1) will link the three modules.

These steps will be performed in the next phase of this project.

3. Results

3.1 Consumption elasticities on a micro level

The purpose of this section is to highlight and discuss some of the results presented in Appendix 2. For this purpose we will focus on those relationships that showed high or significant relations. We will start with few static observations on the data, then focus on the elasticities, and finally address the high variability of the data.

3.1.1 Data characteristics

Sample information

The Japanese Panel Survey of Consumers (JPSC) dataset was provided from the Institute for Research on Household Economics (IRHE) of Japan. The JPSC longitudinal panel data include the variables of time-use data, consumption data, and quality of life and life satisfaction, necessary for our study. The panel cohort consists of at least 1,500 women who are geographically distributed throughout the nation. The latest dataset available is from the survey in 1999. The data consist of Cohort A (in the age range of 28-38 as of 1997) which has been covered since the first year's research in 1993, and Cohort B (in the age range of 24-27 as of 1997) which IRHE has covered since the fifth year's research in 1997. We decided to use the most recent available panel datasets (1997, 1998 and 1999), married and single samples combined, as well as Cohort A and B combined, for this study.

Correlation between independent variables

The data set offers an impressing richness of data. It includes about 40 aspects of changes to the women's life themselves or their family. Since this report assumes that consumption is changing in patterns we also wanted to see whether such life changes occur in patterns. Table 4-2 in Appendix 2 shows the correlation matrix between the variables and reveals some insights, e.g.:

- giving birth to a child is negatively correlated with taking a leadership position
- taking the parents at home is correlated with heavy burden on taking care
- if a family member transfers this goes together with big expenditures and may have been caused by a divorce or separation
- finding a new job and showing symptoms of depression are correlated as well. However, it may well be that the depression refers to the time before finding a job, because changing job correlates as well with depression.
- Depressions and other psychiatric symptoms are also correlated with illnesses, loan or credit card troubles, a loss of a good relationship, and divorce or separation.

Although these results confirm some patterns they are not especially highly correlated and no truly surprising correlations have been identified. In a next step we asked ourselves whether some of these independent variables may have a more severe impact on our analysis than the use of three goods in our case studies.

Life changes and their impact on happiness, life satisfaction and the purchase of goods

Tables 4-6, 4-10, 4-14, and 4-18 in Appendix 2 look into the regression coefficients that determine subjective well-being and the purchase of goods. The regression with happiness revealed the high negative impact of loosing good relationships with other family members, a divorce or separation in the family, and depression. The enrolment to a graduate or professional school explains for young Japanese women as well loss in happiness. The divorced or separated women consider themselves to be happier and the same holds for women that find a new job.

For life satisfaction we find a different picture that confirms the assumption that happiness and life satisfaction measure two different aspects of subjective well-being. Leaving for an independent life is considered to increase life satisfaction. Income cuts or depreciation of properties are considered to reduce life satisfaction. Similar to the results above, school enrolment, loosing good relationships and depression correlate with reduced life satisfaction. These differences could be interpreted in the direction that life satisfaction includes more aspects of achievement and material satisfaction.

From tables 4-14 and 4-18 we can learn that the transfer of a family member, starting new lessons/training and entering exams or enrolment are explaining differences in possession of the goods analysed in our case studies.

Good possession
The three analysed goods show very different characteristics of possession. Most women own a mobile phone and the percentage increased a lot from 1997 to 1999. The same increase can be seen for PCs but on a much lower absolute level of possession. The possession of automatic cloth dryers stayed stable at around 20% of all households.

While users of the three goods usually earn more than non-users and have also higher savings, the latter is not true for users of mobile phones. One might suggest that mobile phone users do so more often at the expense of savings.

Tables 4-31-4-37 confirm that cross-sectional analysis would not be able to inform the question *what* happens *if* somebody purchases a new good/starts a new activity. It basically confirms that users and non-users are very different types of people and families.

3.1.2 What changes if a new good is purchased?

Section D in Appendix 2 includes four strata for each of the case study products. These four groups separate those that did not own the good in two consecutive years, those that purchased the good under consideration, those that already owned the good before the observation started and finally those that initially owned the good but then reported a year later that they do not own it anymore.
With this stratification we are able to see what other aspects of life changed for women that purchased one of the case study goods. However, at this stage we do not know whether this was a trend that all households showed and whether the observed difference is indeed due to the purchase of the new good or whether other life changes are actually the cause (e.g., giving birth to a baby). Nevertheless, this way of analyzing the data allows focusing on all women that purchased the new good.

Analyzing the household spending allocation reveals that indeed many significant changes from 1998 to 1999 could be observed. However, the increase in expenditure for transportation and communication was true for all four groups and reflects a general trend mentioned above.

Households that purchased an automatic cloth dryer showed between 1997 and 1998 a significant decrease in time spent by the husbands for house keeping and taking care of children during week days. However, this significant decrease of 10 minutes per day was more than compensated by the wives (15 minutes more per work day, 28 minutes more on weekends) and by the husbands contributions on weekends (19 minutes more per day). These other changes were not significant but in their absolute magnitude even higher. Therefore, the interpretation needs to be done very carefully.

Tables 4-42a-f show probably best how the observed Japanese households did not make single isolated purchasing decisions but were likely to do so in patterns, i.e., together with other goods. This is not only supported by significant changes of household possession of durable consumer goods or expenses to buy them but also due to significant changes in those households that “lost” possession of the case study good.

Buying an automatic cloth dryer was often accompanied by buying a dining set, a micro waver, a laundry machine, but also a fax machine. While the laundry machine goes well together with the automatic cloth dryer, the change in other good possessions is less obvious[5]. For personal computers we observe again a surprising significant increase in the possession of microwavers. Other significant increases include VCR’s, TV games, fax machines, and mobile phones. Some of those are not consistent for all years and they concern the other three subgroups as well. For mobile phones we only find between 1997 and 1998 significant changes. TV sets, other non-mobile telephones, PCs and fax machines increased significantly. This indicates that communication needs increased significantly in this group. Rather than substituting one form of communication with another one a pattern of communication goods was purchased.

In order to increase the power of the sample we combined the data on the two comparisions 1997-98 and 1998-99. These results are shown in Appendix 2, section E. Tables 4-48a-c but also other tables confirm that increasing the power of the sample helps to produce more statistically significant results. However, the variation remains large and for many variables no significant changes can be observed.

3.1.3 Elasticities

Section G of Appendix 2 provides the elasticities that have been calculated by comparing the group of households that purchased the case study group with the group of households that still does not own the good.

The comparison of the household spending allocation (Tables 4-59a-c) reveals some surprising insights. However, one needs to be aware of the lacking significance of most results. For all three examples the spending for transportation was reduced compared to the households that did not purchase these goods. This had no obvious consequences for households that bought an automatic cloth dryer. This group did not move to a more expensive place and did also not increase the purchase of cloths and shoes. Therefore, the family size was probably constant. However, the expenditures for going out, food and leisure activities increased a lot compared to the group of NN. New PC users are likely to have also moved to a more expensive place. Probably, this was due to need for office space. New mobile phone users show exactly the opposite trend, they reduced the expenses for housing. This may be an artefact of the sample, where young women may still live at the place of their parents *and* are more likely to purchase a mobile phone.

[5] Some of these possessions increased for the other subgroups as well. One may also suggest that the changes may have to do with moving into a new and larger apartment or with the fact, that buying a cloth dryer implies that one visits a store for electric and electronic goods and therefore increases the exposure to all other durable consumer goods.

