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Buying back household waste electrical and electronic equipment: Assessing Thailand's proposed policy in light of past disposal behavior and future preferences

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ABSTRACT

This article assesses the potential and the limitations of Thailand's proposed policy which would have local governments buy back targeted waste electronic and electrical equipment (WEEE) from households at designated locations. The proposal relies on the premise that a monetary incentive at the time of disposal is needed to gain participation from households which would otherwise sell to private waste dealers who purchase and then introduce WEEE into the pollution-causing informal recycling sector. To see whether the premise and the proposed policy were valid, a large-scale survey of 1529 households was conducted. This article reports these households' past behavior in, and future preferences for the disposal of 10 particular WEEE items: televisions, digital cameras, portable media players, desktop printers, mobile phones, personal computers, refrigerators, air conditioners, fluorescent lamps, and dry-cell batteries, which were prioritized under the Thai WEEE Strategy. We also tested the effects of population density, distance to the hypothetical drop-off location, car ownership, product weight and the financial incentive offered on the respondents' past decisions and future choices. The survey results show that creating a standardized program to buy back WEEE at designated drop-off locations has a potential of getting household WEEE introduced into the formal recycling sector. It could also help eliminate the psychological hurdle of parting with obsolete products and encourage their disposal. However, the program may not be enough to convince people to stop selling WEEE to waste dealers, especially if they had done so in the past. Based on the results, recommendations to improve the viability of the proposed policy and to direct and enhance future research are outlined.

1. Introduction

Households play a crucial role in the management of waste electrical and electronic equipment (WEEE) and the success of WEEE recycling programs depends on their participation. Getting WEEE to designated drop-off locations is a household's statutory duty in countries like Germany, Japan, South Korea, and Switzerland. In Japan, under the Specified Home Appliances Recycling Act, households have to buy recycling tickets for large homes appliances they want to dispose of. Most other systems, however, do not follow this pay-as-you-throw arrangement. Previous research indicates that households preferred a program without the obligation to pay a fee at the time of disposal. Nixon et al. (2009) found that a majority of Californians preferred to drop cathode ray tubes (CRTs) off at regional collection centers and have the recycling program funded by an environmental handling fee assessed on the retail sales. Most extended producer responsibility (EPR) programs follow this arrangement: manufacturers and retailers of electrical and electronic equipment are obligated to take back WEEE free of charge to encourage households to act responsibly in disposing of WEEE.

However, the free take-back service available in many developed countries is not a panacea. Household preferences are not formed in a vacuum and are framed in its immediate context. Prior to the enactment of the Electronic Waste Recycling Act in California in 2005 the disposal option that was widely available to households was a pay-as-you-throw arrangement. A free drop-off at a collection site was considered more financially attractive than the then existing option, which turned out to be the least preferred option in the survey; the study in California also reported that

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nearly all survey respondents had a car that would enable them to deliver waste CRT to regional collection centers (Nixon et al., 2009). While a free drop-off collection site worked well and encouraged the delivery of large appliances for disposal, previous studies in Europe show that the return of smaller items like mobile phones to regional drop-off locations was negligible (Manomaivibool and Tojo, 2010; Darby and Obara, 2005).

The prevailing conditions in developing countries underscore a need to rethink WEEE collection systems. The status quo option of recycling WEEE in developing markets is for households to sell their WEEE, as opposed to utilizing a public recycling program that is funded with local taxes or user charges. Some waste dealers who buy recyclables at people's doorsteps have been involved in WEEE disposal ever since WEEE's presence in the household waste stream became more prominent. WEEE recycling has had a significant community impact. Sae-tang et al. (2009) reported a transformation of farming villages in Kalasin Province, in northeast Thailand, into recycling communities where some 64 tons of WEEE are processed every month. Previous studies have shown that common, yet illegal recycling practices such as open-burning and acid bathing conducted by the informal sector have profound and negative impact on health and the environment because of the toxins these practices release (Gullet et al., 2007; Wong et al., 2007). Not being subject to governmental controls, health and safety standards, and the costs associated therewith, recyclers in the informal sector are able to pay a higher price for household WEEE than authorized facilities in the formal sector (Manomaivibool, 2009; Streicher-Porte and Yang, 2007). Thus, the informal sector can garner a larger share of the market and thereby magnify the overall negative impact it has on communities and the environment.Against this backdrop the Thai government, led by the Pollution Control Department (PCD), proposed the idea that local governments buy back WEEE from households. At the time this research was conducted, a law was drafted under the National Integrated Strategy for the Management of Waste Electrical and Electronic Equipment (henceforth the Thai WEEE Strategy) (PCD, 2007) to allow the government to levy fees on the sales of certain products, and to use the revenue to sponsor a buy-back program and to subsidize recycling. Fullerton and Wolverton (2005) explained that this arrangement is a variation of deposit-refund systems (DRS). It has two-parts, a front-end product fee, or a "deposit", and a back-end buy-back mechanism, or a "refund". The targeted products are: televisions, digital cameras, portable media players, desktop printers, mobile phones, personal computers, refrigerators, air conditioners, fluorescent lamps, and batteries. Manomaivibool and Vassanadumrongdee (2011) provides a detailed analysis of the entire proposal. This article only focuses on the back end of the two-part instrument, the buy-back mechanism.Buy-back is an interesting yet unproven mechanism in WEEE collection. It was first conceived in a study commissioned by PCD (2004) which observed that recycling in Thailand was not driven by a legal mandate or environmental awareness, but mainly by financial incentive. Previous studies in other developing countries however did not come to the same conclusion as to the extent to which households actively engage in selling WEEE. A survey in Beijing, China reported that more than 60% of its respondents had sold their old computers and large home appliances to "peddlers" for recycling (Liu et al., 2006). On the other hand, Kahhat and Williams (2010) found that less than 15% of their respondents in Lima, Peru sold used computers and other electronic devices; the majority kept them as spares or in storage. Moreover, even if the premise that households widely sell WEEE is true, combining a buy-back offer with drop-off collection is not necessarily a preferred arrangement. Wang et al. (2011) found that the acceptance of DRS as a future disposal option was unexpectedly low among their respondents in Beijing. In addition, other systems that employ a two-part instrument for the management of WEEE do not have a buy back mechanism as their back end. Instead of dealing directly with households the State recycling program in Taiwan, for example, uses the revenue from product fees to pay subsidies to local governments and authorized waste management companies.

