ENABLING CLOSED RESOURCE LOOPS IN ELECTRONICS: UNDERSTANDING CONSUMER DISPOSAL BEHAVIOUR USING INSIGHTS FROM DIFFUSION MODELS

Deepali Sinha Khetriwal[1]

Ivana First[2]

The paper explores consumer disposal behaviour, especially in the context of durable electronic products. The purpose of the research is to understand why, how and when consumers dispose of their durable products. The research aims to provide policy makers, waste managers and product marketers new insights on consumer disposal behaviour that will help improve policy, encourage better resource management and incentivise product designs that maximise environmental and social benefits.

We apply knowledge from the extensive literature on diffusion modelling to develop and test our hypothesis regarding triggers and influencers of obsolescence and disposal of durable products. Our results show that failure is often not the reason that products are disposed, and consumers take disposal decisions based on perceived obsolescence of the product which in turn is driven by psychographic variables, the technology landscape as well as product market characteristics.

Keywords:

Replacement

Obsolescence

Disposal

Behaviour

[1] *Institution/Affiliation: University of St.Gallen, Postal Address: 11, St.Peter's Court, NW4 2HG, London, UK, Phone: +44 20 8457 1255, E-mail address: sinha.deepali@gmail.com*

[2] *University of Rijeka, Faculty of Economics, I.Filipovića 4, 51000 Rijeka, Croatia, Phone: +385 51 355 169,Fax: +385 51 355 169, E-mail address: ifirst@efri.hr*

I. INTRODUCTION

In the past decades, electronic products have multiplied and become more accessible, affordable and numerable. Such vast quantities of products require equally large amounts of raw materials to manufacture which are becoming scarcer to find. Therefore sustainable production and consumption has emerged as one of the key challenges of a growing aspirational global society. In order to move towards a sustainable future, it is vital that production and consumption of electronics uses fewer resources more efficiently, and to do it in closed material loops.

Eco-design, efficient recycling technologies and progressive policies are no doubt also essential in the creation of a closed-loop system. However, the overall efficiency of any closed-loop system is determined by the weakest link in the chain. In many ways, the consumer is the weakest link in creating sustainable global electronic product chains, with consumer behaviour influenced by many, often unknown, factors.

In order to create more efficient take-back systems it is therefore imperative to understand consumer disposal behaviour. However, this area of research has not been the focus of interest of either research on e-waste or marketing. E-waste research have focussed their attentions on estimating quantities (Widmer et al., 2005; Oguchi, 2008), evaluating the effectiveness of policy instruments (Zoeteman et al., 2010) and assessing the hazards and toxins (Osibanjo and Nnorom, 2008). Some authors of WEEE estimation models (Elshkaki, 2004; Oguchi, 2008) have hinted that technological advancement and social acceptability may also be factors that influence disposal. However, their models do not include these factors as there is no research yet to suggest specifically what these factors are and how significant their influence may be.

Marketing research has in turn focussed on acquisition and usage as the first two phases of consumption, neglecting disposal, although it is third and final stage of consumption. According to Raghavan (2010), understanding disposition behaviour is as important for marketers as understanding acquisition and use behaviour, as it helps a) design products with suitable lifecycles, which reduces wastage and cost; b) design effective trade-in and price promotion programs, and c) turn their sustainable disposition programmes to unique selling points. A more profound connection of disposal and marketing lies in marketing defining itself. Marketing as defined by American marketing association (2007) is “the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large”. By obliging themselves to provide value for the society at large, marketers have taken the responsibility to understand disposal behaviour and foster sustainable consumption. Nevertheless, in comparison to the research on product acquisition, especially on new product diffusion (see Mahajan et al., 1990 and Meade and Islam, 2006 for an extensive review of the literature), research on product disposal remains marginal.

This paper makes a contribution to the understanding of consumer disposal behaviour using insights from the vast research on diffusion models. Such insights are specially relevant given that the large majority of consumer products are replaced not because they stop functioning, but for reasons motivated by consumer decisions, which in turn are dependent on consumer profile. We believe that by getting insights into why, when, how and why so consumers dispose their durable products, specially electronics, we will provide valuable information to policy makers, waste managers and marketers. Policy makers will get valuable information on how to motivate better consumer behaviour. Waste managers’ models will be informed for better forecasting waste flows

and more accurately estimating and improving collection efficiency and achieving more sustainable closed-loops material cycles. Finally, marketers will get insights how to better meet the changing needs of consumers.

II. RELATED RESEARCH

Apart from looking at literature on disposal of consumer durables, we also look at literature on replacement and adoption of consumer durables. This is because consumer replacement and adoption behaviour greatly influence consumer disposal behaviour. In addition theoretical models behind replacement and adoption behaviour, help explain disposal behaviour as well.

A. Research on Disposal of Consumer Durables

Research on disposal of durable goods started in the late 70s as an offshoot of consumer behaviour research. In his seminal article, based on a review of 463 research papers on consumer research published between 1968 and 1976 (a period when consumer behaviour research in general exploded), Jacoby (1976) concluded that although consumption consists of three stages, namely acquisition, actual consumption and disposition, the research focus had been largely on acquisition phase, and almost non-existent on the disposition stage. Very soon together with his colleagues Jacoby (et al., 1977) focuses on disposition research and shows that factors influencing disposal behaviour are psychological characteristics of a decision maker, factors intrinsic to the product, and situational factors extrinsic to the product. Disposition behaviour thus is a function of disposition intention, social factors and situational factors (Hanson, 1980). Later Antonides (1991) also notes that the lifetime of a durable good is determined by a consumer's decision which is in turn determined by economic, psychological and product-technical factors.

Studies by DeBell and Dardis (1979), and more recently Cooper (2004) show that disposition decision varies for various product categories (where some are more likely to get discarded prior to their failure and other less likely). Cooper's (2004) survey on replacement purchases across 15 durable goods categories in the UK revealed that discretionary replacement was second lowest for washers and dryers, and highest for mobile phones.