The time use changes (Tables 4-60a-c) show somewhat expected changes for the group of cloth dryer purchasers. The wives work less out of the house and spend more time with house-keeping work and taking care of children. Husbands sleep less but enjoy more time for leisure activities and going out. For the case of PCs the change for wives is very similar: less external work, more house-keeping and taking care of children. However, both men and women report less time for leisure, hobby, and going out. In the case of mobile phone purchase the trends are less obvious (wives again spend more time with housekeeping and taking care for children). One reason may be that it is not clear who got the mobile phone (wife, husband or other family member).

The possession of goods (Tables 4-61a-c) increased in general in all three case studies. However, the increased was most pronounced in the case of purchasing a cloth dryer. About 10 to 40% more durable goods are possessed by this group compared to those households that did not acquire a cloth dryer. As stated earlier this may have to do with family or/and apartment size.

Cars, cupboards and air conditioners dominate the absolute magnitude of differences in terms of expenses for the purchase of durable consumer goods. However, the size of the bars (Figures 4-24-4-26) should not disrupt from the fact that some differences are not significant in a statistical sense.

No significant changes in happiness and life satisfaction (Tables 4-63a-c) were found. Therefore, the elasticities take arbitrary signs and magnitudes and differ a lot between the two chosen periods (97-98, 98-99). See Section 3.2 for further elaboration on this issue.

For more insights we refer to the data and explanations provided in Appendix 2. These elasticities will be used in the last phase of this project to calculate the consequences of CO_2-emissions (see Section 3.3.).

3.1.4 Variability of consumption patterns and changes in patterns

The analysis of consumption patterns provided in Appendix 2 produced a wealth of interesting data. Many expected correlations could be confirmed. However, only few relationships proved significant at the $p<0.05$ level and in many cases one would expect that causes not explicitly included into the analysis may be more important than the observed variables.

What are the reasons for this observation? Why did the sample of almost 1000 women and their households not produce more significant results? This sample size that consists only out of young women is usually considered to be sufficient for even detailed type of analyses.

A recent Swiss survey was looking into the use of computer games. Among boys age 12-16 the average time spent with computer games was 68 minutes per day. Girls spend only 16 minutes per day in front of computer games[6]. This gives a hint on how important it is that the used sample includes only young Japanese women. The variability would be even larger if a representative sample for the Japanese population would have been used. This example makes the questions asked above even more pertinent. Where does this variability come from?

There are some experiences from other fields that explain the problems of detecting statistically significant relationships:

---

[6] see http://www.hapzh.ch/pdf/F_Jugendliche_und_Medien.pdf

1. In epidemiology, very similar type of analysis is performed. Health endpoints for a large group of people are monitored, ideally also over time in a longitudinal panel approach. At the same time, potential causing factors are collected (sometimes in the same survey, sometimes ex post based on, e.g., air quality monitors and interpolation methods). There are many risk factors that may affect the observed health endpoints and in addition genetic predisposition adds a natural variability. Therefore, such studies often need many thousands of observations to produce any significant results. This holds especially true in environmental epidemiology when chronic impacts based on environmental impacts are determined.
2. Consumer research is another example where the variability of individuals plays a major role. The variability is not restricted to sex, age and life stage but includes more subtle aspects such as taste, tendency to follow the fashion, world view, and social, economic and physical environment. Therefore, consumer research does usually develop advertisement strategies for small subgroups that show similar interests and taste and therefore similar consumption behaviour. An incomplete survey of such classifications can be found in Hofstetter (1998) and confirms the difficulty of generalizing behaviour.

The problem of weak relationships was also found to hold in other related studies on time use. As discussed in Hofstetter & Madjar (2003), the results on time use when people adopt the use of internet show large differences between women and men. If the grouping would have been made based on further criteria, e.g., whether the internet is used for shopping, dating, or study/research one might easily find more significant consequences of using the internet (or *vice versa*?). Another grouping between introverted versus extraverted characters would produce yet another picture of potentially increased predictability of behavioural consequences from adopting internet.

These examples explain well why the analysis in this project is insufficient to predict with high certainty the behaviour of young Japanese women that purchase good X (where stands for any good). It may be necessary to adopt groupings used in consumer research in order to improve the significance of the identified relationships. This makes also sense from the perspective of dissemination of insights from research into sustainable consumption. These results will need “marketing” and in order to be attractive to consumers, such marketing needs to focus on target groups that show similar interests. Therefore, it would make sense to use the same consumer groups in the analysis and the dissemination.

From the data one can also see that the economic development of the household may explain much of the observed variation. Correcting for this other causal factor may reduce the noise in the data.

What is the value of the presented data analysis? The value is at least twofold. First, non-significant coefficients do not mean that there is no relationship or that the sign is necessarily opposite. Non-significant coefficients may well serve to gain insights. Second, this project produces data that allows calculating empirically the average direct and indirect rebound effect for three case studies. This information is highly significant because rebound effects need to be considered not just for target groups but for all consumers of a service or good. These two applications are the core of this project and will be performed in fiscal year 2004.

3.2 Changes in happiness and life satisfaction

In this subsection we shall critically discuss what the results in Appendix 2 and 3 tell us about happiness and life satisfaction and what we can learn from this initial analysis. Results from another project that will be finished shortly are discussed and finally a pre-view is given on where phase 2 should focus on with respect to happiness analysis.

3.2.1 Results from this project

The results in Table 4-2 (Appendix 2) and Appendix 3 indicate that the analysis was able to show significant relationships between major changes in live and happiness/life satisfaction. The results confirmed that happiness and life satisfaction are not a complete substitute for each other but measure slightly different aspects of subjective well-being. This is also discussed in some detail in Section 5A) of Appendix 3.

However, while the data proved to be valid in general it failed to produce any significant results for three case studies under consideration. Instead of analyzing the achieved results we shall list here some reasons why we may have failed to do so:

- Section 3.1.4 discusses in some detail why the sample size and grouping was not sufficient to reveal more statistically significant relationships. With respect to sample size one must keep in mind that we are looking into very small changes in happiness because it was clear from the beginning, that the studied goods have minor impacts on happiness. With respect to grouping one should imagine the case of buying a computer. If this means that one has to work extra hours at home there is no reason to assume that this increases the happiness. However, if this allows to be in contact more often with friends, to date new people, or to work one more day from home and see the family more often once can easily imagine that this will impact happiness in a positive way.
- We did not have a prior hypothesis on how our three case study goods will affect happiness, i.e., the case studies have not been chosen because we believed that they will alter happiness in a relevant way. All three cases can easily be seen as making life easier or more efficient but they can also mean:
  -- that the amount of laundry increased a lot,
  -- that the need to do computer work was due to the fact that the housekeeping person needed to earn some extra money, or
  -- that the purchase of a mobile phone was necessary because the requirements on availability increased or the amount of short-term arrangements increased.
  Therefore, we did not expect a large signal to begin with and are faced with cases where the sign can go both ways.
- Due to data constrains we had to focus on the purchase of goods. Although the purchase itself may have an impact on the subjective well-being this effects would be very short-lived and certainly outside the scope of the collected data. In sustainable consumption we should rather focus on activities and their contribution to subjective well-being. If we do so, the goods become enabler of activities and are not the purpose by themselves.

