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Abstract

The increasing attention towards the environmental impact of IT (Information Technology) demands reorientation from IT hardware and service organisations. Consumers are more than ever sensitive about the environmental impact of products and services they buy. Environmental attributes therefore play an important role in the buying process. While the concept of Green IT has been primarily researched from the corporate perspective, the consumer perspective has widely been neglected. The purpose of this paper is to evaluate the influence of Green IT attributes of PCs (Personal Computers) on the buying behaviour of consumers. As a contribution to the ongoing discussion of Green IT, we provide marketing data from 500 participants on the importance of Green IT using conjoint and cluster analysis. It is shown that the market share for Green IT PCs could be up to 26.6%. Especially female customers value environmentally friendly attributes. Thereafter, we draw recommendations for the marketing mix of IT hardware and service organisations. The results should provide researchers and practitioners with new insights and measures about the relevance and application of Green IT in the scope of PCs.

Keywords: Green IT, Conjoint analysis, Marketing research, Personal computer, Sustainability

1 INTRODUCTION

Due to the growing global impact of IT (Information Technology) on economy, ecology and the society, the management of IT hardware manufacturers and IT service organisations are increasingly challenged to take the concept of sustainability and Green IT into account for their products and services. A study from 2005 on the global power consumption of servers revealed that servers worldwide, including related cooling and auxiliary infrastructure, used 123,000 GWh (Giga Watt hours) of electricity, an amount comparable to the power consumption of a country such as Poland (Koomey 2007; Schmidt et al. 2009). IT accounts for two percent of the 820 million tons of CO2 emissions per year (Heng 2009). Waste of electronic products (e-waste), is increasing three to five percent each year, making it the fastest growing waste stream in the industrialized world (UNEP 2007). A minimum of five million tons per year of ICT (Information and Communication Technology) related waste is being produced, an amount comparable to the weight of almost 9,000 fully loaded Airbus A380 passenger planes containing dangerous metals, such as lead, mercury and cadmium. These environmental impacts of IT have been recently discussed under the headline of Green IT (Schmidt et al. 2009).

Scientific literature on Green IT primarily looks at the topic from a corporate perspective (Mines and Davis 2007; Velte et al. 2008; Molla 2008; Erek et al. 2009). To determine the general relevance of Green IT this one-sided standpoint is insufficient. It is necessary to ask if Green IT attributes actually influence the consumers' buying behaviour for a product or service. The hardware manufacturer Apple for example follows a Green IT product strategy for its notebooks with its MacBook Pro (Apple Inc. 2009).

From this derives the question if Green IT attributes are potentially able to influence the consumers' behaviour when buying a PC. Marketing research on green purchasing behaviour for other product types indicate that consumers appraise environmentally friendly product attributes and that women value them higher than men (Chitra 2007; Lee 2009).

In the setting of this study we presented twelve different product concepts of PCs to 500 participants asking them order them according to their own preferences. Using conjoint analysis we were then able to calculate partial utility estimates for each of the Green IT attributes. Through cluster analysis implications for the marketing mix of IT hardware and service organisations were derived. Through this research these organisations are able to efficiently address the environmental demands of their customers in the scope of PCs.

2 THEORETICAL BACKGROUND AND RESEARCH QUESTIONS

The term Green IT comprises a very large domain of many different measures and perspectives, making its underlying concept diffuse and ambiguous. In practice, no common definition has been found for Green IT, thus, hampering a clear view on the topic. One widespread definition is provided by the Green IT Observatory from the RMIT University (Royal Melbourne Institute of Technology University), which has defined Green IT as following:

"Green IT addresses a broad range of business sustainability and corporate social responsibility concerns. This includes the efficient design of data centres and IT architecture to reduce both energy consumption and cost, as well as IT's adoption of environmentally friendly technologies and environmentally preferable IT management practices" (RMIT University 2009).