The purpose of this article is to examine the potential and limitations of the proposed policy for the collection of household WEEE in Thailand. We used data from a large-scale household survey to explore:

- How Thai households dispose of different types of targeted WEEE items.
- Which future disposal option was preferred.
- The relationship between past behavior and future preferences.

Section 2 describes the purpose of the survey and includes its instrument, a sample, and the variables that are analyzed in this article. Section 3 presents and discusses key findings. The last section concludes the article with recommendations and suggestions for future research.

2. Methods and materials

The research presented in this article is based on data from a survey conducted between May 24, 2009 and June 25, 2009. The survey was part of a project to estimate the total cost of a buy-back program. The survey's main aim was to elicit how much households were willing to accept (WTA) in exchange for WEEE items, i.e. to approximate the material cost of the buy-back program. Table 1 shows the ten products covered in the survey, their weight, default buy-back rate and median reported selling price. The buy-back offer was a method of payment of the answers to the WTA questions in the survey (see Section 2.1). The rates were based on the price of recyclables in Thailand, the material cost of the recycling program in Taiwan (Hsu and Kuo, 2005), and the retail price. The median of reported selling prices from our survey was provided only for comparison. It should be noted that this was based on a small number of respondents who sold used products and answered the follow-up question on selling price ($n < 10$ for 11 subtypes). The median selling price of used mobile phones ($n = 5$), for example, more likely represented a resale value of second-hand products than a material value of broken handsets.

2.1. Survey instrument

We developed a questionnaire consisting of four parts. Part I measured the respondents' familiarity with the management of household hazardous waste (HHW). Some local governments in Thailand had campaigned to encourage people to separate HHW such as fluorescent lamps and dry-cell batteries, from general household refuse. The respondents were also asked whether they recalled such campaigns and whether they practiced source separation of HHW. Part II collected information about households' ownership of the products and how they were eventually disposed of. It used a set of six predetermined answers: store at home, throw away with general household waste, donate for reuse, trade in for a discount when buying new products, sell as recyclable to waste dealers, and others. Part III elicited information about households' future disposal preferences and contained questions about what they were willing to accept for items (WTA). Fig. 1 shows a set of the four future disposal options in the survey. The default buy-back rates (Table 1) were reduced by 40% and rounded off for the pick-up option with buy-back to reflect the cost of this enhanced service. The respondents were given the option of naming their price if they were not satisfied with the default offers. Questions related to the convenience of participating in WEEE recycling, such as the

Table 1
The list of products covered in this survey, their weight, default buy-back rate, and median of reported selling price. 1.00 THB was approximately 0.03 USD in June 2009.

Product type	Category	Weight (kg)	Default buy-back rate [a] (THB/unit)	Median of reported selling price of used equipment [b] (THB/unit)
1. Television	Home appliance			
1.1 Small CRT[c] (≤21 in.)		12.00	120.00	100.00
1.2 Large CRT[c] (≥25 in.)		30.00	150.00	100.00
1.3 Small FPD[c] (≤32 in.)		10.00	180.00	140.00
1.4 Large FPD[c] (≥33 in.)		35.00	230.00	140.00
2. Digital camera	ICT[c]	0.29	60.00	–
3. Portable media player	ICT[c]	0.06	20.00	50.00
4. Desktop Printer	ICT[c]	4.00	90.00	50.00
5. Mobile phone	ICT[c]	0.08	50.00	500.00
6. Personal computer	ICT[c]			
6.1 Desktop CRT[c]		16.70	180.00	200.00
6.2 Desktop FPD[c]		11.20	230.00	250.00
6.3 Notebook		2.30	150.00	200.00
7. Refrigerator	Home appliance			
7.1 Small refrigerator (≤6 ft^3)		33.00	240.00	200.00
7.1 Large refrigerator (>6 ft^3)		48.00	300.00	500.00
8. Air conditioner (AC)	Home appliance			
8.1 Small AC (≤12,000 BTU[c])		70.00	750.00	500.00
8.2 Large AC (>12,000 BTU[c])		74.00	900.00	500.00
9. Fluorescent lamp	Consumable	0.17	0.75	–
10. Dry-cell battery	Consumable	0.02	0.50	–

[a] In the survey, the amount of money a respondent would hypothetically get in exchange for his/her WEEE from the government's buy-back program. To test the effect of a starting bid, three levels of default bidding were prepared. Because the respondents' willingness to accept as such was not the interest of this article, only the default rates of the medium level are shown in this table.
[b] The median of the amount of money the respondents claimed to have received from waste dealers in exchange for their used equipment in the past.
[c] CRT, cathode ray tube; FPD, flat panel display; BTU, British thermal unit; ICT, equipment used in information and communication technology.

availability of a vehicle and the distance WEEE had to be transported for disposal were also included in this part. Part IV consisted of questions about demographics. The questionnaire ended with an open-ended question providing respondents with an opportunity to comment or provide suggestions about the proposed buy-back policy in Thailand.