These reasons indicate that the problems observed would be smaller if “real” examples of sustainable consumption are analyzed and if possible as a bundle of activities. Such an example might be the example of a car free settlement (Hubacek 2003) that includes good access to public transportation, availability of car sharing, increased sense of community and potentially a very different social environment. This supporting environment for “less is more” is also needed if one expects that using energy saving devices will have a (positive) impact on happiness. Examples are fluorescent compact lamps, white goods that fulfil A+ standard, or wearing pullover rather than room temperatures above 20 °C.

In Section 3.2.3 we will indicate what focus should be taken during the second phase of this project.

3.2.2 E-living: Results from another project

A project called "E-living" produced recently first results on how information technology impacts live. Among the subjects studied they looked into environmental impacts (Marletta et al. 2004) and impacts on social capital and quality of life (Anderson 2004). The work on quality of life is of particular interest to us for several reasons:
- the use of mobile phones and computers were part of the analysis
- the data were collected as well with a longitudinal panel approach covering 6 European countries
- the data is publicly available and therefore accessible for re-analysis
- the quality of life indicators cover as well aspects of subjective well-being.

The e-Living quality of life (QoL) scale comprises 5 different elements with which respondents were asked to agree/disagree via a Likert scale:
1. Overall the conditions of my life are excellent.
2. I have enough free time to do what I want.
3. The environmental conditions in my area are good.
4. I have good communications with friends.
And for those in paid work only:
5. In most ways my working life is close to ideal.

Figure 3.1 shows a simple analysis of the mean change in the individual perceived quality of life scores for those UK wave 1 respondents who did not have home Internet access but who had acquired it by wave 2. We can see that those who had acquired Internet access in their household did not report a statistically significant increase in any quality of life score except for 'good communications with friends' and this result may not be reliable given the location of the error bars. Interestingly the control group who did not acquire Internet access reported an increase in satisfaction with their environmental conditions and their overall quality of life at wave 2 compared to wave 1.
Figure 3.2 shows a similar analysis for those UK wave 1 non-mobile phone owners who had acquired a mobile phone by wave 2. Given that the group of people in the UK who did not have a mobile phone at wave 1 is relatively small (the 32% who were 'laggards') and also biased towards older citizens it is not surprising that the error bars are large. However those who acquired a mobile phone reported an increase in their perception of their free time for reasons that are not at all clear. It may be that these respondents felt more in control of their time or could better organise their free time using their mobile but this argument is tenuous at best.

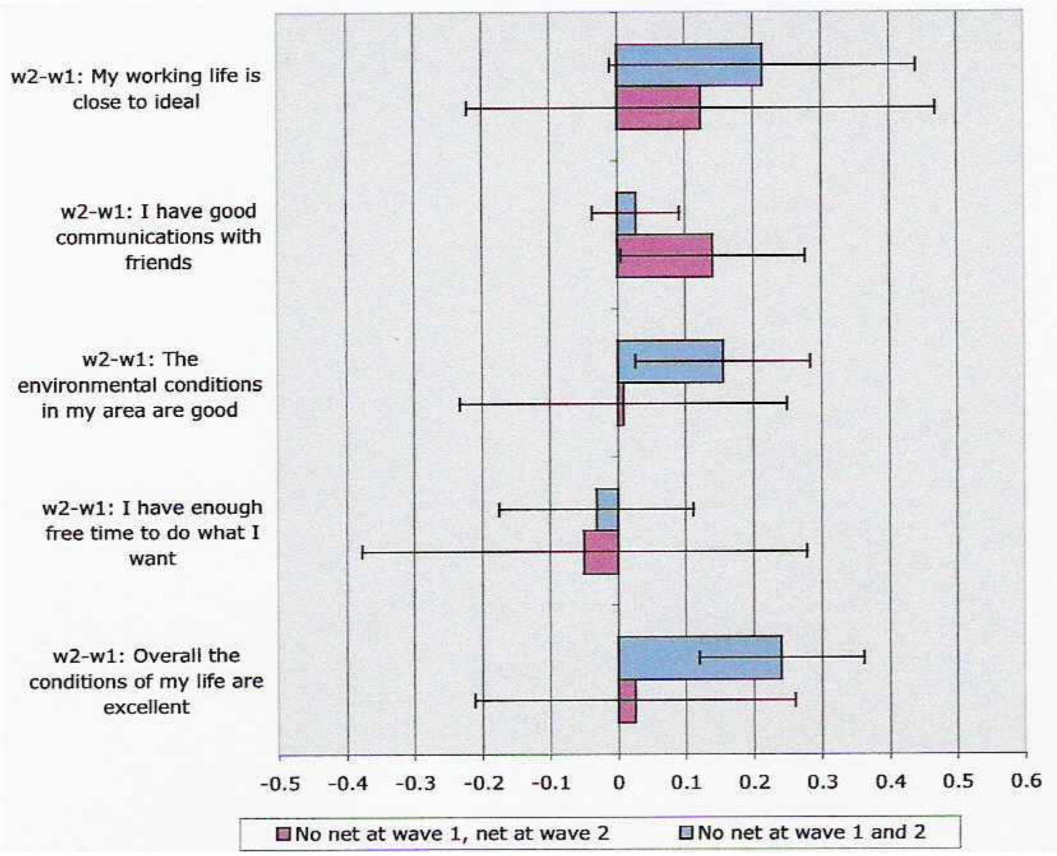

Figure 3.1: Mean differences in QoL scores for wave 1 UK respondents who acquired home internet access by wave 2. A negative score indicates a decrease from wave 1 to 2, error bars are +/- 2 SE. Error bars spanning 0 indicate no significant change. N = 469 (no net), 120 (got net) (Anderson 2004)

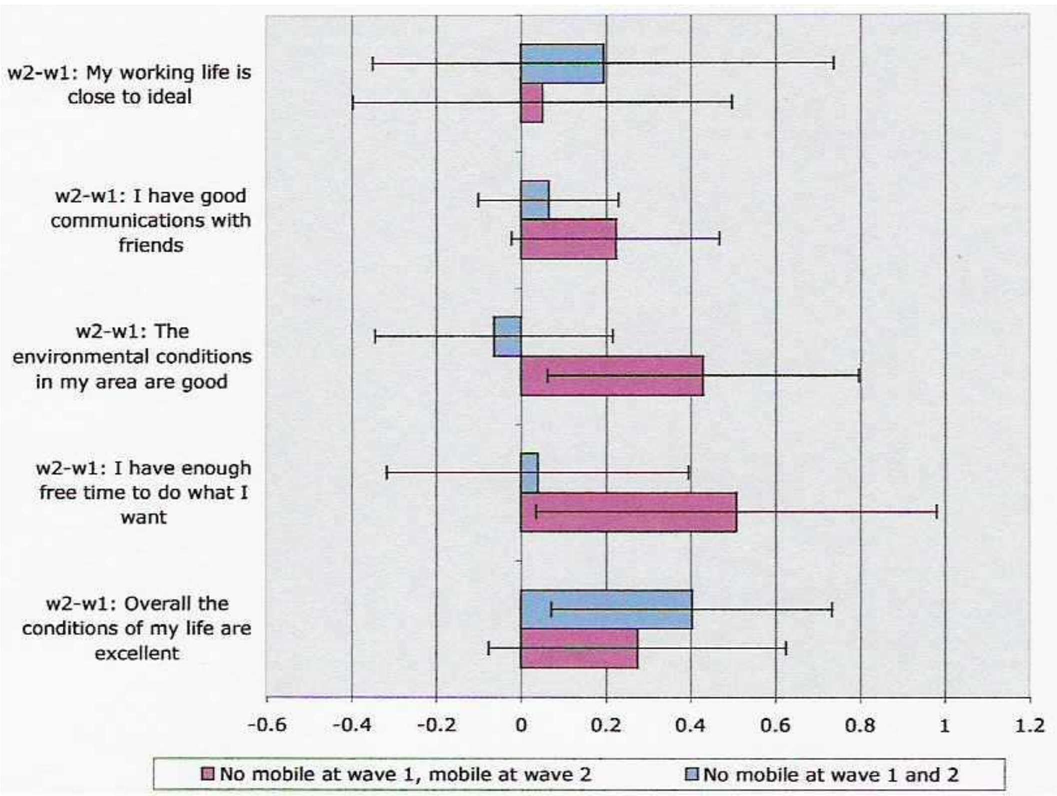

Figure 3.2: Mean differences in QoL scores for wave 1 UK respondents who acquired a mobile phone by wave 2. A negative score indicates a decrease from wave 1 to 2, error bars are +/- 2 SE. Error bars spanning 0 indicate no significant change. N = 77 (no mobile), 62 (got mobile) (Anderson 2004)