This broad definition from a business perspective refers to the general strategic, organisational and technical aspects of Green IT. For this research a more technical and consumer oriented definition is needed, from which Green IT attributes for PCs can be derived. The definition followed in the paper is provided by Elliot and Binney (2008), who refer to Green IT as "the design, production, operation and

disposal of ICT and ICT-enabled products and services in a manner that is not harmful and may be positively beneficial to the environment during the course of its whole-of-life". PCs arc among ICT. From the customers' perspective the energy consumption during operation and the disposal of a PC at the end of its lifecycle can be considered as Green IT attributes.

Initial studies in Germany have demonstrated that Green IT attributes operationalised through energy consumption and disposal specifications potentially have an influence on the buying behaviour of ICT, such as notebooks, mobile phones, and PCs (BITKOM 2009). For the specific case of PCs this leads to the first question to be answered in this research.

Question 1: What impact do Green IT attributes of a PC have on the consumers' buying behaviour?

From the operationalisation of Green IT attributes into energy consumption and disposal specifications two subordinated questions are derived.

Question 2: What impact do energy attributes of a PC have on the consumers' buying behaviour?

Question 3: What impact do disposal attributes of a PC have on consumers' buying behaviour?

Consequentially the question arises how big the potential market share for PCs with Green IT attributes could be. Hints are provided from the consumer group called "LOHAS". "LOHAS" stands for Lifestyle of Health and Sustainability and describes a "movement with strong influence on consumption and values" (Ray and Anderson 2000; Wenzel et al. 2007) within the society. This lifestyle does not portray an exclusive target group but a "new social majority" (Wenzel et al. 2007). This trend can be observed in the food industry with the increasing prominence of organic food. It is likely to disseminate into other types of industries (Ray and Anderson 2000).

The expanding share of the LOHAS on the German market was estimated to be one-third in 2007 (Wenzel et al. 2007). Applying these findings on the market for PCs leads to the expectation that one-third of PC consumers would potentially prefer a PC with Green IT attributes compared to an ordinary PC. Therefore the fourth question to be answered is:

Question 4: How big would be the potential market for a PC with Green IT attributes?

After estimating the potential market size the possible measures to market a Green IT PC need to be developed.

Question 5: Which measures should be applied to successfully market a Green IT PC?

The measures for marketing planning will be structured according to the different dimensions of the marketing mix. In this four-element framework marketing has to take decisions for the product, the price, the promotion and the place (McCarthy 1960). The theoretical concept of marketing mix is widely accepted by researchers and practitioners (Constantinides 2006). Regarding the product decisions have to be made about the product program as well as the development and improvement of existing products. The price for a product or service has to be set regarding the target group and the given market situation. Promotion covers all aspects of communication, which aim to influence the knowledge, attitude and behaviour of market participants. The place is related to all decisions dealing with the way of the product to the end consumer (McCarthy 1960).

3 METHODOLOGY

The conjoint analysis is used for the development of new products and services. It is a statistical technique used in marketing research to determine how people valuate different attributes that make up an individual product or service. With the traditional conjoint analysis market shares with a deviation of 5.1% can be predicted (Heidbrink 2006). It belongs to the category of multivariate statistics of interdependence analysis. The conjoint analysis is a widely used and scientifically approved approach in marketing research (Luce and Tukey 1964; Wittink et al. 1994; Dellaert et al. 1996; Hair et al. 2008). It enables to test different product concepts for a market by a simulation

(Wyner 1992). Thereby the respondents have the task to bring a representative sample of product concepts into an order according to their own preferences. On the basis of the overall assessment comparative importance and utility estimates of attribute specifications can be calculated. Compared to the self-explicated approach the conjoint analysis tends to deliver more precisely results regarding the consumers' buying behaviour (Agarwal and Green 1991; Backhaus et al. 2006; Hair et al. 2008). For the data collection an online survey is recommended. This allows a fast and economic investigation of a bigger sample size.

