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Consumer's Perceptions toward Longer Product Use and Their Influence on Product Lifespan

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Keywords: Product Lifespan; Consumer Behavior; Survival Time Analysis; Attitude; Expected Lifespan.

Abstract: Product lifespan extension is effective for reducing material throughput and thus turning our resource use to a more sustainable style. It is crucial not only to design a more durable product but to encourage consumers to actually use their products longer. Therefore, the understanding of the influences of consumer's psychological attributes upon product lifespan is required. This paper attempted to quantitatively assess the influences of consumer's perceptions toward longer product use to the actual and expected lifespan through a questionnaire survey. It was shown that intention and attitude toward longer product use both had significant influences of extending both the actual and intended lifespan. However, the intended lifespan was influenced also by several other perceptions, while the actual lifespan was influenced by none of the others. In addition, consumers who had a stronger intention or attitude were more likely to experience a larger gap between the intended and actual lifespan. The paper concludes with an implication to researchers and policymakers that work on product lifespan.

Introduction

The realization of more sustainable resource use, especially the reduction of natural resource consumption, is urgent in order to sustain the global economy and environment (UN Environment, 2011). Material circulation approaches such as reusing and recycling are indispensable to reduce input of natural resources (European Commission, 2015), while our resource throughput must be reduced, too. Extending product lifespan has vast potential to reduce both input and throughput (Dominish et al., 2018). (Hereinafter, "product lifespan" is just referred to as "lifespan.") (Note that, in this research, the term "lifespan" only signifies the period during which only a single consumer uses a specific product, which is referred to as "duration in use" in Murakami et al. (2010)).

To design a highly durable product, if consumers accept and use that product, seems one possibility (Wilhelm, 2012). However, many researches have shown that a large extent of End-of-Life products could still be used (Wieser and Tröger, 2018; Echegaray, 2016). It is, therefore, not sufficient to simply extend the physical/mechanical life of products. There is a need to encourage consumers to actually use products longer so as to extend their actual

lifespan. Therefore, the understanding of the influences of consumer characteristics on lifespan seems essential. In particular, in social psychology and behavioral science research, psychological attributes such as attitude and awareness of consequences of a specific behavior are regarded as predictors of the behavior itself (Ajzen, 1991; Schwartz, 1977). These relationships have been verified for various behaviors concerning sustainable resource use, such as recycling (Chan and Bishop, 2013), reusing (Barr, 2007), and remanufacturing (Wang et al., 2018). Similarly, with regard to lifespan, relationships with psychological attributes such as attitudes and expectations, as well as socio-demographic variables, have been pointed out (Evans and Cooper, 2010; Cox et al., 2013). However, these are only indicated by qualitative analysis, and few studies have performed quantitative analysis. Fernandez (2001) and Gutiérrez et al. (2011) analyzed the influences of socio-demographic variables using survival time analysis, but consumer's psychological attributes were not taken into consideration. Grewal et al. (2004) analyzed the influences of attitudes toward products themselves but did not analyze those of attitudes toward longer product use.

Another key subject regarding lifespan is the expected lifespan, which represents a period during which consumers expect to use or want to use the product (Oguchi et al., 2016). This is because the gap between the expected lifespan and the actual lifespan is considered to show the potential for extending the actual lifespan (Gnanapragasam et al., 2017). In addition, we can assume that the expected lifespan, which represents the lifespan based on the consumer's expectation or intention to use a product, is more directly influenced by consumer's psychological attributes compared to the actual lifespan which is more strongly affected also by external factors. Therefore, it is expected that the comparison between the influences of consumer's psychological attributes on the actual lifespan and those on the expected lifespan may deepen our understanding of the actual lifespan. Based on the aforementioned background, in this research, the influences of the consumer's perceptions toward longer product use on the actual lifespan as well as the expected lifespan are analyzed quantitatively. By comparing these results, implications for encouraging longer product use are discussed.

Method

Survey design

An online questionnaire survey was conducted in March 2018 in Japan, with a total sample size of 2310. The population balance of gender, age and area followed the national census. PC was selected as the product subject since it is one of the widespread electronic devices around the world and has a considerable environmental impact during its lifecycle (Ahwulia and Nema, 2007). In addition to demographic variables (see Appendix 1), the following data were obtained through the questionnaire.

1. Lifespan of PCs

Respondents were asked to answer the lifespan of the PC which they acquired most recently and were using (hereafter referred to as "In-use PCs"), and that of the PC which they most recently disposed of ("End-of-Life PCs") as well. The actual lifespan and the intended lifespan (how long respondents intend or intended to use their PC (Oguchi et al, 2016)) were asked for each item in a year unit.

