A Study Of A Sustainable Environmental Management Towards Manufacturers' E-Waste Disposal: A Pls-Sem Approach

การศึกษาการจัดการสิ่งแวดล้อมเพื่อความยั่งยืนของการกำจัดขยะอิเล็กทรอนิกส์ของผู้ผลิต: ด้วยวิธีศึกษาตัวแบบสมการโครงสร้างกำลังสองน้อยที่สุดบางส่วน

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Abstract

This research is to present a structural equation model of variables affecting e-waste management intention for a sustainable environment. Electronic waste or e-waste is classified as hazardous waste and different from common waste. There are various and complex parts which cannot be decomposed naturally. Most of the e-waste contains heavy metals and dangerous chemical substances such as lead, mercury, and cadmium. An improper disposal may lead to the leakage of hazardous substances into the environment and human. It requires a complicated procedure and advanced technology for e-waste management which importantly depends on manufacturer's responsibility for a better environment. Quantitative data surveyed from a sample of 270 Thai managers working in electronics, electrical products and appliance manufacturers. Partial Least Square (SmartPLS) software was conducted to analyse Structural Equation Model (SEM). Subjective norms and attitude are the highest two impact factors respectively towards the intention of the manufacturers to manage e-waste issues sustainably.

Keywords: E-waste Management Intention, Subjective Norms, Awareness, Attitude, Knowledge, Perceived Behavioural Control, SEM

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Introduction

The growth of technology in today's digital age and the fast development of innovative devices has become a big factor in the rapid increase in electronic waste at presence. Besides large household appliances, products from the communication and entertainment industry such as computer, mobile phones, televisions, CD/DVD players, game consoles, digital camera, and etc. have tremendously increased. The global presence is likely to reach 40 million tons per year (Awasthi et al, 2016). Eventhough technology and sustainability seems to mesh well together and digital devices such as smartphones, tablet or digital files or streaming services that could reduce a large number of physical recordings, one big issue left behind these technologies have brought is the potentially dangerous dawn of e-waste towards the environment (Heacock, 2016).

Waste Electrical and Electronic Equipment (WEEE) or shortly known as Electronic waste (E-waste) is the waste from obsolete electrical and electronic products that are discarded, expired, or out-dated. These wastes are classified as hazardous waste and different from common waste. There are various and complex parts which cannot be decomposed naturally. Most of the e-waste contains heavy metals and dangerous chemical, for example, lead, mercury, cadmium, beryllium, brominated flame retardants, and etc. An improper disposal may lead to the leakage of hazardous substances into the environment and people (Son et al, 2016). This risk causes significant health issues both short and long terming and special care must be taken to avoid unsafe exposure in disposal operations and leaking of hazardous materials. Therefore, it is one of the major environmental issues that have seriously impacted on the environment and human health (Lindqvist, 2000). Many countries have given importance to the awareness and study of the e-waste effects, such as the European Union, the United States, Japan, South Korea, India and China have set policies and regulations to force manufacturers or e-waste producer to take responsibility for the environmental impact of their products over the lifetime of their products covering from how the materials are selected, production process, usage and disposal when the end of product life cycle is met based on the manufacturer's responsibility (Breivik et al, 2014). Also, the manufacturers would be the persons who know best about their e-waste management even they can manage by themselves or let the third party involves. (Van Rossem et al, 2006a).

Due to the e-waste disposal cannot be done by general waste disposal process, it requires more complicated knowledge and not every country, especially developing ones does not have a system to handle the process properly. The numbers European Unions and the United States are the largest producers at 8-10 million tons a year. However, in the near future, developing countries will cause the problems not different from the developed ones, especially electronic product. The researcher also predicted that by the end of 2018, developing countries will have abandoned more e-waste especially computers than the developed countries for the first time, and in the year 2030, the amount of left computer in developing countries will be doubling (400 million, compared to 200 million in developed countries) (Yu et al. 2010).

The problem of e-waste today in developing is intensified and increasing every year. The process of e-waste management throughout the life cycle of electrical and electronic products, collection, sorting, transport, recycling, treatment and disposal require high intention and appropriate treatment. These responsibilities should be taken care from the producers with enforcement and support from the government and even consumers. The environmental awareness and intention to manage the problem are highly requires from the manufacturers to environmentally friendly produce products or devices by decreasing the use of hazardous substances and designing easily recycle products, and importantly including manage the cost to properly disposal the e-waste. These actions will support sustainable production and consumption in a long run.