For the survey an online questionnaire with twelve different product concepts of PCs was developed. Three of these product concepts served as test cases to determine the validity of the results. To achieve feasibility for the conjoint analysis the attributes of a product concept for a PC were limited to four, which were price, performance, energy and disposal. Pre-tests had indicated that consumers perceive price and performance as the two most important attributes of a PC. The attributes of energy efficiency and disposal were derived from the Green IT definition of Elliot and Binney (2008) and proved to be relevant to consumers in the pre-test. For each of these four attributes three different attribute specifications were described. These specifications were set accordingly to characteristic specifications of real PC offers. Attributes used in a conjoint analysis are regarded as being discrete (Albers 1984). Therefore the assumption was made that all attribute specifications for price, performance, energy and disposal are discrete.

The survey was advertised by pop-up ads on approximately 30,000 German speaking web pages. From 16/May/2009 until 11/July/2009 the survey was completed by 556 participants. Because of obviously false and non-coherent data the sample was revised leading to 500 analyzable data sets. Besides the preferences regarding certain product concepts of PCs also questions of socio-demographic characteristics and general data concerning the utilization of PCs were asked. The collected sample consists to 80.2% of male and 19.8% of female participants. The average age is 26.6 years.

4 FINDINGS

The compilation of the preference order illustrates the PCs which were the first choice for the respondents (Table 1). It has to be mentioned that the attribute of performance does not strictly refer to a real processors but to a processor with multiple cores.

Rank	Specifications	First choice of the respondents
1.	Performance: 4 processors with 3 GHz Price: 400 Euro Energy: Energy consumption of 100 watt Disposal: No information about recycling	n = 228 45.6%
2.	Performance: 4 processors with 3 GHz Price: 400 Euro Energy: Energy consumption of 175 watt Disposal: PC can completely be recycled	n = 125 25.0%
3.	Performance: 2 processors with 3 GHz Price: 500 Euro Energy: Energy consumption of 100 watt Disposal: PC can completely be recycled	n = 50 10.0%
…		
12.	Performance: 1 processors with 3 GHz Price: 500 Euro Energy: Energy consumption of 175 watt Disposal: No information about recycling	n = 3 0.6%
		Total: n = 500

Table 1: Preference order of the first choice PC concepts for the respondents

The conjoint analysis was applied on the collected preference orders from the respondents to evaluate the values for the partial utility estimates for each of the attribute specifications (Table 2). The partial utility estimates are absolute values. A positive value indicates a utility increase. A negative value stands for a utility decrease by the attribute specification. Under the assumption of an additive model the partial utility estimates for the attribute specification and the general utility, which in this case is 5.000 for all respondents, added up to the total utility of a PC concept. The highest utility increase is achieved by the processor with the highest performance. This specification takes the first rank. The second highest utility increase is achieved by the ability to recycle the PC entirely.

To evaluate the quality of the conjoint analysis the correlations between observed and estimated preferences are calculated. The correlations after Pearson as well as the rank correlation Kendall's tau have a value of 1.000 with a significance of 0.000. The Kendall's tau for the three test cases (concept to verify the results validity) results in a value of 1.000 with a significance of 0.059. This indicates that the results of the conjoint analysis condense the collected data in a very good way.

Attribute	Attribute specifications	Utility Estimate	Rank
+ Performance	1 processor with 3 GHz	-1.414	12.
	2 processors with 3 GHz	-.004	7.
	4 processors with 3 GHz	1.418	1.
+ Price	400 Euro	.587	4.
	500 Euro	.005	6.
	600 Euro	-.592	9.
+ Energy	Energy consumption of 100 watt	.614	3.
	Energy consumption of 175 watt	.023	5.
	Energy consumption of 250 watt	-.637	11.
+ Disposal	PC cannot be recycled	-.619	10.
	No information about recycling	-.098	8.
	PC can completely be recycled	.717	2.
= Total utility			

Table 2: Partial utility estimates for each of the PC specifications from the consumers' perspective

Backhaus et al. (2006) recommend classifying the results of a conjoint analysis. It can be assumed that the answers are seldom homogenous. To classify the data we executed a cluster analysis following the Ward method. To determine the distance the squared Euclidean distance was used (Backhaus et al. 2006; Hair et al. 2008).