These results from the UK sub-project confirm the difficulties of finding correlations between indicators for subjective well-being and the use of IT products. It can be noted that the used QoL indicators are probably closer to life satisfaction than happiness.

In Table 3.1 Anderson (2004) summarizes the results of a model that looks into factors that explain differences in perceived overall quality of life. He writes:

“This table makes clear the significance of perceptions of free time, environmental conditions and communications with friends in nearly all countries in affecting overall quality of life scores. The balance of importance clearly differs between the countries with environmental conditions being the most important in all countries except Italy where communications with friends dominates (and changing environmental conditions are not important at all). Perceived free time appears less important than communications with friends in the UK, Italy, Germany and Norway but roughly equal in Israel.

Of the other variables, few are consistent across all countries perhaps reflecting their different socioeconomic conditions. Meeting friends more frequently may have a positive effect in Israel whilst reading newspapers and books has a negative effect in Germany. Retiring from paid work has a positive effect in Italy but may have a negative one in Germany whilst getting a job has positive effects in Norway and Bulgaria but a negative effect in Italy. Getting married has a positive effect in Italy. Of the IST variables getting broadband internet in Norway is associated with a decrease in overall QoL for reasons that are not at all clear. Watching more TV may be associated with a decrease in QoL in the UK but an increase in Israel whilst using the Internet more at home is associated with a decrease in QoL in Italy. Sending more emails to friends and relatives is associated with a decrease in QoL for Bulgarians.

		UK	Italy	Germany	Norway	Bulgaria	Israel
Controls:	Age	0.069*					0.090**
	Gender						
Change in:	‘Free time to do what I want’	0.063*	0.083**	0.096**	0.064*	0092**	0.098**
	‘Environmental Conditions are good’	0.166***		0.157***	0.162***	0.125***	0.134***
	‘Good communications with friends’	0.098**	0.145***	0.113***	0.096**		0.091**
	(‘Quality of work life’)	(0.14***)	(0.135**)	(0.126**)	(0.182***)	(0.262***)	
Change in frequency of:	Playing sport etc		0.056+				
	Reading newspapers etc			-0.072*			
	Meeting with friends						0.064+
Employment changes:	Become unemployed			0.075+			
	Retired from paid work		0.125*	-0.076+			
	Got a job		-0.070*		0.070*	0.088**	
Co-habitation changes	Was single, now married		0.071*				
	Widowed						-0.061+
IST changes:	Got broadband internet				-0.100**		
	Got narrowband internet				0.056+		0.060+
	Got a mobile phone			0.055+			
	Time watching TV	-0.060+					0.084*
	Time using Internet at home		-0.072*				
	Frequency of email sent to friends and relatives					-0.133**	
	Frequency of phoning friends and relatives		-0.055+				
N		1052	988	1045	1119	760	927
Adjusted r sq		0.039	0.039	0.054	0.056	0.043	0.047

Notes: OLS regression, values are Beta (standardised co-efficient), + = p < 0.1, * = p < 0.05, ** = p < 0.01, *** = p < 0.001

Table 3.1: Summary longitudinal model of the statistically significant factors associated with change in overall quality of life score (item 1) for all countries. (Anderson 2004) Notes: OLS regression, values are Beta (standardised co-efficient), + = p < 0.1, * = p < 0.05, ** = p < 0.01, *** = p <0.001

Overall then the consistent patterns across countries focus on the importance of perceptions of free time, environmental conditions, communications with friends and quality of work life with some variation in magnitude and balance within each country. The other variables are far more country specific in their effects and highlight both the impossibility of European-wide actions and the problem with considering IST access or basic usage as a necessary contributor to overall quality of life. These data at least simply do not support such a simplistic view. The results also show some unexpected results. For example getting a job in Italy between 2001 and 2002 was associated with a reported decrease in QoL. If not a spurious result this might remind us that for some, being in employment is not always a positive life choice and the same might be said of the result for unemployment in Germany. Similarly for some people a change in co-habitation form couple/married to single might be a positive change, whilst for other it is a negative one which would explain why these transitions did not produce any consistent effects. This should remind us that QoL is necessarily a personal perception related to what went before and what might be neither of which may be accurately captured in a general survey such as e-Living.

However we must also be cautious in interpreting these results from the point of view of the data itself. The low explanatory power of the models (6% at best) suggests that most of the changes in QoL observed between waves 1 and 2 could be simply random fluctuations in people's reporting or perceptions of their lives and/or the result of changes in their lives not measured in the e-Living survey or not included in the models. It would therefore be advisable to seek confirmation of these results from longer term longitudinal quality of life surveys or by using other analytic methods such as the regressor variable approach..."

These results basically confirm our own findings in terms of variability and the difficulty to detect statistically significant relationships between activities of minor importance such as use of mobile phones and truly relevant aspects of life such as quality of life or happiness.

The example of getting a mobile phone produced only in Germany a positive impact on QoL that was statistically significant at a $P<0.1$ level. Therefore, this is consistent with the Japanese results. There has been no question relating to PCs but they report access to internet. Getting narrowband access was improving QoL in Israel and Norway at $P<0.1$. However, broadband use in Norway and increased internet use in Italy had a negative impact on QoL. All other country studies did not show significant results. Therefore, our own results are again supported.

3.2.3 Focus in Phase 2

There are two major focuses within the module H for phase 2: First, find more data on change in happiness for activities that could be part of sustainable consumption including the three case study examples. Second, look more carefully into research results on what characteristics/type of activities make people more or less happy.

The first focus will build on the search in Hofstetter & Madjar (2003) with the expectation to come up with more examples and more reliable data for these examples. At least the final results of e-living will be included in this survey.

For the second focus, one needs to keep in mind that since the 1960's when such comprehensive research began, there have been over 3,000 published papers on subjective well-being, and the number of publications is increasing exponentially (Veenhoven, in press). During these last forty years, however, less than a dozen published studies have attempted interventions to increase happiness (see e.g., Fava 1999; Fava et al.1998; Fava & Ruini 2003; Fordyce 1977, 1983; Lichter et al. 1980; Sheldon et al. 2002). Those few studies should be analyzed with respect to insights that may be useful for sustainable consumption. In the best case these insights would translate into a checklist that can be used to screen candidates for sustainable consumption for their potential to increase happiness.

3.3 CO_2 emissions

The results of the CO_2 calculations are reported in Appendix 1. These calculations will be used in phase 2 of this project as described in Section 2. The presented calculations in Appendix 1 can be best characterized as standard practice in screening level of a life cycle assessment. Therefore, no additional discussion of these interim results are provided here.