The questionnaire was pre-tested with 150 subjects in the Greater Bangkok Area (GBA). The pre-test led to several revisions to the questionnaire and data collection protocol. The most profound change was the format of the future-preference questions in Part III. In the pre-test the respondents were asked whether they would accept each of the four future options individually beginning with the drop-off without buy-back as the first option to the pick-up with buy-back as the final option. In the actual survey they were asked to pick the most preferred of the four options. This change greatly reduced interviewing time and minimized the fatigue effect, although information about the willingness to accept each future option that would have been obtained in the original format was lost. Another notable change was the removal of fluorescent lamps and batteries from Part II. The pre-test showed that households had difficulty in recounting the number of lamps and batteries they had previously owned. In addition, the disposal options listed in Part II were too elaborative for fluorescent lamps and batteries which had no market value. Thus, we assumed that all households had disposed of lamps and batteries and their disposal behaviors were sufficiently encompassed in the questions on source separation of HHW in Part I. A translated copy of the questionnaire can be found as a supplement to this article.

2.2. Sample and data collection

The overall sample size was set at 1500 which is at the upper end of Mitchell and Carson's (1989) recommended range for a robust policy-driven valuation. Quotas were assigned to GBA and the other six regions proportionate to their share of WEEE generation. The WEEE shares, presented in Table 2, were estimated by PCD (2008) based on population and regional gross product. The subjects were randomly selected from urban areas in the most populous provinces within these regions.

The survey produced 1529 completed questionnaires. All respondents were interviewed face-to-face which allowed for the use of visual aids in presenting hypothetical scenarios when discussing future recycling options. Face-to-face administration of the survey also secured responses from a more varied cross-section of the population when compared to a self-administered mail survey that would require literate and self-motivated subjects. Nevertheless, the percentage of respondents in our sample who were educated was greater than the percentage of educated people in the general population as shown in the 2000 Census. Table 3 compares the demographics of our respondents and statistics regarding their ownership of durable products with the data from the 2000 Census and other recent National Statistical Office (NSO)'s surveys. Our

		Collection Mode	
		Drop-off	**Pick-up**
Buy-back offer or not?	**Without**	Drop-off without buy-back	Pick-up without buy-back
	With	Drop-off with buy-back	Pick-up with buy-back

Fig. 1. Future disposal options for waste electrical and electronic equipment (WEEE) in the survey. The drop-off option without buy-back is an example of the free take-back arrangements commonly found in developed countries. The drop-off option with buy-back is the arrangement contained the proposed policy in Thailand which would have local governments establish buy-back centers.

Table 2
Sampling sizes by region and the number of subjects from each province. The quotas were set proportionate to the share of waste electrical and electronic equipment (WEEE) generated in each region.

Region	WEEE share	Quota (set *n*)	Selected provinces (actual *n*)
Greater Bangkok Area	35%	520	Bangkok (311), Nonthaburi (71), Pathum Thani (59), Samut Prakan (80)
North-east	19%	285	Khon Kaen (99), Nakhon Ratchasima (100), Ubon Ratchathani (100)
South	13%	185	Songkhla (100), Surat Thani (91)
Central	10%	150	Ayutthaya (75), Nakhon Pathum (76)
East	10%	150	Chonburi (83), Rayong (70)
North	9%	140	Chiang Mai (73), Nakhon Sawan (70)
West	4%	70	Ratchaburi (71)

survey focused on highly urbanized areas where we would expect respondents to generally have higher incomes and a higher rate of equipment consumption. As such, the differences in monthly income and ownership rates were expected. Caution, however, is needed when generalizing from our findings to the Thai population because factors such as car ownership can affect households' WEEE disposal patterns (see Section 3.2).

2.3. Variables and data analysis

This article focuses on the data collected in Parts I–III of the questionnaire and the information in the responses to the open-ended question. The information about past behavior detailed in Section 3.1 was derived from Parts I and II. Statistics regarding disposal of fluorescent lamps and dry-cell batteries as HHW are presented separately from those of the other eight products because they have different disposal categories. The respondents' recollection of local HHW campaigns and its impact on the degree of HHW sorting is examined using Fisher's Exact Tests. Because of the limited number of responses per product type, the frequency and mode of past disposal behavior of the eight products are reported in the aggregate. Contingency tests were performed to see if people in Bangkok, which had the highest population density in the country of 3634 per km^2 (Bangkok Metropolitan Administration, 2011), had any distinctive disposal behaviors. Previous research has shown that inhabitants in a densely populated city faced disposal constraints and formed preferences that might justify alternative or complementary arrangements to a DRS-like program (Wang et al., 2011; Liu et al., 2006). The eight products were also divided into two general categories before applying contingency tests and analyzing the data: home appliances and equipment related to information and communication technology (ICT). Group percentages were compared and the p value results of statistical tests were reported to facilitate interpretation of those results.