For a cluster analysis the optimal quantity of clusters has to be assigned. The computation should be based on statistical criteria and not on a plain logical interrelation like the division into LOHAS and Non-LOHAS (Backhaus et al. 2006). Therefore the sum of squared errors of the distances of the respondents between themselves was calculated. The so-called "elbow method" is used to calculate the optimal quantity of clusters, which in this case leads to four clusters.

With a given quantity of clusters the analysis shows that for each cluster one of the attributes is especially important. Because of this the clusters are labeled as performance, price, energy and disposal oriented (Figure 1). The performance oriented respondents captured the largest fraction with 45.6%, followed by the price oriented respondents with 27.8%. For up to 26.6% of the participants, one of the Green IT characteristics is an important issue while purchasing a PC. From these 62% are disposal oriented while 38% are more energy oriented. It is surprising that more consumers look as disposal than at energy since energy contributes to life cycle costs which disposal generally doesn't. An explanation could be that consumers relate issues of disposal and waste management stronger to environmental protection than electrical energy consumption, which only accounts for indirect CO2 emissions. Also, the recent public attention towards IT hardware manufactures regarding hazardous substances, take back policies and general environmental behavior might provide an explanation for the results (Greenpeace International 2009; van Huikstee and de Haan 2009).

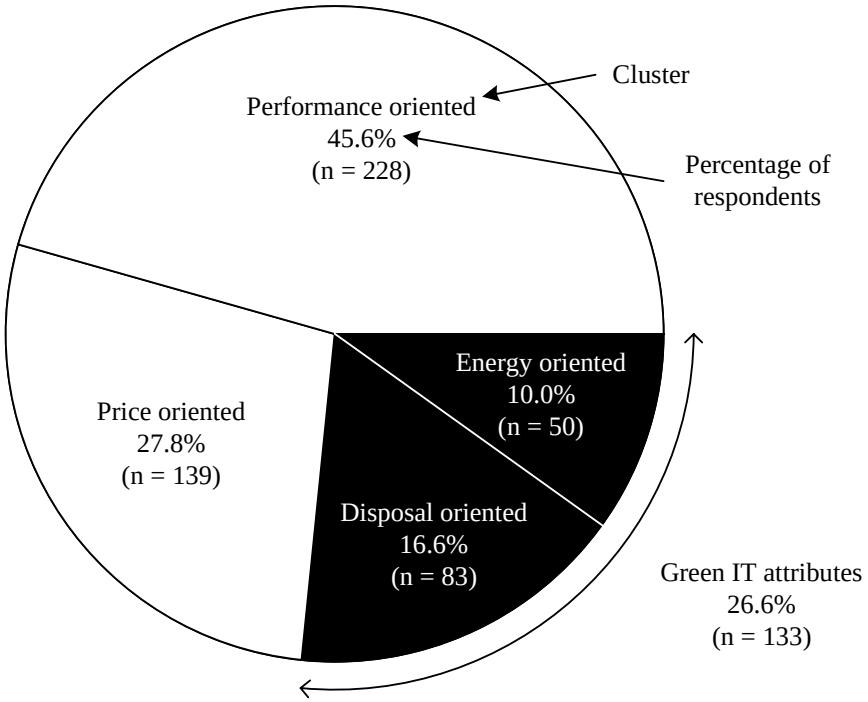

Figure 1: Clusters of respondents according to their preferred attribute

To quantify the importance of the attributes the relative importance is calculated. For that purpose, like in Table 3, the spread of the partial utility estimates of an attribute is set in relation to the sum of all spreads. The higher the importance of an attribute the larger is the impact on the potential purchase decision of a consumer. The sum of all relative importance adds up to 100%. The importance of the energy consumption results in 19.2%. The disposal attributes are with 21.2% close behind the price with 21.6%. The performance attributes have the highest importance with 37.9%. Summarizing, the cumulated importance of the Green IT attributes amounts to 40.4%, which is below the expected average value of 50% for two out of four attributes. Therefore it can be noted that Green IT attributes posses a below average importance for the consumers.