4. Conclusions and outlook

This project is only half-way finished and it is too early to draw final conclusions. However, it is worth to summarize some of the preliminary findings:

- The Japanese longitudinal panel data proves to be extremely detailed and the data was useful in our analysis.
- On the other side we found that the data did not provide the level of detail we would need to select activities that are truly relevant for sustainable consumption.
- The data on time use was not detailed enough and we instead will rely on direct elasticities between consumption activities.
- The variability of the data is larger than initially anticipated. Although the sample size is large (>1000) and concentrates on a sub-group (young Japanese women) the individual behaviour of this group is too diverse to easily find statistically significant impacts.
- Among the reasons for this finding we could consider a grouping that respects findings from consumer research, correcting for economic household developments, or the selection of activities that are more life altering than getting a mobile phone.
- It is important to add the planned literature search part in order to understand better what type of activities are likely to increase happiness (or *vice versa*).

The appendices 1 and 2 provide the essential data to actually calculate the CHap indicator and get insights into the direct and indirect rebound effect. Especially appendix 2 provides a wealth of data that is very stimulating in terms of thinking about consumers and their consumption patterns. These remaining tasks will provide the needed feedback on the framework proposed in Hofstetter & Madjar (2003).

Outlook beyond FY04: Cross-national comparisons and beyond CO_2

The project described here and to be finished in FY04 allows refining the development of the new assessment method and the application to three examples.

However, the following further steps may be needed to fully evaluate and later operationalize the suggested framework:

- expanding the work with longitudinal panel data by including at least data sets from e-living, UK, and Denmark with the potential addition of Sweden and Australia or other surveys that appear relevant.
- differentiate short-term and long-term time elasticities
- calculate elasticities for different sub-groups, i.e., expanding beyond the young females and consider results from consumer research
- compare elasticities among different nations and cultures
- study in detail cross-national differences in happiness related to activities that are relevant for sustainable consumption
- calculate CO_2 emissions using national intensities and country-specific data
- extend the studied impacts to other energy and non-energy-related pollutants
- study the question of pure time rebound effect versus total behavioural consequences due to other limiting factors such as income, space, skills, information, other resources.

This list can be prioritized once the results of this project are derived and evaluated.

References

Anderson B. (2004). Information Society Technologies, Social Capital and Quality of Life. e-Living D11.4b, www.eurescom.de/e-living

Binswanger M. (2001). Technological progress and sustainable development: what about the rebound effect? Ecological Economics 36:119-132

Fava, G. A. & Ruini, C. (2003). Development and characteristics of a well-being enhancing psychotherapeutic strategy: well-being therapy. *Journal of Behavior Therapy and Experimental Psychiatry, 34, 45-63.*

Fava, G. A., Rafanelli, C., Cazzaro, M., Conti, S., & Grandi, S. (1998). Well-being therapy: A novel psychotherapeutic approach for residual symptoms of affective disorders. *Psychological Medicine, 28, 475-480.*

Fava. G (1999). Well-being therapy: Conceptual and technical issues. *Psychotherapy and Psychosomatics, 68, 171-179.*

Fordyce, M. W. (1977). Development of a program to increase happiness. *Journal of Counseling Psychology, 24, 511-521.*

Fordyce, M. W. (1983). A Program to increase happiness: Further studies. *Journal of Counseling Psychology, 30, 483-498.*

Gershuny J. (2002). Web-use and Net-nerds: A Neo-Functionalist Analysis of the Impact of Information Technology in the Home. ISER Working Paper 2002-1. Colchester: University of Essex.

Greening LA., Greene DL., Difiglio C. (2000). Energy efficiency and consumption - the rebound effect - a survey. Energy Policy 28:389-401

Hertwich E & Katzmayr M. (2003). Examples of sustainable consumption: review, classification and analysis. Final report to the Society for Non-Traditional Technology, Japan/IIASA Laxenburg

Hertwich E. (2003). Consumption and the rebound effect: The consideration of information and communication technology, in Proceedings of Environmental Assessment in the Information Society, Joint SETAC Europe, ISIE meeting and Swiss LCA Forum, 3-4 December 2003; Lausanne Switzerland: SETAC Europe, Brussels, 47-50

Hofstetter P. & Madjar M. (2003). Linking change in happiness, time-use, sustainable consumption, and environmental impacts; An attempt to understand time-rebound effects. Final report to the Society for Non-Traditional Technology, Japan/ BAO & Consultrix, Zürich

Lichter, S., Haye, K., & Kamman, R. (1980). Increasing happiness through cognitive retraining. *New Zealand Psychologist, 9, 57-64.*

Marletta P., Pasquirini A., Vicario L. (2004). Environmental Impact of ISTs: A Cross-Sectional Analysis. e-Living D11.2, www.eurescom.de/e-living

Sheldon, K. M., Kasser, T., Smith, K., & Share, T. (2002). Personal goals and psychological growth: Testing an intervention to enhance goal attainment and personality integration. *Journal of Personality, 70, 5-31.*

Veenhoven, R. (in press), The greatest happiness principle; happiness as an aim public policy in Linley, A. and Joseph, S. (Eds.) *Positive Psychology in Practice*. Hoboken, New Jersey: John Wiley and Sons.

Yamana H. & Seto K. (2003). Social receptivity of an ecological lifestyle. in Proceedings of the Second International Workshop on Sustainable Consumption, December 12-13, 2003, Tokyo, SNTT/AIST, p 30-34

Hofstetter P. (1998). Perspectives in Life Cycle Impact Assessment, A structured approach to combine models of the technosphere, ecosphere and valuesphere. Kluwer Academic Publishers: Boston

Hubacek K., Korytarova K., Haas W., Hertwich E., Ornetzeder M;., Weisz H. (2003). Approaches for evaluating sustainable consumption initiatives. in Proceedings of the Second International Workshop on Sustainable Consumption, December 12-13, 2003, Tokyo, SNTT/AIST, p 82-88

Appendices

Appendix 1
Working Paper 1: Module C: Analysis on the relationship between consumption patterns and CO2 emissions in Japan

Appendix 2
Working Paper 2: Consumption elasticities calculated based on longitudinal panel data from young Japanese women

Appendix 3
Working Paper 3: Analysis of life-happenings influencing the happiness and life-satisfaction based on longitudinal panel data from young Japanese women

Appendix 4
Workshop Paper: Minimizing CO_2-emissions per unit of happiness

Appendix 1

Module C: Analysis on the relationship between consumption patterns and CO2 emissions in Japan

Kayo Sugai,[7] Satoshi Toyoda[8]

1 Introduction

This document contributes to the project on Sustainable Consumption and is expected to be a part of research paper entitled “CHap: CO2-emissions per unit of happiness: a new indicator for sustainable consumption that considers and minimized rebound effects” implemented by Dr. Patrick Hofstetter.[9] According to his proposal, whole research project entitled “CHap” consists of three modules as follows:

> **Module CP** (Consumption Patterns):
> The Institute for Research on Household Economics implements the “Japanese Panel Survey of Consumers (JPSC).”[10] By using this Cohort study data, which asks the same sample group every September, Japanese consumption patterns are analyzed.
>
> **Module C** (CO2):
> Based on JPSC data, three durable goods (cloths dryer, personal computer, and mobile phone) were chosen and their CO2 emissions were calculated. The CO2 analysis was based on a hybrid approach. CO2 intensities per sector within the Japanese Input-Output table was used and complemented by process analysis data that concerned the use phase.
>
> **Module H** (Happiness):
> The goal of this module is to quantify the change in happiness when the three durable goods/activities are adopted including all behavioural changes.