2. Perceptions toward longer use of PCs

10 items of statements concerning longer use of PCs shown in Table 1 were prepared. The

statements were constructed based on existing studies of lifespan (Cooper, 2004; Evans and Cooper, 2010) as well as of social psychology (Ajzen, 1991; Schwartz, 1977). Respondents were asked to choose whether they agreed or disagreed with the statements in 5-point Likert scale.

Statements	Abbreviation
I actually intend to use my PC longer.	INT
I want to use my PC longer.	ATT
I think using a PC longer is a good thing.	EVL
I think using a PC longer is economical.	ECO
I think using a PC longer is good for the environment.	ENV
I think using a PC longer can save energy consumption.	ENE
I think using a PC longer can save material consumption (metals, plastics).	MAT
Actually using a PC longer is difficult.	DIF
I think using a PC longer takes a lot of trouble.	TRO
I am negative about using my PC longer because its functions become obsolete.	OBS

Table 1. Statements of consumer's perceptions toward longer use of PC.

Statistical analysis

Cox proportional hazard model was utilized to assess the influences of variables on lifespan. In the model, the hazard function is defined by the following equation

$$h(t, x) = h_0(t) \exp(\beta x)$$

where $h_0(t)$ denotes the non-parametric baseline hazard function, x the explanatory variables vector, and β the regression coefficients vector. Positive coefficients indicate the corresponding explanatory variables have influences of shortening the lifespan, whereas negative coefficients indicate the influences of extending the lifespan.

In this research, explanatory variables include psychological variables concerning consumer's perceptions toward longer use of PCs, and demographic variables as control variables. Since there existed missing values in household income and personal income, multiple imputation by chained equation was conducted 50 times each using the other demographic variables. Generalized VIF was used to check the multicollinearity.

Proportional hazard assumption of each explanatory variable was verified by the log-log plot of lifespan and cumulative hazard function, and by scaled Schoenfeld residuals. As for variables that didn't satisfy the assumption, interaction terms of the variables with the natural logarithm of survival time were added as time-dependent variables if they were psychological variables, or if they were demographic variables they were utilized as stratification variables. The overall fit of the model was evaluated using deviance residuals and the following fit index proposed by Royston (2006) which is similar to R^2 of linear regression.

$$R_{p,v}^2 = \frac{R_{p,e}^2}{R_{p,e}^2 + \frac{\pi^2}{6}(1 - R_{p,e}^2)}$$

where

$$R_{p,e}^2 = 1 - \left\{ \exp \left[\frac{2}{m} (L_0 - L_p) \right] \right\}$$

(L_0 denotes the log-likelihood of the null model, L_p the log-likelihood of the estimated model, and m the number of events).

Result

Descriptive statistics

- Actual and expected lifespan

The number of collected data was 2,177 for In-use PC and 1,572 for End-of-Life PC. Kaplan-Meier method was utilized to estimate the median lifespan of both the actual and intended lifespan. The median actual lifespan was estimated to be 7.5 years whereas the median intended lifespan to be 6.5 years. This result that the actual lifespan was longer than the intended lifespan occurred due to a large number of censored data, i.e. data of In-use PCs, for actual lifespan, while for intended lifespan data are not censored. When we look at the gap between the intended lifespan and the actual lifespan (Figure 1), there are more End-of-Life PCs that have a positive gap, indicating that people tend to use their PCs shorter than they have intended. This is also supported by the fact that, when we only use data of End-of-Life PCs, the median actual lifespan decreased to 5.5 years. Most of the PCs had the lifespan of shorter than 10 years for both actual and intended lifespan, while some had extreme values, especially for the intended lifespan. The median lifespan values

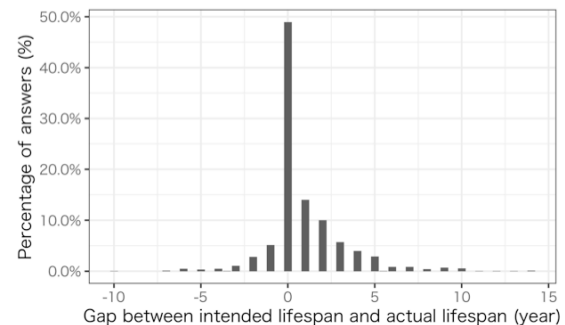


Figure 1. Gap between the intended lifespan and the actual lifespan of End-of-Life PCs (positive gap indicates the intended lifespan is longer than the actual lifespan).

of this study are similar to surveys in other countries (Wieser and Tröger, 2015; Echegaray, 2016; Hennies and Stamminger, 2016).