In this article, we are only interested in the respondents' preferred future disposal option of each WEEE item, not the respondents' WTA. Section 3.2 first describes the distribution of the responses in the aggregate to identify the preferred mode of future disposal. The effect of the level of convenience in dropping off WEEE was then examined using contingency tests. The respondents were told that the drop-off location would be at the office of their local government. They were then asked to estimate the distance from their home to the office using a five-point scale: <0.5, 0.5–1, 2–5, 6–10, >10 km. The ownership of a car was also factored into the contingency tests. The impact of incentives and the level of convenience on the preferred mode of disposal were tested by examining the default buy-back rate for each product and its weight. Because the ranges of default buy-back rates and product weights in Table 1 were unwieldy, they were converted into a log scale before testing the significance of Pearson's Correlation Coefficient (*r*). Finally, Section 3.3 cross tabulates past disposal behaviors and future preferences to explore their relationship.

Section 3.4 reports the answers to the open-ended question: "Do you have any comments or suggestions to the government's project to develop a buy-back system for WEEE from households?" The comments and suggestions are grouped, counted, and discussed.

Table 3
Comparison of the demographics and product ownership statistics of the sample and the data from the National Statistical Office (NSO).

Characteristics	Categories	Sample	NSO's data
Gender	Female	62%	51%[a]
	Male	38%	49%[a]
Marital status	Single	32%	31%[a]
	Married	63%	69%[a]
	Widowed/divorced	5%	n/a
Age of family head	<20	1%	1%[a]
	20–29	25%	10%[a]
	30–39	26%	26%[a]
	40–49	27%	27%[a]
	50–59	15%	18%[a]
	≥60	7%	18%[a]
Household size	Average (person/household)	4.2	3.8[a]
	1	5%	9%[a]
	2	14%	17%[a]
	3	20%	24%[a]
	4	25%	28%[a]
	5	16%	16%[a]
	≥6	20%	6%[a]
Education	No education	2%	7%[a]
	Elementary	22%	57%[a]
	Secondary	39%	26%[a]
	Higher education	38%	10%[a]
Household monthly income	≤15,000 THB	35%	56%[b]
	15,001–30,000	32%	27%[b]
	30,001–50,000	20%	11%[b]
	50,001–100,000	9%	6%[b]
	≥100,001 THB	4%	2%[b]
Ownership of durables	Automobile	60%	24%[a]
	Television	99%	97%[c]
	Image recorder	51%	n/a
	Portable media player	35%	n/a
	Desktop printer	32%	n/a
	Mobile phone	96%	n/a
	Personal computer	62%	22%[c]
	Refrigerator	96%	88%[c]
	Air conditioner	55%	16%[c]

[a] The 2000 Population and Housing Census.
[b] The 2009 Household Socio-Economic Survey.
[c] The 2010 Household Energy Consumption Survey.

3. Results and discussion

3.1. Past disposal behavior

We found that source separation of fluorescent lamps and dry-cell batteries from general household waste was not a common practice in Thai households. Only 9% of the 1529 respondents reported that they separated both fluorescent lamps and dry-cell batteries from general household waste, 6% separated only

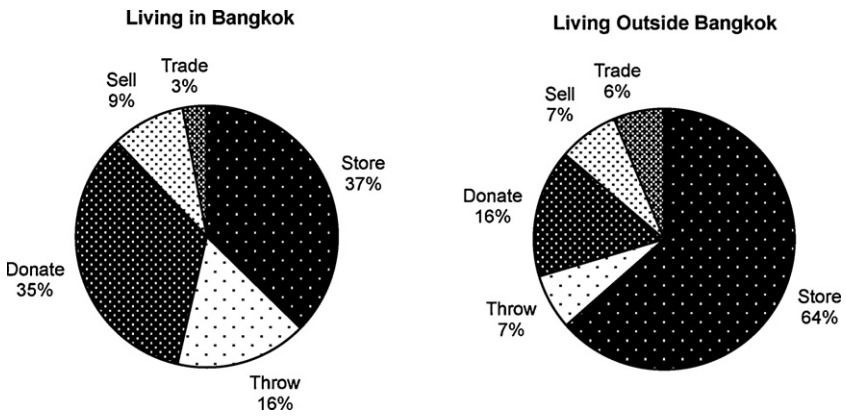

Fig. 2. Past disposal behavior in and outside Bangkok of all types of products, except fluorescent lamps and dry-cell batteries.

depleted batteries and 5% separated only waste lamps. We found that, although only 319 respondents could recall a local campaign promoting source separation of HHWs, such recollection improved the likelihood of sorting these items (18–13%, $p = 0.024$, for waste lamps; and, 19–14%, $p = 0.010$, for spent batteries, using Fisher's Exact Test).