B. Research on Replacement of Consumer Durables

Bayus, (1988) claimed that given the rapid growth and affordability of consumer durables, the large majority of consumer durables are scrapped before they are technically broken. Therefore, consumer disposal research was not only focused on disposition, but also replacement, with the next wave of research directed towards understanding the seemingly irrational consumer behaviour of replacing durables before they failed. It was discovered that consumers replace working units for a variety of reasons, including style preferences (DeBell and Dardis, 1979; Hoffer and Reilly 1984; Sherman and Hoffer 1971), product features and technology advances (Jacoby et al., 1977), marketers' efforts with emphasis on price modification and sales promotions (Bayus 1988; Pickering 1975), changed family circumstances, and improved financial conditions (Pickering 1975). Evidence from Cripps and Meyer (1994) and Grewal et al. (2004) also indicates that discretionary replacements are more likely to occur when the motivation is technological obsolescence than in the case of technical deterioration.

There was also a number of studies which explored the timing of replacement and disposal. Bayus (1991) discovered that "early" buyers, as compared to "late" ones are more concerned with styling

and image and less with costs, have higher incomes, but lower levels of education and occupational status, they engage in less search activities and rely more on marketing communication than late replacers. Coulter and Ligas (2003) studied the timing of disposal, rather than just the timing of replacement as in the preceding studies. In particular they profiled two significantly different consumer behaviours at a point when product ceases to serve its initial purpose i.e. product keeping displayed by packrats and product throwing displayed by purgers.

C. Research on Adoption of Consumer Durables

As discussed above, in particular by Bayus (1991), consumers often times do not first make a decision to replace, but rather a decision to acquire a new product, thereby rendering the older product obsolete, leading to disposal. The adoption of consumer durables is most widely researched in diffusion models, popularised in the marketing literature with the seminal article by Bass (1969). In his paper, building on theoretical concepts presented by Rogers (1962), Bass presented a growth model for the timing of initial purchases of new products suggesting that new technologies are not adopted immediately by all the potential buyers, but rather a diffusion process is set in motion in which there are largely two groups of adopters – the innovators and the imitators.

Many variations and extensions have since been proposed, extending the original Bass Diffusion Model to include marketing mix variables such as effect of price (Kalish, 1985; Jain and Rao, 1990; Kamakura and Balasubramanian, 1988), placement (Jones and Ritz, 1991), and advertising (Horsky and Simon, 1983; Simon and Sebastian, 1987). Others have proposed models for multi-generation products (Norton and Bass, 1987), in the event of technology substitution (Fisher and Pry, 1971) and multiple product ownership (Steffens, 2003).

II. CONCEPTUAL MODEL

We follow Stern's (2000) recommendation on consumer behaviour models and create a two step multi-dimensional model which incorporates all by Stern defined useful elements: motivations, attitudes and values; contextual or situational factors; social influences; personal capabilities and habits.

A. Obsolescence, replacement, and disposal

Obsolescence, replacement and disposal of consumer durables are connected but separated concepts. Replacement and disposal are consumer decision points with a time gap between them ranging from seconds to decades. The distinction made by Bayus (1988) between forced replacements (replacement of a failed unit) and unforced replacement (discretionary replacements of a working unit) provides a useful starting point for the distinction. Forced replacements (eg. broken appliances) are very likely to lead to immediate disposal. Would forced replacement be the only disposal trigger, disposal and replacement could, within waste management, be used interchangeably. However, as many products are replaced before they fail, and/or subsequently often stored or reused elsewhere, the disposal decision can be long after the replacement decision.

We also differentiate replacement from obsolescence. Unforced replacement is a possible outcome of obsolescence, but obsolescence is a more inclusive situational factor which leads to

disposal, regardless of whether the replacement occurred or not. Once the consumer starts perceiving a product as obsolete, a product might be either directly disposed of without being replaced (e.g. once the lifestyle or trends changes) or it can be firstly replaced and then disposed of (immediately or after a period of storage).

Because from the point of view of disposal behaviour, we are not interested on whether the product got replaced or not, we focus on two important points in disposal decision making process: obsolescence and disposal.

B. Why consumer durables become obsolete - obsolescence triggers and influencers

Similar to Bayus (1991), we differentiate variables that lead to obsolescence as "triggers" or "influencers". Triggers are more direct in prompting the disposal while influencers do not necessarily motivate disposal by itself, but play an important role in moderating decision making process.

I. PRODUCT MARKET AS OBSOLESCENCE TRIGGER

Lee et al. (2006) show that the aggressive price competition from LCD TVs replaces purchases of other TVs. Similarly, Bayus (1988) concludes that price has the largest impact on the timing of early replacements. Simon and Sebastian (1987) and Horsky and Simon (1983) suggest that advertising and promotions also play a part in accelerating the speed of adoption, and thereby also replacement. Bayus (1992) cites Pickering (1981) as suggesting that product replacement demand is also contingent on dynamic and feedback effects, allowing for "unanticipated events" including special price/promotion.

VanNes and Cramer (2006) claim that product design can influence replacement decision and identify four possible influencing modes one of which (i.e. new desires awoken) is pure discretional. Bayus (1982) also points to research which shows that attributes such as a availability of product features such as better picture and better sound quality, or product styling and colour etc. and the availability of newer technologies are related to early replacements and may be related to disposal decisions for consumer durables. His results show that marketing mix variables, in particular price and promotion have a significant effect in shifting the mean replacement age of a consumer durable forward. From the elaborated we conclude:

> *H1: Obsolescence of consumer durables is triggered by price of new products, new product features and promotions of new products or a combination of the three.*

II. TECHNOLOGY LANDSCAPE AS OBSOLESCENCE TRIGGER

Islam and Meade (2000) suggest four major drivers leading to replacements of consumer products including improved technology. Disruptive technologies which replace the extant dominant design are also a trigger for obsolescence of older products. We believe that, for example, the emergence of flat screen TVs replaced the existing dominant design of the Cathode Ray Tube (CRT) TV, thereby triggering a perception of obsolescence regarding the CRT TV. Similarly, network externalities with complementary products and services can also lead to obsolescence if older technologies are not suitable, such as digital and high definition broadcasts being incompatible with older models of TVs. Therefore, we deduct:

H2: Obsolescence of consumer durables is triggered by changes in the technological landscape

III. HOUSEHOLD PROFILE AS OBSOLESCENCE INFLUENCER

Higher incomes have been related to higher expenditures on discretionary goods (Horsky, 1990). As average income increases for the population, sales of durables increase, with not only higher incomes leading to greater first time purchases, they lead to earlier replacement among prior adopters, resulting in higher replacement rates (Bayus, 1991; Bayus and Mehta, 1995). Household size as well as the age of the household head can also influence consumer durable purchase and disposal decisions and has been previously suggested by Antonides, 1991, Bayus and Gupta, 1992 among others). Therefore we hypothesise:

H3a: Household's disposable income and demographics (household size and age of head) influence the effect of obsolescence triggers.

Kim et al (2001) suggest that consumer price and technology sensitivity is an important factor that influences consumer buyer behaviour, and is discussed in depth by them in the context of modelling the diffusion of new products.

Morgan and Birtwistle (2009) in a study on textile disposal discovered that fashion innovativeness influenced by media and celebrity is an important predictor of disposal. Similar effect can have peer pressure. We hence propose a more inclusive concept of social sensitivity and define it as being conscious about keeping with the latest fashion. From the elaborated we deduct the following:

H3b: Social, price, technology sensitivity influence the effect of obsolescence triggers.

C. How people dispose and why so – disposal triggers and influencers

The seminal paper by Jacoby et al (1977) recognised nine various disposition behaviours in three main categories:

- keeping the product (original purpose, another purpose, store it);
- getting rid of it (throw it away or abandon it, give it away, sell it, trade it);
- disposing of it temporarily (loaning it, renting it).

Harrell and McConocha (1992) essentially spoke of the same options, but differentiate between non-altruistic (keeping, throwing away, selling), and altruistic behaviour (giving away and donating).

In light of growing environmental awareness, over the years major modification of the disposition option occurred in the area of relinquishing product. So, Coulter and Ligas (2003) suggested that relinquishing a product might include variations such as: discarding a product in a socially

acceptable way (trashcans), abandoning a product in a socially unacceptable way (littering), recycling a product, selling a product and giving away possessions, as donations or gifts.

We identify eight main options for consumers, which can be broadly categorised as a) reuse and storage; b) recycling, and final disposal. Each of the three categories has different implications for closing material loops. While reuse and storage have an impact on the timing of final disposal of the product and when it becomes available for recycling the choice of recycling or final disposal has an impact on the amount of material available, or permanently lost, from the material loop.

We believe that if all the described disposal options are taken into account, the most influential trigger on the type of disposal is trigger that initiated the decision to dispose. This is because a product that has failed is unlikely to be used by anyone else, and therefore the consumer is more likely to decide to send it for recycling or final disposal than a product which is still functional, and which the consumer might decide to reuse or store. Therefore, we hypothesise,

> *H4a: Consumer disposal behaviour is highly dependent on the type of disposal trigger*

Furthermore, those products that are disposed of prior to their failure are likely to have a much shorter lifetime than those disposed due to failure (Bayus, 1991). Cooper (2004) found that the lifespan considered "reasonable" for a household electronic durable was at least two to three years more than the age when the product is actually discarded. Therefore, we suggest that:

> *H4b: The age of the product at time of disposal is highly dependent on type of disposal trigger*

Apart from disposal triggers, previous research indicates that disposal behaviour is also influenced by the disposer's profile. Depending on knowledge, attitudes, and motivation, a consumer makes a decision on how to dispose. For example Jacoby et al. (1977) proposed learning to influence disposal choice. Morgan and Britwistle (2009) indicate that people concerned about the environment are more likely to make the effort to recycle, which indicates that their attitudes influence their disposal behavior. Coulter and Ligas (2003) indicate that depending on value systems and attitudes consumers dispose differently. The rational consumers use when choosing a particular disposal type has been studied also by Harell and McConocha (1992) who particularly focused on motivations behind various types of disposal. Therefore, we propose that:

H5a: Consumer disposal behaviour is influenced by consumer knowledge, attitudes and motivations.

Finally, because consumer behaviour can generally be modified by a "carrot and stick" approach, i.e. incentives and penalties, we believe that disposal behaviour would be no different and hence, we propose our last hypothesis:

H5b: Consumer disposal behaviour is influenced by incentives and penalties

D. Model

From the above discussion, we develop our conceptual model shown in Figure 1. Disposal behaviour is our dependent variable, with the rest being independent, moderating and antecedent variables.