Literature Review

According to the theory of planned behaviour, there are three key functions led to the behavioural intention Ajzen (1991). Subjective norms, when the producers are conscious they are pressured by consumers, governments, or communities surrounding them to perform a proper e-waste management. According to the famous theories related to attitude and behaviour, the theory of reasoned action and the theory of planned behaviour, both attitude and subjective norms are factors with high impacts towards any behavioural intention (Ajzen & Fishbein, 1985). Ajzen (1991) reviewed his own theory of planned behavior and stated that the intentions to perform any behaviour could be accurately predicted from attitudes, subjective norms, and also the new proposed factor, the perceived behavioral control. The perceived behaviour control, the conviction that the producers perceive they can successfully execute the behaviour required to manage the outcome. According to Terry and O'Leary (1995), there were two important factors that the notion of perceived behavioural control (PBC) which were

behaviour control and efficacy expectancies. Lastly, attitude is the ultimate root of any future intended action and behaviour. Ajzen and Fishbein proposed that attitudes are comprised of beliefs and evaluations regarding expected outcomes. Attitude also affects magnificently towards people's intention to behave both ethically or unethically, consciously or unconciuosly. (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980; Ajzen, 1988, 1991). Therefore, it is important to understand the people's attitude as it is the highest impact to determine and influence on any behaviour intention (Leonard & Cronan, 2005). Moreover, awareness and knowledge of the producers which can be supported by government or environmental experts are other suggested factors to create a positive attitude and intention to the proper e-waste management (Masud et al, 2013). Awareness from consumers and manufactorers will enhance a better environment situation while knowledge is also important and acts as a central element for healthy liveable environments (Leiserowitz, 2007; Patchen, 2006). The Figure 1 is a proposed research model of a structural equation model of variables affecting manufacturers' e-waste management intention for a sustainable as derived from a relevant literature review.

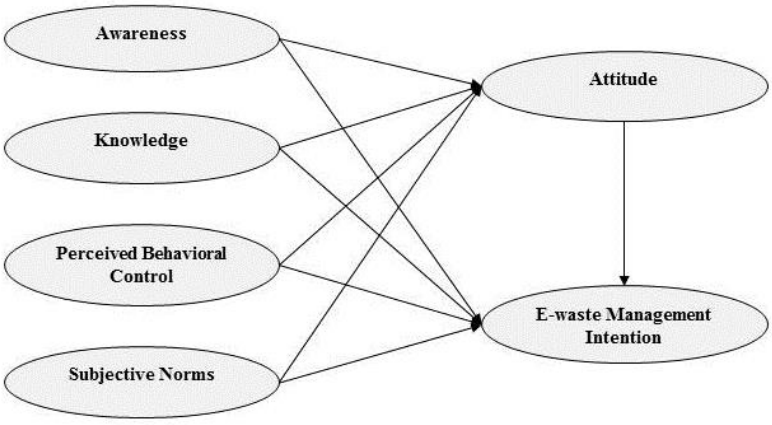


Figure 1: Conceptual Framework

Methodolody

Sample size suggestion usually depends on how the model is complicated, but typically ranges between 5 to 20 questionnaires per observed variable, with entire sample size should exceed 200 cases (Hair et al, 2006). Therefore, a ratio of 15:1 is acceptably reliable for a structural equation model analysis (Schumacker & Lomax, 2010). Thus, the study's sample size of 270 individuals for 18 observed variables (18 x 15 = 270) was highly reliable. The questionnaire was administered to 270 individuals in manufacturers of electrical, electronic

and consumer products in Thailand. The questionnaire was established from the theories and related reviewed literature as a tool to measure the proposed research model.

Measurement

Five experts in the involved industry were asked to check the questionnaire's reliability to ensure that the prospective questionnaire's responders can be collected with reliability and consistency according to the method of the Item-Objective Congruence (IOC), the screening of the survey questions. If the result of ∑x/n is above 0.5, it will be considered as valid. There were 27 questionnaires were responded as a trial prior to the actual survey to check as samples if the questionnaire has a tendency of reliability and consistency. The reliability value was calculated by using Cronbach's **α** (Cronbach, 1951) to ensure internal consistency within the items. According to Best and Kahn (2003), when calculating Cronbach's Alpha (**α**), if it ranges from 0 to 1 and a value of ≥ 0.70, it reflects good reliability of the questionnaire. According to the pre-test, Cronbach's Alpha (**α**) averaged 0.936, indicating reasonable reliability (Hair et al, 2006). All questionnaire items used a 7-point agreement scale response format (Likert, 1972), with 1 representing the manager strongly disagrees with the item's statement, while 7 representing the manager strongly agreed with the item's statement.