- Perceptions toward longer product use

The proportions of answers to the items of consumer's perceptions toward longer use of PCs are shown in Figure 2. All items show a similar trend, that is, a large proportion of respondents agreed with or were neutral to the statements, while very few disagreed, not only for positive perceptions but negative ones (DIF, TRB, and OBS). Therefore, people mostly have positive perceptions toward longer use of PCs, while at the same time they also have negative perceptions, indicating their ambivalent perceptions toward longer product use.

Correlations between the items were mostly moderately strong among positive perceptions (0.4-0.75) as well as among negative ones (0.35-0.45), whereas correlations between positive perceptions and negative perceptions were weak (0.05-0.3).

Influence of consumer's perceptions on lifespan

According to the preliminary analysis, three outlier data points (data of which the intended lifespan was longer than 30 years) were excluded. Age and TRB didn't satisfy the proportional hazard assumption, and thus age was utilized for stratification and a time-dependent term of TRB was added. Result from the main analysis are shown in Table 2 (The result including demographic variables are shown in Appendix 2). For both the actual lifespan and the intended lifespan, INT and ATT

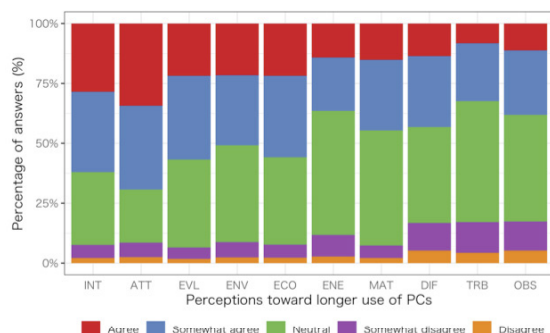


Figure 2. Proportion of answers to statements of consumer's perception toward longer use of PC.

Variables	Actual	Intended
INT	-0.131**	-0.128**
ATT	-0.120**	-0.151**
EVL	-0.020	-0.043
ECO	0.080	0.054
ENV	0.010	-0.063*
ENE	-0.051	0.065*
MAT	0.040	0.020
DIF	0.047	0.043*
TRB	0.048	0.107*
OBS	0.014	0.098**
t(TRB)	-0.043	-0.076**

** p<0.01; * p<0.05

Table 2. Influence of consumer's perceptions on lifespan. (t) denotes the time-dependent term.

had significant negative coefficients, indicating their influences of extending lifespans. However, although several other variables showed significant influences on the intended lifespan, which ENV and t(TRB) had influences of extending the intended lifespan and ENE, DIF, TRB, and OBS had influences of shortening, no other psychological variables had a significant influence on the actual lifespan. The fit index value was 0.034 for the actual lifespan and was 0.055 for intended lifespan, that is, the investigated variables had slightly stronger explanatory power for the intended lifespan than for the actual lifespan.

To further investigate the differences between the influences of consumer's perceptions on the actual lifespan and those on the intended lifespan, respondents were classified into three groups based on their strength of each item of

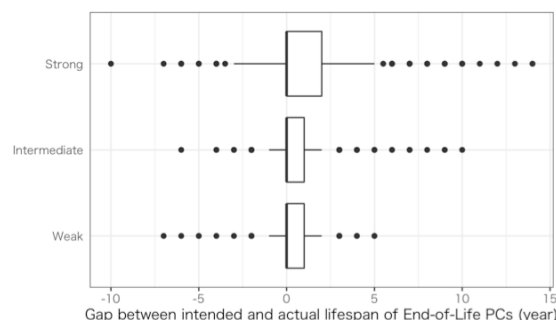


Figure 3. Difference in the gap between intended and actual lifespan among groups classified based on ATT.

perceptions respectively (those who chose "agree" or "somewhat agree" as "Strong", "neutral" as "Intermediate", and "somewhat disagree" or "disagree" as "Weak",) and the distributions of the gap between the intended lifespan and the actual lifespan were compared among groups with one-way ANOVA.

It was shown that there existed significant differences in the gap among groups when we classified based on INT, ATT, EVL, ECO, ENV, and OBS. Particularly, respondents with strong INT or ATT were more likely to experience a positive gap between the intended lifespan and the actual lifespan (Figure 3).

Discussion

The influences of consumer's perceptions toward longer product use on the actual and intended lifespan were sought in this study. The result from the Cox proportional hazard model showed that, similar to the other behaviors concerning material circulation (Chan and Bishop, 2013), intention and attitude toward longer product use had significant influences for extending the actual lifespan, which supported the findings from existing studies of lifespan in a quantitative method (Evans and Cooper, 2010). We can, therefore, state that it is indeed effective to promote longer product use by improving consumer's intention and attitude toward it, for example by providing knowledge about the benefits (Barr, 2007).