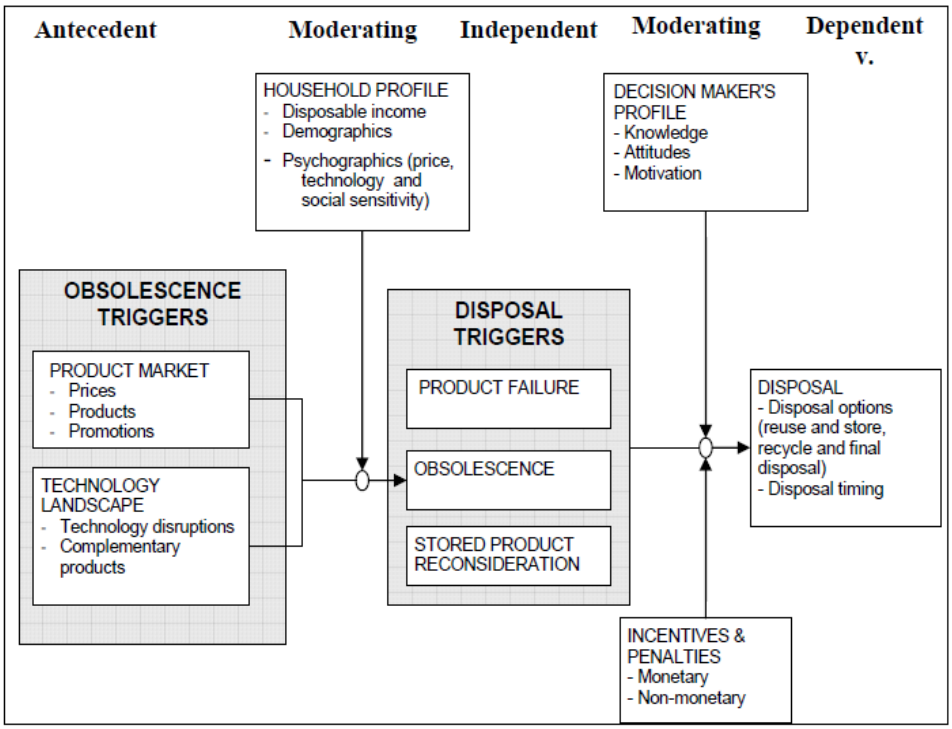

FIGURE 1. CONCEPTUAL MODEL

Source: authors calculation

IV. METHODOLOGY

A. Variables operationalisation

The model presented above has been operationalized on the basis of survey questions. Following previous studies, our demographic variables correspond to disposable income (on a 4-point scales ranging from less than 5,000 HRK to greater than 20,000 HRK), number of persons in household and the age of the head of the household.

For psychographic variables, as well as motivation, attitudes and conceptual knowledge variables, we use a 5-point Likert scale, for types of questions as given in table 1. We additionally asked a

question to find out the awareness level of the consumers regarding the legislated free collection option, which we consider to be practical knowledge.

Finally, although we gave an elaborated explanation of the distinction between obsolescence and replacement, because replacement, unlike obsolescence, is an objective point in time that consumers can easily define and describe, in our questionnaire we ask consumers to think of the replacement decision and ask them to define reason for their replacement. Ten reasons for replacement of a TV were offered to respondents, including product failure, three different developments in technology landscape and three developments in product market, an intention to give away a current TV, move to a new household and unintended replacement of a TV caused by an awarded TV. We coded the results so that all replacements caused by technology landscape and product market were coded as obsolescence.

TABLE 1. VARIABLE OPERATIONALISATION

	Operationalisation
Price Sensitivity (adapted from Goldsmith and Flynn, 1992)	1. We are less willing to replace a TV if we think that prices will come down. 2. We don't mind paying more to try out new technology. 3. The cost of replacing the TV is generally important to us. 4. Really good TV is worth paying a lot of money for
Technology Sensitivity (adapted from Goldsmith and Hofacker, 1991; Goldsmith and Nevell, 1997)	1. We are among the last in our circle of friends to replace our old TV 2. Compared to our friends, we do little shopping for new electronic gadgets. 3. We know more about new electronic gadgets before others. 4. We will consider buying a new electronic device, if we see it in the store, although we haven't heard of it yet.
Social Sensitivity (adapted from Goldsmith and Hofacker, 1991; Goldsmith and Nevell, 1997)	1. Our purchase is informed by media 2. We often discuss electronic products we own with our friends and colleagues 3. We like to be seen as those with the trend.

Continue

End of table 1.

Motivation (adapted from Antonides, 1991; Harrel and McConocha 1992)	1. Convenience 2. Environmental soundness 3. Cost 4. Earning 5. Helping others
Attitude (Morgan and Britwistle, 2009)	1. We recycle as much as possible 2. Disposing responsibly and environmentally is important
Conceptual knowledge	How environmentally acceptable are the following disposal options: 1. storing 2. giving/selling it to someone for further use 3. sending for recycling 4. throwing it in big items container 5. putting with other household garbage / general waste container 6. leaving it in the streets 7. e. using it or its parts for another purpose
Practical knowledge (awareness of legislation)	1. Do you think that you are allowed to dispose your old TV at a place at which you bought a new one (1 for 1)? 2. Do you think that for electronic items > 30 kg you can call a disposal company free of charge to pick it up? 3. Do you know where to take your old electronic equipment to properly disposed of?

Source: Authors calculation

B. Object and context of the study

For this study we consider TVs to be appropriate research object for several reasons:

- Though advances in television technology have increased the reliability and technical lifespan, televisions are frequently disposed prior to their technical failure, as a result of discretionary consumer behaviour.

- It is a mature product category and has reached saturated markets in developed countries, with a large installed base. Therefore, replacement sales are a much larger proportion of total sales as compared to first time purchases, thereby having a significant impact on disposals as well.
- Furthermore, since the introduction and explosive growth of flat panel display technologies (FPD) in the television market, households have been recently, and continue to be, exposed to TV disposal decision situations.

C. Country of study and its regulatory framework

We have conducted our study in Croatia. E-waste disposal in Croatia is regulated by Regulation on e-waste (NN, 2007). According to this regulation it is forbidden to dispose e-waste together with other general waste, but it has to be disposed so that its recycling is ensured, i.e. it can be a) taken to a recycling point which exists in each bigger town, b) returned to a seller when a new one is bought at a one per one basis, or c) for disposals heavier than 30 kg a recycling company can be called to take it away. All three mentioned options are free of charge for the disposer. However, there are no monetary incentives or penalties to practice any of the three disposing options.

D. Procedure and sample

We have used a snowball sampling method to collect empirical data. The self-administered questionnaire was designed online at www.surveymonkey.com. Online data collection channels offer practical advantages, however create a bias towards younger and more educated respondents, which was the case in our survey as well as shown in table 2. We tested whether responses among groups of different education level and different age differ and found no significant differences, neither in terms of disposal reasons nor in terms of knowledge, motives, and attitudes on disposal, therefore, we conclude the biased sample does not cause important disruptions of our results.

TABLE 2. AGE AND EDUCATION OF RESPONDING HOUSEHOLDS

Household head age					
Under 35		35-45	45-55	55-65	Above 65
88		37	45	19	0
Household head education					
Primary	Secondary	Bachelor	Master	MSc	Phd
2	53	21	79	21	13

Source: authors calculation

When applied to consumer durable products, the marketing literature on diffusion models considers the adopting unit normally as a household, based on the assumption of the implicit long-term commitment involved in purchasing a durable. We extend this to disposal, and consider our unit of study a household as well. In total we collected data on 219 households.