The results show that Thais' experience, or lack thereof, with disposing of the other eight types of WEEE varies greatly. Nearly half of all respondents had never disposed of any of the eight products, while a little more than half had done so. In total, we obtained 2366 responses from 823 respondents about how they disposed of these products. Placing them in storage (52%) was the most popular option followed by donating them (23%) and throwing them away (11%). Only a few respondents received a financial return on WEEE as 8% reported selling them as a recyclable and 5% reported trading them in for a discount on new purchases. The "others" category includes WEEE items that were "lost" or subject to "inventive reuse" (e.g. using an old TV cabinet as a fish tank). The percentage in the "other" category was negligible, thus excluded from the subsequent contingency tests.

Fig. 2 compares the disposal behavior of those living inside with those living outside Bangkok. Our results support Liu et al.'s (2006) hypothesis that limited living space might discourage storing unused products (38–64%, $p < 0.000$ using Fisher's Exact Test). A similar result is seen for WEEE items that were traded in (3–6%, $p < 0.000$ using Fisher's Exact Test). A possible explanation is because households have to keep old products and wait for promotional trade-in campaigns. It is less likely that a household in Bangkok would do so because of the limited storage space. Based on our data, WEEE in Bangkok were more likely to be disposed of either by donating them (34–16%, $p < 0.000$ using Fisher's Exact Test) or by throwing them away with general household waste (16–7%, $p < 0.000$ using Fisher's Exact Test). The increase in selling WEEE, though observable in Bangkok, was not statistically significant (9–7%, $p = 0.168$ using Fisher's Exact Test).

Fig. 3 reflects the distribution of answers at a product level. As a group, the five types of ICT were more likely to be stored at home (61–41%, $p < 0.000$ using Fisher's Exact Test) or thrown away (13–8%, $p < 0.000$ using Fisher's Exact Test) than the other three home appliances. But, they were less likely to be donated for reuse (18–30%, $p < 0.000$ using Fisher's Exact Test), although previous research has shown that ICT, though obsolete, were less likely to be completely unusable or beyond repair than home appliances (Cooper, 2004). In this respect, the call for a more effective way to reuse obsolete but still functioning computers (Kahhat and Williams, 2010) should be extended to other types of ICT. We will show in Section 3.3 that the proposed policy in Thailand has the potential to draw WEEE out of storage. Because they contain smaller amount of recyclable materials per unit, ICT were less likely to be sold to waste dealers (3–15%, $p < 0.000$ using Fisher's Exact Test). There is no discernible difference between obsolete ICT and home appliances when it comes to trade-in (5–5%, $p = 0.773$ using Fisher's Exact Test).

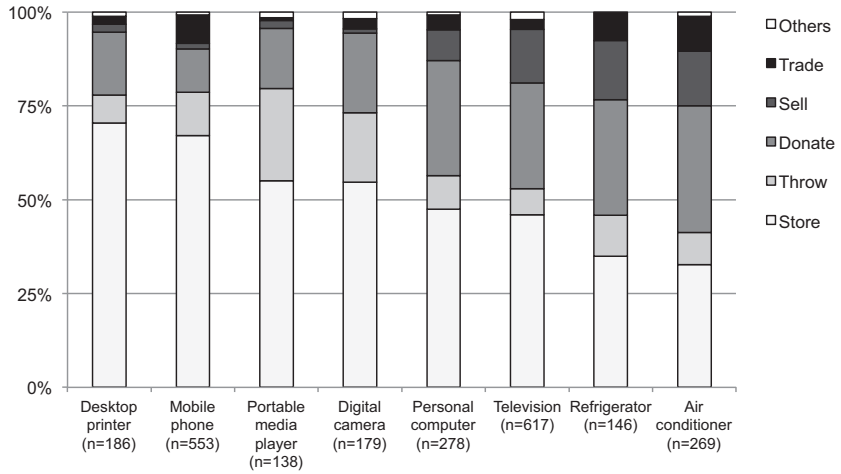

Fig. 3. Past disposal behavior by product types (%). The number in the parentheses after the product name is the number of respondents reporting their disposal for that type of equipment.

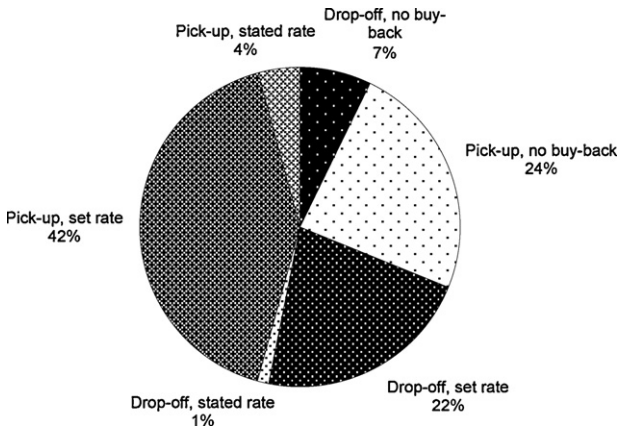

Fig. 4. Future disposal preferences for all product types. The answers that provided a buy-back rate higher than the set default rate are included in the options with stated rate.

3.2. Future disposal preferences

Fig. 4 shows the distribution of preferred future disposal options for all product types. As discuss above in Section 2.1, the question format was changed. That change arguably reduced the viability of the non-buy-back options being selected. In spite of this, the number of respondents indicating a willingness to participate in WEEE disposal even without that incentive was still significant at over 30% (24% pick-up without buy-back, 7% drop-off without buy-back). A total of 69% however would choose a more financially attractive option; 42% said they preferred to forgo part of the buy-back incentive in exchange for pick-up service; 22% would prefer to take WEEE to a drop-off location and receive full compensation; and the other 5% demanded a higher price than the default buy-back rate. Because identifying the preferred disposal option was the focus of this article, the responses that included the default buy-back amount or a stated buy-back amount are combined under the applicable collection mode in the following analysis.