Cluster		Total	Performance oriented	Price oriented	Energy oriented	Disposal oriented
Attribute	Amount	n = 500 100%	n = 228 45.6%	n = 139 27.8%	n = 50 10.0%	n = 83 16.6%
Performance	Importance	37.9%	59.6%	22.2%	20.2%	15.4%
	SD	22.8	12.1	9.9	10.3	9.7
Price	Importance	21.6%	13.8%	42.2%	14.5%	12.8%
	SD	17.0	8.0	17.1	7.4	7.4
Energy	Importance	19.2%	14.4%	17.2%	49.5%	17.3%
	SD	14.1	9.0	10.2	11.9	10.0
Disposal	Importance	21.2%	12.1%	18.4%	15.7%	54.5%
	SD	18.1	9.2	10.9	7.0	11.8

Table 3: Relative importance of PC attributes for the clusters

In the next step it is clarified how the groups, which were determined by the cluster analysis distinguish themselves by further characteristics. Therefore a discriminant analysis with the cluster affiliation and nine variables which were surveyed in the questionnaire was conducted. Table 4 shows the five variables with the highest discriminatory relevance for the clusters. The discriminatory

relevance ranges from 0 to 1. The higher this values the better the characteristic separates the cluster. The intensity how often others, such as family, friends or acquaintances are advised before they purchase a new PC separates the clusters in the best way. This question was answered on a scale ranging from 1 for “very seldom” to 5 for “very often”. Especially the performance oriented advice others above average. A striking fact is that the share of women within the disposal oriented cluster is significantly higher compared to the other clusters. The energy oriented people possess a higher level of education and are slightly older than the average. Overall Green IT attributes are being preferred by older respondents. However this interrelation is with 0.156 not significant and can be randomly originated.

Characteristics / Cluster	Advise others (scale: 1 to 5)	Gender female / male	Education (ratio of graduates)	Average age (in years)	New PC within the next Year
Total	3.2	19.8% / 80.2%	15.2%	26.6	32.2%
Performance oriented	3.5	15.8% / 84.2%	14.9%	25.7	36.1%
Price oriented	2.8	18.0% / 82.0%	10.8%	26.6	31.4%
Energy oriented	3.1	20.0% / 80.0%	30.0%	29.3	28.0%
Disposal oriented	2.9	33.7% / 66.3%	14.5%	27.2	25.4%
Discriminatory relevance	.537	.296	.286	.233	.233
Significance for Tests of Equality of Group Means	.000	.005	.046	.156	.000

Table 4: Characteristics of the clusters

For the sales of PCs the likelihood of a purchase by the respondents within the next twelve months is crucial. Here the Green IT attributes perform below average. Therefore it can be concluded that the market is driven by the performance and price oriented consumers.

The results show that the ability to recycle a PC entirely as well as low energy consumption create a high positive utility for the respondents. For 16.6% of the respondents the disposal of a PC is the most important decision criteria. For 10% of the respondents the energy consumption is pivotal for the selection of a PC. Therefore it can be concluded that Green IT has a positive impact on the customers’ buying behavior. However the importance for the purchase decision just amounts to 40.4% and can thereby be denoted as below average.

As indicated in section 2 the potential market for Green IT PCs was assumed to be comparable to the portion of LOHAS in Germany. By summing up the energy and disposal oriented consumers an estimated market share of 26.6% can be supposed. This value is slightly beneath the amount of the LOHAS. Therefore it can be concluded that the trend towards environmentally oriented products has not yet fully reached the market for IT hardware as it has, for example in the case of the food industry.

The results provide a better understanding about the potential consumers of PCs and offer the opportunity to develop concrete measures to market Green IT PCs.