On the contrary, those who had a stronger intention or attitude to use their product longer were more likely to experience a short actual lifespan compared with their intended lifespan. That is, despite the aforementioned fact that strong intention or attitude can extend the actual lifespan, they did not affect the actual lifespan as much as they affected the intended lifespan. This can be interpreted as one form of

the intention-behavior gap that their influences of extending the actual lifespan are restricted, possibly due to external factors.

This argument is supported by another finding that the other psychological variables had no significant influence on the actual lifespan whereas many of them had significant influences on the intended lifespan. And accordingly, the fit of the model was lower for the actual lifespan than for intended lifespan. This means that, unlike the intended lifespan which represents the consumer's willingness to use their products, the actual lifespan is largely influenced by factors other than psychological attributes.

Above all, although there exist significant influences of consumer's intention and attitude toward longer product use on the actual lifespan, it has a lot to do with other external factors.

Limitations of this study and suggestions for future works

Despite the important findings, there are several limitations to this study. The main limitation is, as is already mentioned, the insufficiency of factors in consideration. Although the main focus of this research was on the influences of consumer's psychological attributes upon lifespan, the overall explanatory power of the model was quite low, indicating that necessary factors were not included in the model. The lack of those influential factors may also pose questions to the reliability of our findings, that obtained data were not adequately controlled.

Another issue is the relationships between the psychological variables. Even though we know that intention and attitude have influences for extending lifespan, it is not yet well known how to improve them. Causal relationships among psychological attributes have been analyzed using structural equation modeling in numbers of studies for other behaviors (Wan et al., 2017), which were not conducted in this study. While there are other limitations (the definition of the expected lifespan, different product subjects, etc.), future studies should primarily focus on including factors other than consumer's psychological attributes and investigating their influences as well as the interactions between themselves.

Conclusion

Product lifespan extension is a powerful approach to reduce resource throughput and accordingly natural resource consumption. This study investigated the influences of consumer's perceptions toward longer product use on product lifespan in order to identify ways to encourage consumers to actually use their products longer. One important finding is that improving consumer's intention and attitude to use their products longer can indeed lead to longer actual lifespan. Therefore, policymakers or product designers aiming to realize longer product lifespan should set approaches that can improve consumer's intention and attitude. While at the same time their influences are limited, and factors other than consumer's psychological attributes have much influence on the actual lifespan. There is a strong need for further studies to analyze the influences of other factors, not only on the lifespan itself but among factors, specifically influences on intention and attitude, so that more detailed, effective approaches can be determined.

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Appendix 1: Sample design

Category	N (%)
Gender	
Male	1116 (48.3%)
Female	1194 (51.7%)
Age	
20-29	289 (12.5%)
30-39	344 (14.9%)
40-49	425 (18.4%)
50-59	340 (14.7%)
60-	912 (39.5%)
Area	
Hokkaido	104 (4.5%)
Tohoku	167 (7.2%)
Kanto	775 (33.5%)
Chubu	416 (18.0%)
Kinki	370 (16.0%)
Chubu	139 (6.0%)
Shikoku	79 (3.4%)
Kyushu	260 (11.3%)
Marriage	
Married	1525 (66.0%)
Not married	785 (34.0%)
Child	
Have children	1455 (63.0%)
No child	855 (37.0%)
Household income	
Low income	721 (31.2%)
High income	1123 (48.6%)
DK / NA	466 (20.2%)
Personal income	
Low income	1433 (62.0%)
High income	482 (20.9%)
DK / NA	395 (17.1%)
Occupation	
Unemployed	979 (42.4%)
Part-time worker	304 (13.2%)
Full-time worker	1027 (44.5%)

Appendix 2: Results of Cox proportional hazard model analysis including demographic variables

Variables	Actual	Intended
INT	-0.131**	-0.128**
ATT	-0.120**	-0.151**
EVL	-0.020	-0.043
ECO	0.080	0.054
ENV	0.010	-0.063*
ENE	-0.051	0.065*
MAT	0.040	0.020
DIF	0.047	0.043*
TRB	0.048	0.107*
OBS	0.014	0.098**
t(TRB)	-0.043	-0.076**
Gender		
Female	-0.073	-0.024
Area		
Tohoku	0.01	0.024
Kanto	0.035	0.023
Chubu	-0.088	-0.073
Kinki	0.044	0.037
Chugoku	-0.073	-0.05
Shikoku	-0.217	-0.074
Kyushu	-0.04	-0.007
Marriage		
Married	0.013	-0.1*
Child		
Have children	0.088	0.093*
Household income		
High income	0.101	0.119*
Personal income		
High income	0.085	0.157**
Occupation		
Part-time worker	0.031	0.127*
Full-time worker	0.033	0.066

** p<0.01; * p<0.05

Age was incorporated in as a stratification variable