This paper is to cover Module C in the above list, focusing on two topics as follows:

1. The average Japanese expenditure on major durable goods and their CO2 emissions with featuring three durable goods (cloths dryer, personal computer, and mobile phone) with consideration of energy consumption or other expenditure in use phase.
2. CO2 emissions change by JPSC categorized expenditure (e.g. food, housing, and transportation)

The goal of this Module C is to calculate the CO2 emissions by considering the average Japanese lifestyles and their possession of durable goods. By implementing these series of

[7] The Society of Non-Traditional Technology (SNTT)
[8] Mitsubishi Research Institute Inc. (MRI)
[9] Büro für Analyse and Oekologie (BAO)
[10] *Japanese Panel Survey of Consumers* provided by The Institute on Household Economics: http://www.kakeiken.or.jp/english/index.html [Japanese exclusive]

analysis it would be possible to assess how Japanese people reduce their CO_2 gas emission by changing their lifestyles as well as changing their pattern of consumption.

Combining the results of Module CP, C, and H enables explaining the CO_2 emissions reduction while increasing one's happiness, which would be one of the most important driving forces to push one's consumption patterns towards more sustainable ones.

2 Basic assumption and methods

All the data used in this module was delivered from JPSC data. However, in order to protect the privacy of sample group, using original JPSC resource was highly limited. Therefore, we used the JPSC-based data, which Dr. Ozawa obtained and assessed in Module CP. Following is the list of Ozawa's JPSC-based data we used in Module C.

Table entitled "Household Possession of Durable Consumer Goods"
Total expenditure and pieces of durable consumer goods
Table entitled "Household Spending Allocation for the Month of September"

The first and the second table were used for CO_2 analysis on durable goods (e.g. dining set, microwave, refrigerator, etc.), and the last was used to assess CO_2 analysis by household activities' expenditure (e.g. food, housing, transportation, etc). The data of 1998 was used to assess CO_2 emissions in this project, thus it was expected to refer 1998 data in other resources. However, it was difficult to find the data of 1998 for some resources, such as mobile phone use frequency. In that case, we used best available data and did not make any adjustments.

To calculate CO_2 emission from durable goods and expenditure, Japanese Input Output (IO) table was used, where tons of CO_2 emission per Japanese million yen was provided.[11] CO_2 emission unit on IO table includes the emissions in the following stages:

1. Emissions in producing
2. Emissions in energy supplying (e.g. electric supply)
3. Emissions in serving

On the other hand, it should be pointed out the limitation of IO table as follows:[12]

International transportation fee is not considered for exporting goods. For imported goods, on the other hand, international transportation fee, insurance fee, and tariffs are taken into account.

Transaction of capital goods were not assessed as domestic activities but counted as gross national fixed-capital, and presented in a section entitled "Final demands." In addition, the depreciation of capital goods is assessed as "Capital Depreciation Allowance" in a section entitled "Other value-added goods."

Secondhand goods, such as recyclable resources, are counted as intermediate transaction goods.

In Module CP, the method, which is combined CO_2-emissions and IO table, is adopted. In IO table, various products are treated as one category. Therefore the results of CO_2

[11] Nansai et al, *Embodied Energy and Emission Intensity Data for Japan Using Input-Output tables*

[12] Management and Coordination Agency, Government of Japan, 1999. *1995 Input-Output Tables Explanatory Report*

calculation in Module CP are reflected above characteristics of IO table. For example, in the CO2 unit of electricity, all of electrical generating systems are considered like oil-based power, nuclear power, geothermal power, and biomass. It is believed that IO table would be the best available data excising in Japan. As far as this analysis is focused on the consumption pattern in Japan, it would be rational to use the data in Japan.

In addition, the selected durable goods are not necessarily reflecting average Japanese household possessions. For example, word processor, one of the listed durable goods on JPSC, is disappeared from Japanese market nowadays. Electric rice cooker, which is one of the most popular durable goods in Japan, was excluded from JPSC.

Same can be said to the analysis by JPSC categorized expenditure patterns. Although it would be difficult to discuss what categories would be appropriate to show the average Japanese household expenditures, it would be important to consider the re-selection of durable goods which fit in current Japanese durable goods possession in future analysis.

3 CO2 analysis on durable goods

In this section, CO2 emissions from durable goods are assessed. The objective of this analysis is to grasp the relation between CO2 emissions and the average Japanese household expenditure by each durable goods.

According to JPSC, twenty six durable goods were used to describe the average Japanese household possession. Total piece of possession and total expenditures for each durable goods were calculated, resulting that the average expenditure per piece of durable goods was obtained. In short, average price per piece of every twenty six durable goods was explained. Referring to the Japanese IO table, CO2 emissions from these durable goods were calculated.

After that, three durable goods (cloths dryer, PC and mobile phone) were focused for detailed analysis between expenditure in their use-phase (e.g. energy consumption and service fee) and CO2 emission. We called this integrated CO2 calculation a “hybrid approach,” which allowed not only to assess CO2 emissions from possession, but also to put any additional CO2 emissions caused by expenses from use-phase. Those results are expected to be connected with the average Japanese lifestyles as well as happiness analysis in future.

3.1 Results of 26 durable goods CO2 emissions

CO2 emissions from the twenty six durable goods were examined. Given by JPSC, total piece and total household expenditure of each durable goods among sample group were obtained then we divided total expenditure by total number of piece so that the average household expenditure per piece of each durable goods was obtained (table 3.1-1).

Table 3.1-1 Japanese average expenditure per piece of durable goods

Contents	Number of piece	Expenditure (yen)	Yen/piece
Dining Set	158	20,530,000	129,937
Cupboard	189	15,690,000	83,016
Microwave	185	6,500,000	35,135
Refrigerator	335	40,850,000	121,940
Automatic Dishwasher	39	3,240,000	83,077
Vacuum Cleaner	352	9,890,000	28,097
Laundry Machine	315	15,600,000	62,222
Cloths Dryer	44	2,500,000	56,818
Sewing Machine	109	8,820,000	80,917
Electric Fan	366	3,410,000	9,317
Air Conditioner	487	56,880,000	116,797
Fan Heater	223	6,560,000	29,417
“Kotatsu” Heater	71	1,790,000	25,211
TV set	543	37,350,000	68,785
Stereo Sound System	139	9,630,000	69,281
CD Radio Cassette Recorder	196	4,150,000	21,173
VCR	415	14,190,000	34,193
Video Camera	206	30,550,000	148,301
Telephone	466	8,320,000	17,854
Bicycle	712	16,260,000	22,837
Car	663	1,175,810,000	1,773,469
TV Game	482	8,440,000	17,510
Word Processor	77	9,000,000	116,883
Personal computer	421	104,620,000	248,504
FAX	266	13,130,000	49,361
Mobile (Cellular) Phone	1179	12,520,000	10,619
TT			3,460,671

Note: JPSC sample N=4560 provided Dr. Ozawa, AIST

Given the average expenditure (yen) per piece, the average price of durable goods, which assumed to be the same as consumer price, was described. Next, each durable goods were translated to Japanese IO table categories to assess CO2 emissions per piece (see table 3.1-2). It is noted that every durable goods’ CO2 were not perfectly fitted to the IO table category. For example, “dining set” and “cupboard” are different products but fall into the same IO category under “wooden products.” As a result, even though they are different products, same amount of CO2 emissions can be obtained if their prices are same. In this document, we simply translated durable goods to the most appropriate category of the IO in order to calculate CO2 emissions.