5 IMPLICATIONS

From these results implications for the marketing mix of IT hardware manufacturers and IT service organisations can be derived. The following measures to market a Green IT PC are structured accordingly to the four instruments of marketing mix, which are product, price, place and promotion (McCarthy 1960).

Product: The results proof that Green IT attributes have a positive influence on consumer choices. Low energy consumption and a disposal concept, which includes recycling, are important arguments for the consumers. The focus of PC developments and improvements should be put on the disposal attribute, which is of higher importance (62%) in comparison to the energy attribute (38%). The

extension of the product line with a limited number of Green IT PCs is recommended to satisfy the demands of the energy and disposal oriented consumers.

Price: Especially for Green IT PCs the price can be seen as a quality indicator. The study revealed a willingness to pay higher prices for PCs with Green IT attributes. The price should be set for the target group of graduates and older persons, who tend to have an above average income and are less price oriented. From this derives the recommendation to place a PC with Green IT attributes in the upper price segment. This also provides the ability to cover the extra costs from necessary developments and recycling.

Promotion: The promotion should use communication channels and advertisements to reach graduates and older consumers. Special attention needs to be paid to female consumers, since they tend to be more interested in Green IT than men. From the fact that Green IT oriented consumers are advising others below the average it can be concluded that this group demands extra arguments for their purchase. Therefore it is recommended to clearly outline the environmental attributes of the PC in commercials and product descriptions.

Place: The distribution of Green IT PCs should differ from the distribution of an ordinary PCs. Since the consumers value environmental aspects, this should be considered for the supply chain, the wrapping of the product and the salesroom. Personal support and sound additional information is needed to fully explain the complexity and the background of the Green IT PC.

With these measures a market segment of up to 26.6% for Green IT PCs could be served. This offers the opportunity to attract new customers and gain extra revenues.

These results also lead to implications for IT service organisations within companies, which are providing PCs for the office environment and are paying attention to customer orientation. It can be assumed that employees value Green IT PCs the same as ordinary end consumers. The consideration of these demands potentially increases the satisfaction of the business with its IT service organisation. Therefore IT service organisations should include Green IT PCs in their service portfolio and communicate the benefits from this to the general management as well as to an environmental or sustainability responsible.

6 CONCLUSION AND FUTURE RESEARCH

In this paper we have shown the relevance of Green IT attributes on consumers' buying behaviour of PCs. The conjoint analysis with 500 participants outlined that Green IT attributes concretised by energy and disposal attributes play a role when buying a PC. Still, performance remains the dominant criteria when buying a PC. It was revealed that the market share for Green IT PCs could be up to 26.6%. Especially female customers value environmentally friendly attributes.

Due to the chosen method of data collection the illustrated results are limited to German speaking online users. The self-selection of the participants was unavoidable. Therefore it could be that people, who are more interested in PCs than the average, participated in the survey with a higher probability. The conclusions drawn from this study are limited to the attributes and specifications used in the survey. Other attributes of PCs such as computer brand, which could have played an important role, were not further investigated due to the feasibility limitations of conjoint analysis.

The derived implications offer IT hardware manufacturers and CIOs the possibility to market Green IT in a way, so they can generate extra profits and increase corporate reputation. Given the rising prices for energy and increasing attention for environmental issues the relevance of Green IT for PCs is destined to gain even more importance in the future.

In the future research will have to further validate the achieved results by conducting comparable studies. It can be expected that the attitude towards Green IT on the German market deviates from other regions. Since most IT hardware manufacturers are distributing their products globally it is

necessary to also collect data from other markets. Future studies should also investigate whether a PC that is manufactured in a way that reduces the environmental impact also influences the decision to purchase a PC. Furthermore the question arises to what extent the results are transferable to internal markets in corporations. For this a survey with employees, who receive their PCs from an internal IT service organisation is scheduled. Finally the impact of Green IT attributes on IT services needs to be investigated further.

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