Respondents were offered to fill in the questionnaire on their replacement caused disposal and stored TV disposal (if they encountered one or both the situations). In total we have collected descriptions of 173 replacement induced disposals and descriptions of 37 stored TV disposals (in total it makes 206 disposal decisions of which 25 respondents provided data on both disposal situations).

Most of the questions in our sample were close ended and those which were open ended were coded in order to be possible to analyse them quantitatively in SPSS.

V. RESULTS

A. Replacement dynamics

Overall replacement dynamics in the studied market is shown in table 3. From the collected 173 replacement behaviours, 163 respondents knew the types of their TVs. As much as 47 described replacements resulted in a purchase of a CRT TV. This initially surprising finding becomes obvious when discovered that such replacements on average happened 3.5 years earlier than the average replacements of CRT to LCD/plasma technology. Replaced TVs were on average 9.5 years old with no statistically significant difference in average replaced TVs' age between four identified types of replacements.

TABLE 3 – REPLACEMENT DYNAMICS

Replacement type	Cases	When replaced (years ago)				Age of a replaced TV (years)			
		Min	Max	Mean	sd	Min	Max	Mean	sd
CRT replaced by CRT	47	1	23	6.2	4.3	5	28	11.0	4.3
CRT replaced by LCD	92	0,1	10	2.6	1.7	2	30	9.3	5.0
CRT replaced by Plasma	15	0,1	6	2.6	1.9	2	15	9.4	3.2
LCD/Plasma replaced by LCD/Plasma	9	0,5	6	2	1.7	3	7	4	1.3
Total	163	0,1	23	3.6	3.2	2	30	9.5	4.9
One way ANOVA's p-value		.000				.264			

Source: authors calculation

From 159 respondents who indicated their replacement reason a) product failure (n=35), b) product market (n=32), and c) technology landscape developments (n=27) were the most common single reasons of a TV replacement. Because respondents were asked to indicate the

level to which each of the offered reasons were motivating for replacement of a TV, 107 respondents offered single main reason, 23 respondents offered 2 main reasons, 21 respondents offered 3 or more equally important reasons, whereas 8 respondents did not consider anything from the offered to be a reason for their TV replacement.

Even if 12 respondents who indicated failure as one of the main replacement reasons are added to those 35 for whom failure was a single most important reason, overall replacement of a TV was cause by product failure in not more than 29.5% of cases.

We tested mean age of replaced TVs for each of the reasons as presented in the first part of table 4. However, to get the clear evidence for supporting or rejecting hypotheses we grouped the replacement reasons to a) product failure vs. b) obsolescence (technology or product market trigger) as presented in the second part of table 4. Other reasons (multiple reasons, non intended replacements or household move) were removed from this particular analysis. Evidently TVs that were replaced due to product failure are statistically significantly ($p=0.03$) older ($M=11.29$; $sd=6.08$) than those replaced for obsolescence ($M=8.32$; $sd=4.04$). After removal of outliers (i.e. products replaced at the age of more than 15 years) as shown in the third part of table 4, the difference in replaced TVs' age among failure induced replacements and obsolescence induced replacements still exists. It is reduced to 2 years ($M=9.33$; $sd=3.36$ for failures and $M=7.79$; $sd=3.16$) for obsolescence, but it is still statistically significant ($p=0.003$).

TABLE 4. TRIGGERS FOR TV REPLACEMENTS

Reason	Age		
	Cases	Mean	sd
PART 1. All respondents - all reasons			
Failure (1)	35	11.286	6.076
Product design (2)	23	7.783	4.572
Technology (3)	27	9.889	4.136
Price (4)	9	7.556	3.127
Household move (5)	8	8.625	2.446
Failure + other (6)	12	10.750	5.328
Product design + Technology + Price (7)	17	6.941	2.883
One way ANOVA's p-value		0.018 (1>7)	
Other reasons	30	9.536	5.217
PART 2. All respondents - failure or obsolescence			
Failure	35	11.286	6.076
Obsolescence	76	8.316	4.044
One way ANOVA's p-value		0.003	
PART 3. Outliers removed - failure or obsolescence			
Failure	30	9.333	3.356
Obsolescence	73	7.795	3.158
One way ANOVA's p-value		0.030	

Source: authors calculation

B. Obsolescence influencers

Although price and technology sensitivities were measured by established measurements (Goldsmith and Flynn, 1992; Goldsmith and Hofacker, 1991); Goldsmith and Nevell, 1997), their Cronbach's alphas were not very high (table 5, columns 5-7). To investigate which items corrupt the results and to see whether items of the originally proposed constructs are correlated among each other, we run Factor Analysis. Results showed that items measure 4 different constructs, with price items clearly loading on two factors (table 5, columns 1-4,). After studying the correlations among the items and using face validity to examine their logical correlations, we decided to measure Sensitivities with variables PriceSen1, TechSen1 and SocSen1, items for which are shown in table 5 columns 8-10. In that way we improved Cronbach's alphas and remain at about similar levels of correlation among the factors.