Table 3.1-2 Tons of CO2 emissions per piece of durable goods

Contents	Yen/piece	CO2		Referred I-O table information	
		t-CO2/Million yen	t-CO2/piece	I-O table ID#	IO category
Dining Set	129,937	2.09	0.272	96	Wood/Wooden Product
Cupboard	83,016	2.09	0.174	96	Wood/Wooden Product
Microwave	35,135	1.49	0.052	232	Applied electronic device
Refrigerator	121,940	2.37	0.289	226	Home appliance
Automatic Dishwasher	83,077	2.37	0.197	226	Home appliance
Vacuum Cleaner	28,097	2.37	0.067	226	Home appliance
Laundry Machine	62,222	2.37	0.147	226	Home appliance
Cloths Dryer	56,818	2.37	0.135	226	Home appliance
Sewing Machine	80,917	2.37	0.192	226	Home appliance
Electric Fan	9,317	2.37	0.022	226	Home appliance
Air Conditioner	116,797	2.37	0.277	226	Home appliance
Fan Heater	29,417	2.37	0.070	226	Home appliance
“Kotatsu” Heater	25,211	2.37	0.060	226	Home appliance
TV set	68,785	1.93	0.133	224	Radio/TV
Stereo Sound System	69,281	1.97	0.136	223	Electric music appliance
CD Radio Cassette Recorder	21,173	1.97	0.042	223	Electric music appliance
VCR	34,193	1.84	0.063	225	Video appliance
Video Camera	148,301	1.84	0.273	225	Video appliance
Telephone	17,854	1.85	0.033	15	Precision instrument
Bicycle	22,837	2.25	0.051	263	Bicycle
Car	1,773,469	2.77	4.913	249	Car
TV Game	17,510	1.49	0.026	232	Applied electronic device
Word Processor	116,883	1.51	0.176	227	Electric calculator
Personal computer	248,504	1.51	0.375	227	Electric calculator
FAX	49,361	1.8	0.089	229	Electric communication device (w/cable)
Mobile (Cellular) Phone	10,619	1.74	0.018	230	Electric communication device (w/o cable)
TT	3,460,671	53.84	8.281		

3.2 Results of three durable goods with a hybrid approach

The results from previous section were now assessed to implement a hybrid approach, which means CO2 emissions obtained from the IO table and CO2 emissions derived from any additional expenditure in use-phase were summed up. For the hybrid approach, we implemented a close look at three durable goods; cloths dryer, personal computer, and mobile phone.

As a basic assumption for assessing CO2 emissions in use phase, we analyzed that electricity, and service fee would be two of the most significant expenditures in use phase. For electricity we used a unit of CO2 emissions provided by Japanese Ministry of Economy, Trade, and Industry.[13]

Electricity: 0.00036 ton-CO2/kWh

[13] Ministry of Environment JAPAN, 2004., *A Document referring to emission calculation for the global warming gases*

For assessment of the service fee as another type of expenditure in use phase, which should be oriented to mobile phone and personal computer, we set forth detail assumption as explained later.

Another important consideration on use-phase was use frequency and actual number of piece possessed. For both of use frequency and actual possession, many literatures were referred. Special consideration was necessary on mobile phone because more than one piece of mobile phone were possessed in one household. This is crucial because amount of CO2 emissions per piece of durable goods was necessary. Detail calculation will be explained later.

We assumed that one piece of cloth dryer was possessed in an average household. Differed from mobile phone, it is unusual for average Japanese household to possess more than two cloth dryer in one household. For the PC, fortunately, we found a data of expense per piece; therefore no adjustment was occurred due to the gap between ratio of possession and actual number of piece possessed per one household. Table 3.2 summarized three durable goods CO2 with a hybrid approach.

Table 3.2 Hybrid CO2 on three durable goods

Contents	IO CO2	Use phase		Hybrid CO2 (t-CO2 per piece)
	t-CO2/piece	Type of expense	t-CO2/piece	
Cloths Dryer	0.1347	Electricity	0.1318	0.2665
Personal computer	0.3752	Electricity	0.0424	0.4459
		Service fee	0.0283	
Mobile Phone	0.0185	Electricity	0.0002	0.0528
		Service fee	0.0341	

Cloths Dryer

A Website of Jukankyo Research Inc provided resources.[14] According to that website, standard energy consumption of a piece of clothes dryer would be 366kWh per year under the following assumption:

Type of clothes dryer: Drum Type 4.5Kg
Use frequency: Twice a week (104 times per a year)

So, annual tons of CO2 emissions per piece of cloths dryer is

366kWh*0.36=0.13176 t-CO2/year/piece[15]

Therefore, the annual tons of CO2 emission per piece of clothes dryer is;

CO2 emissions by possession 0.1347
CO2 emissions by use phase 0.1318 (from electricity consumption)
Total CO2 0.2665 t-CO2/piece/year

Personal Computer

Electricity and internet connection fee as service fee were taken into account for use phase expenditure. The use frequency and energy consumption of the desktop were assumed as follows:

Type of PC: Desktop[16]

[14] Jyukankyo (Living Environment) Research Institute Inc. 2002. http://www.jyuri.co.jp/Shc/Htmls/save-cal.htm

[15] Note: Another references described that it would cost 80yen to use cloths dryer at a time. If we assume that we use 104 times a year, annual electric fee is 8,320 yen. In Japan, one kilo watt hour is 23 yen, so 8,320 yen is equal to 361 kWh. Therefore 0.130 t-CO2 would be obtained.

[16] This PC is representing Japanese major producers' most popular model in 2003 (Display: 15 inch TFT, CPU: Pentium III with 400 MHz, HDD: 3.5 inch with 10-12GB, Keyboard: 106, and CD-ROM, FDD, Modem included): provided by Japan Electronics and Information Technology Industries Association (JEITA), 2004.

Use frequency: 1.9hour/day in use (=693.5h/year)
2.4hour/day in energy-saving mode (=876h/year)[17]
Energy Consumption: When used: 85 Watt[18]
When used in energy-saving mode: 67 Watt[19]

Therefore, annual t-CO2 per PC due to energy consumption is:

When used: 693.5*85=58.95 kWh/year
When used in energy-saving mode:
67*876=58.69kWh/year
Total: 117.64kWh/year*0.36Kg-CO2/Wh=42.35 Kg-CO2/year

The result showed 0.0424 tons of CO2 would be emitted from a piece of PC in a year. Additionally, we attempted to figure out the internet fee as part of expenditure in use phase. Internet Connection Fee (for households possessing PC) was 3,470 yen per month (41,640 yen/year)[20] "Other communication service (ID #334)"in the IO table was referred to assess CO2 emissions;

41,640 yen/piece*0.68 t-CO2/Million yen = 0.0283 t-CO2/piece

So, the total annual tons of CO2 emissions per piece of PC is

CO2 emissions by possession:	0.3752
CO2 emissions in use phase:	0.0424 (from electricity consumption)
	0.0283 (from internet connection)
Total CO2	0.4459 t-CO2/piece/year

Mobile Phone

Electricity CO2 was calculated applying the following assumptions:[21]
When used: Currency 0.265A Voltage 3.6 V Use frequency: 10min/day
Stand-by: Currency 0.002A Voltage 3.6V Use frequency 1430min/day
When charged: Efficiency 80% Loss 96.7Watt hour/piece/year

Electric consumption when used/stand-by was obtained by following formals;

When used	0.265A*3.6V*10/60*365 day	=58 Watt hour/piece/year
Stand-by	0.002A*3.6V*1430/60*365day	=62.6 Watt hour/piece/year

As a result, annual electric consumption in use-phase can be obtained as follows:

(Electric consumption when used&stand-by)/charge-efficiency+charger loss
= (58.0+62.6)/0.8+96.7
=247.4 Watt hour/piece/year = 0.247 kWh/piece/year

In addition, the service fee, as part of expenditure in use phase, was assessed by following assumption.