We find that the drop-off options were more likely to be chosen by those living within 500 m of the hypothetical collection site (46–29%, $p < 0.000$, using Fisher's Exact Test) and among car owners (35–24%, $p < 0.000$, using Fisher's Exact Test). However, only 6% of the respondents lived within that proximity and 60% had a car. The overall effectiveness of the proposed system can be enhanced if in the future more than one drop-off point can be erected for one locality. In an experiment, the city of Malmö, Sweden introduced HHW and WEEE sorting facilities in residential areas to supplement the existing drop-off centers located on the outskirts of the city. A remarkable improvement in source separation occurred (Bernstad et al., 2011). If this requires too many resources from local governments in Thailand, other actors such as retailers and convenience stores can be encouraged or obliged to participate in WEEE collection. In Taiwan on top of the State recycling program, retailers of regulated electrical and electronic equipment have a statutory duty to accept WEEE of the same type that they sell and convenience stores are required to install facilities to collect spent batteries. Based on our survey, an additional 6% of the respondents live within 500 m of an electrical or electronic shop and another 63% live within 500 m of a convenience store.

Analyzing the relationships between incentives, product weight and the respondents' future disposal choices exemplify the power of money. As expected, the number of people choosing the options with buy-back increases as the log of buy-back rate increases ($r = 0.983$, $p = 0.000$). However, because of the intervening effect of incentives, the log of product weight does not significantly impact choosing the drop-off options ($r = -0.165$, $p = 0.526$). As reflected in Table 1, higher buy-back rates tended to be offered for heavier products. To help determine the interaction between weight and the size of buy-back offers, respondents were divided into two groups: those who preferred the options with buy-back and those who did not. Fig. 5 compares the drop-off options for each type of equipment for these two groups. The popularity of the drop-off option decreased sharply with an increase in the log weight among the non buy-back group ($r = -0.961$, $p = 0.000$). A similar inverse relation ($r = -0.654$, $p = 0.006$) is shown among the buy-back group only when controlled for the log of buy-back rate. The log weight and the popular of the drop-off options would be positively correlated if the effect of buy-back was not controlled ($r = 0.511$, $p = 0.036$).

Recent governmental initiatives in China support the notion that monetary incentives, if large enough, could overcome the barriers of WEEE collection in a developing country. On 2 July 2009, the Chinese Government issued the *Old-for-New Appliance Implementation Measures*, which gave a limited time discount of approximately RMB 250–400 (USD 36.5–58.4) on a new television, refrigerator, air conditioner, washing machine, or personal computer if the buyer were to trade-in an old product of the same type (Ying, 2011). Although this was only temporary intervention intended to boost the economy, its impact on WEEE collection cannot be ignored. In 18 months, the campaign resulted in almost 26 million units of used equipment being turned over to the state-funded recycling program (Ying, 2011). However, the plan was very expensive and would not have been possible without a huge subsidy from the government. The incentives inherent in Thailand proposed policy will be weaker than those offered by the Chinese government. Too high buy-back rates would drive up the fees on new sales and would jeopardize the political acceptability of the program. The next section will investigate which population group would nonetheless be most likely to participate in the future program. It will also discuss possible ways to improve collection performance in ways that do not require the program to pay more money when buying WEEE from households.

3.3. Past behavior and future preferences

This section explores the relationship between past disposal behavior and future preferences. First, we tested whether there were any significant differences in the preferred choice between the group that had disposal experience and the group that did not. For the eight durable products, we find a lower demand for buy-back in the group with disposal experience (65–72%, $p < 0.000$, using Fisher's Exact Test). No significant difference was found in terms of the preferred collection mode as both groups preferred the pick-up options (70–69%, $p = 0.843$, using Fisher's Exact Test). Experience might enhance the respondents' understanding of the difficulties of disposing of WEEE without a proper system. As such, the demand for buy-back in our survey might be inflated since 46% of the respondents had no disposal experience. We would not expect a similar artificial inflation when considering fluorescent lamps and dry-cell batteries because we reasonably assume a universal experience in disposing of them. More than half of the respondents turned down the buy-back offers for these HHW items. Table 4 further shows that sorting experience might discourage the respondents from considering taking breakable waste lamps to the drop-off locations.

Table 5 presents the results of the contingency tests for the preferred disposal options as affected by past behavior. Responses relevant to all products, except fluorescent lamps and dry-cell batteries which are addressed above, were considered. Overall, the Chi-Square test shows that future choices were contingent on and impacted by past decisions (Pearson's Chi-Square = 92.626, df = 12, $p < 0.000$). A more detailed analysis reflects similar choices by the group that stored and the group that traded in old products. Both