TABLE 5. PRICE, TECHNOLOGY AND SOCIAL SENSITIVITY

	CRONBACH'S ALPHA - SET 1			FACTOR ANALYSIS*				CRONBACH'S ALPHA FOR SET 2			
	TECHSEN	**SOCSEN**	**PRICESEN**	**1**	**2**	**3**	**4**	**TECHSEN1**	**SOCSEN1**	**PRICESEN1**	**PRICESEN2**
TechSen1	x			**-0.944**	0.006	-0.070	-0.010	x			
TechSen2	x			**-0.831**	0.044	0.064	-0.046	x			
TechSen3	x			**-0.228**	-0.210	0.201	0.176	x			
TechSen4	x			0.106	**0.748**	-0.196	0.159		x		
SocialSen1		x		0.096	**0.541**	-0.103	0.087		x		
SocialSen3		x		-0.069	**0.507**	-0.322	0.000		x		
PriceSen4			x	0.007	0.097	**0.707**	0.243			x	
SocialSen2		x		-0.057	0.135	**-0.510**	0.133				
PriceSen2			x	0.278	-0.073	**0.381**	0.176			x	
PriceSen1			x	-0.029	0.006	0.011	**0.520**				x
PriceSen3			x	0.017	-0.023	0.015	**0.383**				x
Cronbach's alpha	**0.708**	**0.589**	**0.538**					**0.737**	**0.653**	**0.668**	**0.377**
Price	-0.457**	-.308**						0.504**	-0.334**		
Tech		0.413**							0.348**		

**Extraction Method: Principal Axis Factoring. Rotation Method: Oblimin with Kaiser Normalization Rotation converged in 11 iterations.*

*** Correlation is significant at 0,01 level.*

**** Sensitivities are all normally distributed and hence Pearson correlation is calculated.*

Source: authors

Table 6 shows that technology, price, and social sensitivities are all correlated to more obsolescence triggers. More precisely, the more the household is technology and socially sensitive and the less it is price sensitive, the more likely it is to replace a TV for the obsolescence reasons. As table 6 shows, price sensitivity is the most influential (it is correlated with the most obsolescence triggers), whereas technology sensitivity is the least influential. It is important to stress that neither of the studied sensitivities is correlated to failure, which proves the validity of the results as failure is an objective occurrence, whereas obsolescence subjective.

TABLE 6. – CORRELAATION BETWEEN PRICE, TECHNOLOGY AND SOCIAL SENSITIVITY AND OBSOLESCENCE

Sensitivity	Failure	Obsolescence					
		Functional or aesthetical dissatisfaction	DVB-T & HD	CRT to LCD	DVD, playstation	Old for new	Prices fell
Technology	0.092	**0.175***	0.146	**0.233****	0.108	0.086	0.013
Price	0.099	**-0.245****	**-0.211****	**-0.279****	**-0.221****	**-0.161***	-0.111
Social	0.082	**0.146***	0.097	**0.177***	0.104	**0.174***	**0.163***

** Correlation is significant at the 0.01 level.*

***Correlation is significant at the 0.05 level.*

Source: authors calculation

Finally, in our model we have also predicted that household income and demographic characteristics (age and size) influence whether and when the product will be perceived as obsolete. We tested whether the intensity of each of the replacement reasons and the age of replaced TV varies based on households' income, age and size and found very small effect of these variables. The only statistically significant difference was found among age groups so that those younger than 35 more often replace TVs for functional or aesthetical dissatisfaction and that they replace TVs earlier than those aged 45-55.

C. Disposal behaviour

Of a total of 194 disposals of either failed, replaced or reconsidered products as table 7 shows, 79 TVs were kept at home (in use or not), 58 were given or sold away, 30 were given for recycling, i.e.

properly disposed, and 27 improperly disposed, i.e. it was their final disposal with no possibility to be restored and reused.

As table 7 also shows disposal triggers influence disposal behaviour in a way that failed products more often reach end of life, that is get recycled or finally disposed, whereas obsolete ones more often continue to be used (by the same or different users) or get stored. Third disposal trigger, i.e. disposal of products that are reconsidered after a period of storage, depends on product's condition. Failed stored products are more likely to reach end of life whereas functioning ones are more often given or sold away. Chi-square test showed that described differences are statistically significant (p=0.000).

Although there are only 27 final disposals, of all the permanent disposals, they comprise almost 50%. In addition, from altogether 57 end of life disposals, at least 13 were still functioning, which is not an optimal behaviour.

TABLE 7. RELATIONSHIP BETWEENDISPOSAL TRIGGER AND TYPE DISPOSAL

	Disposal behaviour				
	Kept	**Given/sold**	**End of life**		**Total**
			Recycling	**Final disposal**	
No special reason	5	3	0	0	8
Failure	7	4	10	13	34
Obsolescence	51	26	4	3	84
Personal reason	12	6	1	1	20
Failure + other	4	2	3	3	12
Stored for obsolescence		12	3	1	16
Stored after failure		3	7	5	15
Stored unknown reason		2	2	1	5
Total	79	58	30	27	194
Yates Chi-square p value			0,000		

Source: authors calculation

Among TVs that were replaced, there is a statistically significant difference (p=0.005) in age among TVs that are continued to be used by the same, different or potential user (M=8.88; sd=4.72) and those that are disposed of permanently (M=11.51; sd=4.92). Such difference does not exist among TVs disposed after a period of storage.

D. Disposal influencers

We investigated the motivation behind the type of disposal and discovered that none of the tested motivations (practicality, ecology, cost, earning, helping others) is on average particularly high. They all range from M=3.69 (sd=1.08) for practicality to 3.37 (sd=1.08) for helping others, with an exception of motive to earn being low at 2.26 (sd=1.18). ANOVAs were run to discover whether motivations vary for various types of disposal. No statistically significant connection between certain motivation and certain disposal type was discovered.

As for attitudes as influencer of behaviour, we discovered that people on average have very high theoretical attitude towards importance of recycling (M=4.13; sd=0.96), however, that attitude is not always converted into their practically demonstrated attitude (M=3.29; sd=1.16) with the correlation among the two being r=0,608. We also discovered no difference in strength of either attitude indicator among different disposal types.

As for the conceptual knowledge, i.e. beliefs, on average respondents consider recycling to be the most environmental disposal type (M=4.6; sd=0.81), followed by selling/giving (M=3.65; sd=0.93). The least ecological is considered leaving a TV in the streets (M=1.19; sd=0.61) and in general waste containers (M=1.56; sd=0.98). Such results indicate respondents' high conceptual knowledge of right and wrong disposal habits. However, practical knowledge on how to dispose in an appropriate way is pretty low as shown in table 8. Furthermore, no difference in knowledge was discovered among respondents who dispose in different ways.