Quantities of Mobile Phone Possessed: 1061 (per 1000 households)[22]
Cost for using: 6,145 yen per month per one household (73,740 yen/year)[23]

A number of quantities implies that 1.061 piece of mobile phone is possessed in one household. Therefore, the annual expenditure per piece of mobile phone with actual possession was calculated as:

Summary of Personal Computers' Life Cycle Inventory. (Japanese exclusive) Note: The PC in 1998 would be less energy efficient.

17 "The Energy Conservation Center, Japan" http://www.eccj.or.jp/pamphlet/nacs/01/action.html (Japanese exclusive)

18 50Watt for body and 35Watt for Liquid Crystal Display (LCD); source: JEITA

19 32Watt for body and 35Watt for LCD; source: JEITA

20 Ministry of public management, home affairs, posts and telecommunications, Japan 2000. Communications Usage Trend survey http://www.johotsusintokei.soumu.go.jp/public/data2/HR200000_005.pdf

21 Communications and Information network Association of Japan. 2002., *LCI data of Mobile Phone.*

22 Static Bureau, Japan 1999. http://www.stat.go.jp/data/zensho/1999/zuhyou/a317.xls

23 Static Bureau, Japan 2002. Survey of Household Economy http://www.stat.go.jp/data/joukyou/2002ns/zuhyou/01.xls

73,740/1061/1000 = 69,500 yen per piece

We then referred “Mobile communication (ID #332)”in the IO table to assess CO_2 emissions;

69,500 yen/piece*0.49 t-CO_2/Million yen = 0.0341 t-CO_2/piece

So, the total annual tons of CO_2 emissions per piece of mobile phone is

CO_2 emissions by possession:	0.0185	
CO_2 emissions in use phase:	0.0002	(from electricity consumption)
	0.0341	(from internet connection)
Total CO_2	0.0528	t-CO_2/piece/year

4 CO2 analysis of durable goods by household expenditure

4.1 Method of CO2 emission calculation

By following 1 and 2 processes below, the CO2 emission intensities per household expenditure category were calculated:

Step1. Based on the JPSC data, major expense patterns were summarized and categorized into twelve (See table 3.4-1). Then CO2 emission for each twelve expense pattern was calculated referring to the Japanese IO table.

Step2. For "Water, Gas, Electricity" and "Transportation," CO2 emission due to energy consumption in combustion was taken into account and the results were added to the results of Step 1.

The amount of CO2 emissions obtained from these two steps was integrated into one table as a total CO2 emission by possessions of each durable goods.

4.2 CO2 emissions per household expenditure

Based on JPSC, each activity was translated into most appropriate contents on Japanese IO table. It was observed that sometimes one activity could be translated into more than two contents of IO table. Thus, CO2 emission unit on IO table was translated into a linear regression based upon annual expenditure per person. As a result, the table 4.2-1 was obtained (note that this table excludes the CO2 emissions when combusted).

Table4.2-1 CO2 emission per household expenditure by JPSC category

JPSC data category	CO2 emissions [t-CO2 / million yen]
Food	1.96
Housing (Rent/Mortgage)	0.22
Water, Gas, Electricity	15.38
Furniture and Household Appliances	2.09
Clothing and Shoes	1.86
Medical and Insurance	1.51
Transportation	3.81
Communication	0.77
Education	1.05
Hobby and Leisure	1.74
Going out	1.81
Allowances	1.81

4.3 Hybrid approach of CO2 emissions with energy consumption

CO2 emission unit on IO table includes the emissions in the following stages:

1. Emissions in producing
2. Emissions in energy supplying (e.g. electric supply)
3. Emissions in serving

Note that the combustion stage especially of gases is not taken into account in the IO table. So, here we decided to examine town gas, Propane gas (LPG), Kerosene and gasoline when combusted. To do so, the price data of town gas, Propane gas (LPG), Kerosene and gasoline were obtained and the combusted efficiency was considered.[24] Especially for the

[24] Tokyo Gas Co. 2004., Energy Price for household http://home.tokyo-gas.co.jp/chg/keizaisei.html

gasoline, marketing research on price per one liter was assessed. Then CO_2 emissions per yen were calculated as shown in table 4.3-1.[25][26] In addition, based upon JPSC and National Survey of Family Income and Expenditure implemented by Japanese Statistics Bureau, table 4.3-1 was obtained.

Table 4.3-1 CO2 emission unit per price (yen)

Town gas	Propane Gas (LPG)	Kerosene	Petrol
0.01690	0.01030	0.04253	0.02100

Unit: kg-CO2/yen

Table 4.3-2 Expenditure of Propane gas (LPG), Kerosene and gasoline

	Expense [yen/month]	Unit [kg-CO2/yen]	Note
LHW (Lighting, heating, and water expenses)	20,195	0.01538	(*1)
Town gas (within LHW)	2,302	0.01690	(*2)
LPG (within LHW)	2,312	0.01030	(*2)
Kerosene (within LHW)	704	0.04253	(*2)
Transportation	39,485	0.00381	(*1)
Petrol (within transportation)	5,324	0.02100	(*2)

Note: - (*1) CO2 unit exclude when combusted see table 4.2-1
- (*1) Expenditure based on JPSC
- (*2) Expenditure referred to "A Document referring to emission calculation for the global warming gases" and calculated the ratio of energy expenditure of electricity & light, water, and transportation costs, then the results were applied for the expense of (*1).[27]

From the table 4.3-2, the CO_2 emission unit of electricity & light, water, and transportation when combusted was obtained by following formula:

$$\text{Unit of LHW} = 0.01538 + (2302 * 0.01690 + 2312 * 0.01030 + 704 * 0.04253) / 20195$$

$$= 0.01996 \text{ [kg-CO2/yen]}$$

$$\text{Unit of transportation} = 0.00381 + 5324 * 0.02100 / 39485$$

$$= 0.00665 \text{ [kg-CO2/yen]}$$

From the results above, the CO_2 emissions with consideration of energy consumption when combusted can be summarized as table 4.3-3.

---

25 Ministry of Environment JAPAN., *The Guideline for Calculation of Total Emissions*

26 Ministry of Environment JAPAN, 2004., *A Document referring to emission calculation for the global warming gases*

27 1999 National Survey of Family Income and Expenditure, Statistics Bureau, 2000-2001 http://www.stat.go.jp/data/zensho/1999/menu.htm

Table 4.3-3 CO_2 emission unit due to expenditure and energy consumption

JPSC data category	CO_2 emissions [t-CO_2 / million yen]
Food	1.96
Housing (Rent/Mortgage)	0.22
Water, Gas, Electricity	19.96
Furniture and Household Appliances	2.09
Clothing and Shoes	1.86
Medical and Insurance	1.51
Transportation	6.65
Communication	0.77
Education	1.05
Hobby and Leisure	1.74
Going out	1.81
Allowances	1.81