Analysis and Results

According to the analysis result of scale validity and reliability, scale investigation has been conducted using internal consistency measurement coefficient cronbach's alpha to calculate the average value of the correlation coefficient. It was found that alpha coefficients ranged from 0.752 to 0.954 and the total is 0.923. The corrected item to total correlation (CITC) was used in the data collected to purify items. The researcher suggested the items with a CITC score of higher than 0.5 are acceptable. Individual item reliability was examined by looking at the loadings, or correlations, of each indicator on its respective construct. For reflective indicators, it is generally accepted that items must have a factorial load (**λ**) of 0.707 or above (Table 1) (Hair et al, 2006).

Table 1: Convergent validity of the latent variables

Construct/Item	CITC	Cronbach's Alpha	Loading	t-stat
E-waste Management Intention (EMI)		**0.929**		
EMI1	0.858		0.843	47.997
EMI2	0.872		0.876	49.189
EMI3	0.832		0.860	46.872
Attitude (ATT)		**0.954**		
ATT1	0.905		0.842	36.310
ATT2	0.914		0.922	108.576
ATT3	0.892		0.887	68.401
Awareness (AWE)		**0.752**		
AWE1	0.596		0.935	70.872
AWE2	0.531		0.944	118.519
AWE3	0.617		0.929	81.618
Knowledge(KNO)		**0.904**		
KNO1	0.811		0.956	137.436
KNO2	0.848		0.963	207.971
KNO3	0.769		0.954	161.982
Perceived Behavioural Control (PBC)		**0.860**		
PBC1	0.667		0.846	44.827
PBC2	0.821		0.753	23.088
PBC3	0.724		0.849	38.937
Subjective Norms (SUN)		**0.824**		
SUN1	0.593		0.915	84.472
SUN2	0.738		0.942	148.042
SUN3	0.714		0.890	54.798
Total		**0.923**		

Table 2 and Figure 2 show factor analysis results affecting manufacturers' e-waste management intention with the Composite Reliability (CR) greater than 0.50 with the AVE values also greater than 0.50. Hooper et al. (2008) indicated that items with low multiple R2 values (≤ 0.20) should be removed from an analysis as this is an indication of very high levels of error. Hair et al. (2006), used higher criteria and suggested that the R2 values should be greater than 0.25, representing the reliability of the measurement (Lauro & Vinzi, 2004; Henseler et al, 2009) Reliable measurements can be found in the column of interest which is higher than the cross construct correlation values in the same column.

Table 2: Statistics showing the discriminant validity

Construct	CR	R^2	AVE	cross construct correlation					
				ATT	AWA	EMI	KNO	PBC	SUN
ATT	0.917	0.370	0.782	**0.884**					
AWA	0.955		0.876	0.493	**0.936**				
EMI	0.895	0.467	0.739	0.513	0.430	**0.860**			
KNO	0.971		0.917	0.443	0.498	0.176	**0.958**		
PBC	0.858		0.668	0.506	0.484	0.425	0.482	**0.817**	
SUN	0.940		0.839	0.432	0.480	0.583	0.364	0.490	**0.916**