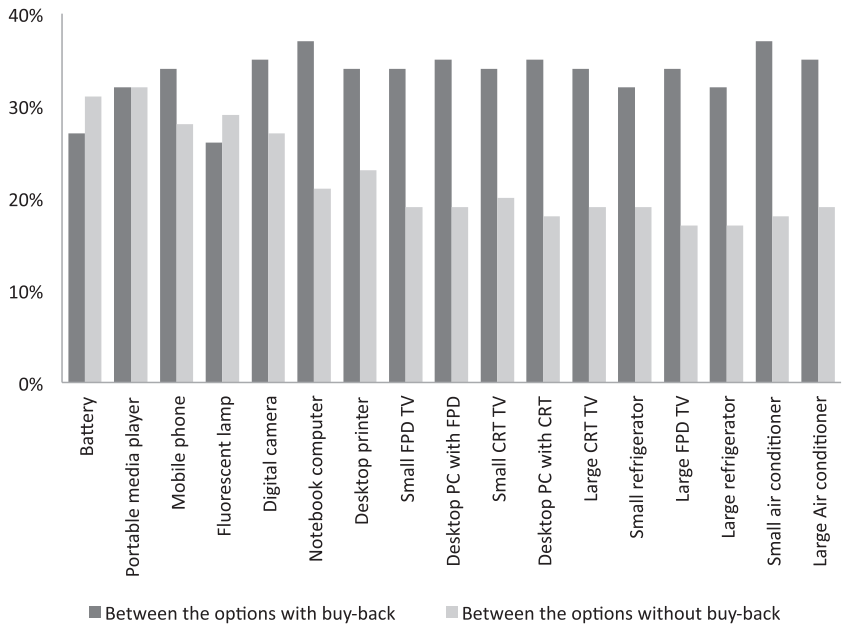

Fig. 5. Percentage of respondents choosing the drop-off options by product types with the presence of the buy-back offer and without. The products are listed according to their weight, lightest to heaviest, left to right.

Table 4
A cross tabulation between past disposal behavior and future preferences for disposing of fluorescent lamps and dry-cell batteries.

	Future preferences			
	Drop-off without buy-back	Pick-up without buy-back	Drop-off with buy-back	Pick-up with buy-back
Past behaviors				
Fluorescent lamp				
All	15%	37%	13%	35%
Sort	10%*	47%**	11%	32%
Not sort	16%*	36%**	13%	36%
Dry-cell battery				
All	16%	37%	13%	35%
Sort	15%	47%***	12%	26%**
Not sort	16%	35%***	13%	35%**

Note: Numbers might not add up to 100% due to rounding.
Fisher's Exact Tests are performed to examine whether the preferences of sorters and non-sorters differed for each of the future option:
* $p < 0.050$.
** $p < 0.010$.
*** $p < 0.001$.

Table 5
A cross tabulation between past disposal behavior and future preferences for durable WEEE items (Pearson's Chi-Square = 92.626, df = 12, $p < 0.000$).

	Future preferences			
	Drop-off without buy-back	Pick-up without buy-back	Drop-off with buy-back	Pick-up with buy-back
Past behavior				
Store	7%	26%***	26%***	41%
Trade in	6%	17%***	40%***	37%
Sell	3%*	20%***	21%	56%***
Donate	7%	39%***	18%***	36%***
Throw away	13%***	33%	16%***	38%
Overall	7%	29%	23%	41%

Note: Numbers might not add up to 100% due to rounding.
Fisher's Exact Tests are performed to examine the relationship of each pair:
* $p < 0.050$.
** $p < 0.010$.
*** $p < 0.001$.

were more willing to go to the drop-off location and receive a full refund but were less inclined to opt for the pick-up option without buy-back than the average. Former donors, on the other, were more likely to prefer the pick-up option without buy-back and less likely to choose the options with monetary incentives. More than half of the respondents who had sold WEEE for recycling in the past preferred the pick-up option with buy-back. For those who disposed of WEEE as general household waste, they demonstrated an unusual pattern. They were less likely to participate in a drop-off option with a buy-back than the others. On the other hand, they had the highest propensity to participate in a drop-off without a buy-back.

The survey data suggest that the proposed buy-back program has a potential to get WEEE consolidated into the formal recycling sector from households that want to recoup its perceived value. The drop-off option with buy-back would stand a better chance of collecting WEEE than the option without buy-back. In particular, those who sold their WEEE to waste dealers would not likely select the latter which is an example of the free take-back arrangements available in developed countries.

The proposed program to have local governments buy back WEEE at designated locations might be more successful in drawing WEEE out of storage than directly diverting WEEE from the informal sector. Despite the demand for future buy-back, the respondents who stored obsolete equipment did not materialize its perceived value by selling it to waste dealers. Comments to the open-ended question (Section 3.4) and previous research (Manomaivibool, 2005) indicate that the image of being unprincipled that is often ascribed to waste dealers might discourage people from dealing with them. The proposed buy-back program can help overcome this psychological barrier. This would be comparable to a trade-in that can encourage a replacement purchase by writing off the "mental book value" of an old product (Okada, 2001). It is, thus, no coincidence that two groups with different past behavior show a similar pattern of preferences in future disposal options. On the other hand, those who sold WEEE for recycling were either unaware or unconcerned with the ill reputation of waste dealers who offered them a financially attractive *and* convenient disposal option. As such, they continue to prefer that someone pay for and pick-up WEEE in the future. The local governments' buy-back program is

not likely to have a significant impact on the market of the informal sector unless the buy-back rates are set high enough to make waste dealers resell WEEE to the program.