TABLE 8. KNOWLEDGE ON APPROPRIATE DISPOSAL

Knowledge	Respondents who know
It is possible to return to a dealer an old TV when new is bought	30%
E-waste heavier than 30 kg can be taken away from the household for free	49%
I know where to dispose in an appropriate way	39%
Level of knowledge (based on the three questions above)	
Level of knowledge 0	33%
Level of knowledge 1	29%
Level of knowledge 2	25%
Level of knowledge 3	13%

Source: authors calculation

Finally, we also tested the influence of penalties and incentives on appropriate disposal and found out that most respondents would be motivated by both incentives (70%) and penalties (73%), however, on average a penalty of 460 HRK (60 EUR) would be required to motivate more ecological behaviour, whereas an incentive of 280 HRK (35 EUR) would suffice. Although respondents were asked to define a motivating incentive and penalty monetary, several respondents explicitly mentioned that symbolic reward would be motivating. It is believed that respondents imply that ecological behaviour is less practical and therefore they would like to be reimbursed for their proper behaviour.

VI. DISCUSSION

Predicted relationship among obsolescence triggers and influencers were mostly confirmed by results. More precisely, we found evidence for the support of hypotheses H1, H2, H3b which confirms that TV replacement is triggered by price of new products, new product features and promotions of new products, as well as by changes in the technological landscape. Furthermore, social, price and technology sensitivity influence the effect of obsolescence triggers.

What our results did not support is H3a which predicted that household's disposable income, size and age influence the effect of obsolescence triggers. We ascribe such result to sample bias towards more educated. Despite their age and even disposable income, more educated respondents are more likely to follow the trends than those less educated. We further assume that disposable income might influence the model of replacement TV, but not the decision whether to replace.

As for the second part of the model, i.e. influence of disposal triggers and influencers, we

found support for hypothesis H4a, H4b, and H5b which predict that consumer disposal behaviour is highly dependent on the type of disposal trigger, that products disposed because of failure get disposed later than those disposed for obsolescence, and that disposal would be more proper would there be incentives for proper behaviours and penalties for misbehaviours. However, we did not find support for H5a which predicts that knowledge, attitudes and motives would modify disposal behaviour. We believe that a reason for such result might be a relatively

small sample which did not allow us to perform more refined statistical analysis, which we believe would discovered certain correlations.

VII. CONCLUSION

Consumer behaviour is key to the impact that society has on the environment. The actions people take and choices they make have direct and indirect impacts on the environment. Yet, the literature on consumer disposal behaviour is sparse, and it remains as yet little understood.

Applying insights from diffusion literature, we developed a model to understand consumer disposal behaviour. The results of our research show that consumer disposal decisions on why, when, and how to dispose of a durable product are not only based on the product life, but also on subjective reasons and consumer perceptions.

Our results show that a product mainly gets replaced not because it failed, but because newer products are considered more attractive. In addition such non forced replacements happen on average earlier then the forced ones. For waste managers and recyclers, this is important to bear in mind while forecasting expected end-of-life products in the waste stream. For marketers finding is important as it shows that consumers do not expect their products to last "forever" and can therefore identify opportunities to make trade-offs between durability and other parameters such as weight, or material content etc. Additionally, of interest to both marketers and waste managers is that there could be opportunities to design products that can be easily dismantled and recycled, even at the expense of reducing the product's life time slightly.

Though consumers may replace their old products, they rarely dispose of these immediately. For policy makers and waste managers, it is essential to bear in mind that even in saturated markets, with most sales being replacement sales, they may not find as many products disposed of due to extensive storage periods as well as high importance of second hand market. Because of material scarcity, stored products equally to improperly disposed ones lead to suboptimal resources usage. Waste managers and marketers should inform and motivate replacers to forward unnecessary products to the recycling pipelines as all three sides benefit from reduced costs of the recycled materials.

Finally, and perhaps most importantly for policy makers, is our finding that when consumers do dispose of their products permanently, almost half do not dispose of it in the channels that ensure that it goes to recycling and recovery.

To encourage a cradle-to-cradle approach for consumer durables, it is therefore pertinent for all stakeholders to better understand consumer disposal behaviour in order to develop policies and systems that incentivise (or alternatively penalise) behaviour that causes products to be disposed of improperly.

Our research has several limitations in that it looked at only the replacement of TVs in specific market, namely Croatia, and across a biased sample. Further research validating the results across product categories and geographies would be necessary for generalisation of findings. Nevertheless, we believe our research sheds valuable insights on consumer disposal behaviour that can help inform models for forecasting waste flows to more accurately estimate and improve collection efficiency and achieve more sustainable closed-loops material cycles. Furthermore, we used this research as an indicative study in order to be able to get an initial understanding of the disposal dynamics. Having discovered the huge importance of the second hand market, we realise

it should be given special attention in the subsequent research. In addition, it was discovered that certain hypothetical triggers and influencers are more important than others and therefore those identified as crucial, would have to be given more thorough attention in the future research.

REFERENCES

Antonides, G., 1991. *An economic-psychological model of scrapping behavior*. Journal of Economic Psychology, 12(2), pp.357-379.

Bass, F.M., 1969. *A New Product Growth for Model Consumer Durables*. Management Science, 15(5, Theory Series), pp.215-227.

Bayus, B.L. & Gupta, S., 1992. *An empirical analysis of consumer durable replacement intentions*. International Journal of Research in Marketing, 9(3), pp.257-267.

Bayus, B.L., 1988. *Accelerating the Durable Replacement Cycle with Marketing Mix Variables*. Journal of Product Innovation Management, 5(3), pp.216-226.

Bayus, B.L., 1991. *The Consumer Durable Replacement Buyer*. Journal of Marketing, 55(1), pp.42-51.

Cooper, 2004. *Inadequate Life?Evidence of Consumer Attitudes to Product Obsolescence*. Journal of Consumer Policy, 27(4), pp.421-449.

Coulter, R.A. & Ligas, M., 2003. *To retain or to relinquish: Exploring the disposition practices of packrats and purgers*. Advances in Consumer Research, 30, pp.38–43.