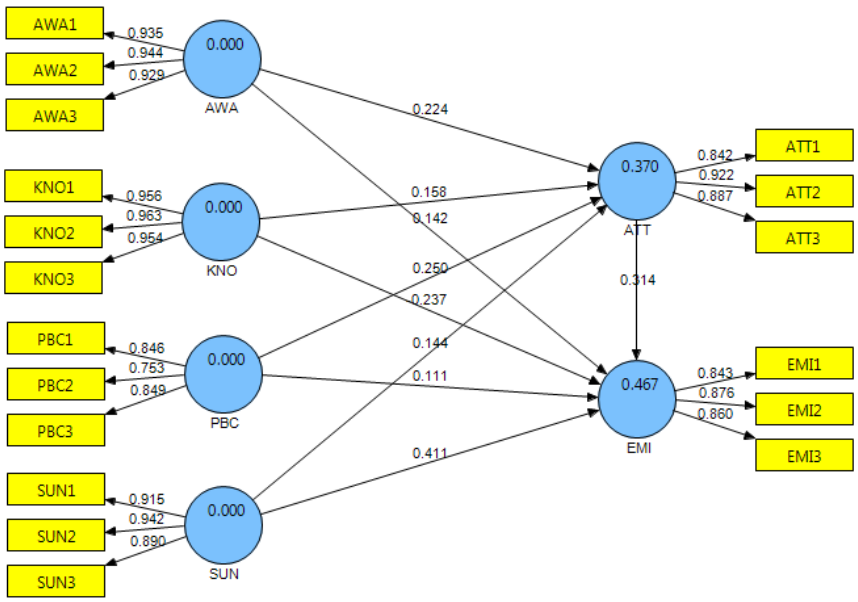


Figure 2: Test to Model Fit

All hypotheses had statistical significance which have high reliability (Table 4) by |t|≥1.96, means significance at p ≤0.05 (Lauro & Vinzi, 2004; Henseler et al, 2009).

Table 3: Results of hypotheses testing

Hypotheses	coef.	t-stat[1]	Results
H1 :Awareness directly influences Attitude	0.224	3.949	**Supported**
H2 :Awareness directly influences E-waste Management Intention	0.142	2.649	**Supported**
H3 :Knowledge directly influences Attitude	0.158	2.386	**Supported**
H4 :Knowledge directly influences E-waste Management Intention	0.237	4.654	**Supported**
H5 :Perceived Behavioural Control directly influences Attitude	0.250	4.012	**Supported**
H6: Perceived Behavioural Control directly influences E-waste Management	0.111	2.200	**Supported**
H7 :Subjective Norms directly influences Attitude	0.144	2.832	**Supported**
H8 :Subjective Norms directly influences E-waste Management Intention	0.411	8.805	**Supported**
H9 :Atittude directly influences E-waste Management Intention	0.314	6.185	**Supported**

[1] |t|≥1.96, means significance at *p* ≤0.05.

An Influence of each of the variables that affect manufacturers' e-waste management intention is shown in Table 3 below.**Table 4**: Direct (DE), indirect (IE), and total (TE) effects of the independent variables

Table 4: Direct (DE), indirect (IE), and total (TE) effects of the independent variables

Variable	R^2	Effect	Independent Variables				
			AWA	KNO	PBC	SUN	ATT
E-Waste Management Intention (EMI)	0.467	DE	0.142	0.237	0.111	0.411	0.314
		IE	0.071	0.087	0.078	0.045	N/A
		TE	0.213	0.324	0.189	0.456	0.314
Attitude (ATT)	0.370	DE	0.224	0.158	0.250	0.144	N/A
		IE	N/A	N/A	N/A	N/A	N/A
		TE	0.224	0.158	0.250	0.144	N/A

From Table 4, it was found that the variables that influence E-Waste Management Intention the most is subjective norms, however, in which the other three variables are influenced by attitude.

Discussion and Conclusion

It is an urgent need of a great responsibility from producers and manufacturers to enter the new age of e-waste management to support public health and the environment. From this research, it is shown that there are 5 factors would affect the producers in order to have an intention to properly manage electronic waste from their manufactures which are awareness, knowledge, subjective norms, perceived behavioural control and attitude. However, Subjective norms are the highest impact factor towards the producers' intention and attitude is the second highest one which also acts as a mediator of other exogenous variables indirectly affecting the producers' intention. Therefore, all exogenous variables should be encouraged by government policy and regulations to support and force all manufacturers to have a full-function of an appropriate e-waste management system. Meanwhile, the awareness can be raised from consumers who reflect the need of safe environment to the producers and establish the norms to pressure the manufacturers to create a win-win situation between their business and the environment. The clear policies from the government should be raised on who and how to manage the e-waste disposal. Otherwise, no one would voluntarily offer their responsibilities according to the high cost and complex process. The manufacturers need to understand the core problems and figure out the solutions to promote safe e-waste disposal of their products to gain trust and expectation from the consumers. Moreover, their products

should be designed to be environmentally friendly with the limited use of dangerous components and products that would harmfully affect the environment and people as the least as possible.

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