Cripps, J.D. & Meyer, R.J., 1994. *Heuristics and biases in timing the replacement of durable products*. The Journal of Consumer Research, 21(2), pp.304–318.

DeBell, M. & Dardis, R., 1979. *Extending Product Life: Technology Isn't the Only Issue*, Advances in Consumer Research, 6 (1), pp. 381-385.

Elshkaki, A. et al., 2005. *Dynamic stock modelling: A method for the identification and estimation of future waste streams and emissions based on past production and product stock characteristics. Energy*, 30(8), pp.1353-1363.

Fisher, J.C. & Pry, R.H., 1971. *A Simple Substitution Model for Technology Change*. Technological Forecasting and Social Change, 3(1), pp.75–88.

Grewal, R., Mehta, R. & Kardes, F.R., 2004. *The Timing of Repeat Purchases of Consumer Durable Goods: The Role of Functional Bases of Consumer Attitudes*. Journal of Marketing Research, 41(1), pp.101-115.

Hanson, J.W., 1980. *A Proposed Paradigm for Consumer Product Disposition Processes*. Journal of Consumer Affairs, 14(1), p.49.

Harrell, G.D. & McConocha, D.M., 1992. *Personal factors related to consumer product disposal tendencies*. Journal of Consumer Affairs, 26(2), pp.397–417.

Hoffer, G. & Reilly, R.J., 1984. *Automobile styling as a shift variable: An investigation by firm and by industry*. Applied Economics, 16(2), pp.291–97.

Horsky, D. & Simon, L.S., 1983. *Advertising and the Diffusion of New Products*. Marketing Science, 2(1), pp.1-17.

Horsky, D., 1990. *A Diffusion Model Incorporating Product Benefits, Price, Income and Information*. Marketing Science, 9(4), pp.342-365.

Jacoby, J., 1976. *Consumer Psychology: An Octennium*. in Paul Müssen and Mark Rosenzweig, eds. Annual Review of Psychology, 27 , pp. 331-358.

Jacoby, J., Berning, C.K. & Dietvorst, T.F., 1977. *What about Disposition*? Journal of Marketing, 41(2), pp.22-28.

Jain, D.C. & Rao, R.C., 1990. *Effect of Price on the Demand for Durables: Modeling, Estimation, and Findings*. Journal of Business & Economic Statistics, 8(2), pp.163-170.

Jones, J.M. & Ritz, C.J., 1991. *Incorporating distribution into new product diffusion models.* International Journal of Research in Marketing, 8(2), pp.91-112.

Kalish, S., 1985. *A New Product Adoption Model with Price, Advertising, and Uncertainty.* Management Science, 31(12), pp.1569-1585.

Kamakura, W.A. & Balasubramanian, S.K., 1988. *Long-term view of the diffusion of durables A study of the role of price and adoption influence processes via tests of nested models.* International Journal of Research in Marketing, 5(1), pp.1-13.

Kim, N., Srivastava, R.K. & Han, J.K., 2001. *Consumer decision-making in a multi-generational choice set context.* Journal of Business Research, 53(3), pp.123-136.

Lee, J. et al., 2006. *Forecasting future demand for large-screen television sets using conjoint analysis with diffusion model.* Technological Forecasting and Social Change, 73(4), pp.362-376.

Mahajan, V., Muller, E. & Bass, F.M., 1990. *New Product Diffusion Models in Marketing: A Review and Directions for Research.* Journal of Marketing, 54(1), pp.1-26.

Meade, N. & Islam, T., 2006. *Modelling and forecasting the diffusion of innovation - A 25-year review.* International Journal of Forecasting, 22(3), pp.519-545.

Morgan, L. R. & Birtwistle, G., 2009. *An investigation of young fashion consumers' disposal habits.* International Journal of Consumer Studies, 33 (2), pp. 190-198.

NN - Narodne novine Republike Hrvatske, 2007. *Pravilnik o gospodarenju otpadnim električnim i elektroničkim uređajima i opremom* (NN 74/07, 133/08, 31/09).

Norton, J.A. & Bass, F.M., 1987. *A Diffusion Theory Model of Adoption and Substitution for Successive Generations of High-Technology Products.* Management Science, 33(9), pp.1069-1086.

Oguchi, M. et al., 2008. *Product flow analysis of various consumer durables in Japan.* Resources, Conservation & Recycling, 52(3), pp.463–480.

Osibanjo, O. & Nnorom, I.C., 2008. *Material flows of mobile phones and accessories in Nigeria: Environmental implications and sound end-of-life management options.* Environmental Impact Assessment Review, 28(2-3), pp.18–213.

Pickering, J.F., 1981. *A behavioral model of the demand for consumer durables.* Joranal of Economic Psychology, 1(1), pp.59–77.

Sherman, R. & Hoffer, G., 1971. *Does Automobile Style Change Payoff?* Applied Economics, 3(3), pp.153–65.

Simon, H. & Sebastian, K.H., 1987. *Diffusion and Advertising: The German Telephone Campaign.* Management Science, 33(4), pp.451-466.

Steffens, P.R., 2003. *A model of multiple-unit ownership as a diffusion process.* Technological Forecasting and Social Change, 70(9), pp.901–917.

Stern, P.C., 2000. *New Environmental Theories: Toward a Coherent Theory of Environmentally Significant Behavior.* Journal of Social Issues, 56(3), pp.407-424.

Van Nes, N. & Cramer, J., 2006. *Product lifetime optimization: a challenging strategy towards more sustainable consumption patterns.* Journal of Cleaner Production, 14(15-16), pp.1307-1318.

Widmer, R. et al., 2005. *Global perspectives on e-waste.* Environmental Impact Assessment Review, 25(5), pp.436–458.

Zoeteman, B.C.J., Krikke, H.R. & Venselaar, J., 2010. *Handling WEEE waste flows: on the effectiveness of producer responsibility in a globalizing world.* The International Journal of Advanced Manufacturing Technology, 47(5), pp.415–436.