For those who just need a proper and simple way to dispose of their WEEE a buy-back option is unnecessary and rather awkward when coupled with drop-off collection. This describes the groups that sort HHW and the two sub-groups at the bottom of Table 5. These respondents were not so concerned with making money on WEEE and possibly find the buy-back procedure to be overly complicated. Wang et al. (2011) cited this as a reason for the unpopularity of DRS as a future arrangement for WEEE in Beijing, China. Not only can this explain the unusual choice pattern of those who had thrown away WEEE, but it might also suggest that not everyone who preferred the drop-off option without buy-back would be willing to participate in a buy-back program. In order to encourage participation, we recommend that local governments schedule free pick-up for WEEE in conjunction with the buy-back program. With far more people donating or discarding WEEE than the rest of the country, the densely populated Bangkok would be an ideal place for a cost-effective implementation of this recommendation.

3.4. Qualitative comments and suggestions

Six hundred and seventy-nine respondents answered the open-ended question. Considering the length of our questionnaire, we consider this to be a significant number of responses. Seventy three percent (73%) of them supported the development of a buy-back program. In general, the answers indicate that Thais want to obtain at least some symbolic value for their old equipment. As one respondent succinctly stated:

> *Some may think that WEEE has no value. But for me, when I buy [the equipment], I buy [it] with money. So, in returning there must be money in exchange [for WEEE] even if the amount will not be so much.*
>
> ID 1134, female, aged 22, from the South.

Twenty-four people suggested that the buy-back rates should be set higher than the default offers. Six respondents, on the other hand, stated that they were willing to participate even without the money.

Many said they did not know how or where to dispose of WEEE. This highlights the need to develop a proper system and a standard way to dispose of WEEE. Forty-eight respondents described the difficulties in dealing with obsolete equipment citing the space it occupied and the handling dangers that might arise in particular from broken lamps and spent batteries that leaked chemicals. Seventy-one respondents recommended that more information be given to the public to raise awareness about WEEE and its handling. There was also a call for the establishment of standards in WEEE dealing, as a few people believed they had previously been cheated by waste dealers.

> *Agree with the project; [I] would like to see the old way of buying [waste] transformed and having the same standard as [proposed] in this project.*
>
> ID 1439, female, aged 22, from the North.

> *This is a good project, better than getting some kilos cheated by waste dealers.*
>
> ID 159, male, aged 50, from Bangkok.

Ninety-eight respondents suggested ways to further improve the collection of WEEE such as including a pick-up service, having nearby community facilities, and regular collection schedules. Several suggestions were in line with the analysis of Darby and Obara (2005) wherein they found that there was no one-size-fits-all solution for a waste stream as diverse as WEEE:

> *This will be a good and useful project. Perhaps the buy-back sites should be divided [for different types of products]. Large appliances cannot be lift by a single person and households may find it inconvenient to delivery them to the buy-back center. For small items like batteries the project may cooperate with convenient stores to make it easy for the public to dispose of this type of WEEE.*
>
> ID 1507, male, aged 36, from the East.

In addition to recycling, seven respondents advocated product reuse and repair. This would be relevant if the program is to buy back obsolete but functioning ICT that would otherwise be put in storage.

The government's proposed buy-back program was not without critics. Twenty-seven respondents criticized it or at least showed some skepticism. The criticism ranged from the cost of a buy-back to a fear of bureaucratic red tape, inefficiency and corruption. In addition, a few respondents disagreed with the principle:

> *The manufacturers should take back [used equipment]. The government should enact a law to have the manufacturers responsible for the recycling and disposal of the products they made. [They should] not be allowed to just make profits [from selling products] and put all the burdens to the government and the consumers when it becomes waste.*
>
> ID 1468, female, aged 32, from the East.

Others questioned the effectiveness of the proposed program in light of the existing ease with which WEEE can be sold without the program:

> *Would it work? Now peddlers come and buy [WEEE] at the doorstep. It is simple and there are a lot of them.*
>
> ID 6, female, aged 24, from Bangkok.

On the other hand, a few people expressed fear that the government's program would jeopardize the livelihood of the poor who work in the waste dealing business. Our analysis however shows that this is unlikely as their former customers are likely to continue selling WEEE to waste dealers who pay and pick them up from their home.

4. Conclusions

The proposed policy in Thailand calls for local governments to buy back and consolidate WEEE for environmentally sound recycling. Assessing this proposal and its premise in light of households' past disposal behavior and future preferences yields mixed reviews. On one hand, the proposed policy has a potential to get household WEEE consolidated into the formal recycling sector. In the context where households can easily sell their WEEE to private waste dealers, the incentive offered in the government's buy-back program will stand a better chance than the free take-back arrangements that are available in many developed countries. On the other hand, the economic instrument will not be sufficient to stop the flow of WEEE into the informal recycling sectors. Our findings show that because of their convenient pick-up service, waste dealers will continue receiving WEEE from most of their former customers. Therefore, other measures including a more stringent enforcement of regulations are needed to curb these illegal, polluting recycling activities.

The analysis also indicates that the effort by the Thai government to establish a public recycling program for WEEE is welcomed by households for two reasons. First, the buy-back mechanism can put households at ease with their mental accounting. The survey data show that, although they were not actively selling obsolete equipment, many Thais still kept it in storage because of their perception of its remaining value. The buy-back offers from the government will encourage WEEE collection by providing households

with a way to write off this mental book value. Because the offer is likely to attract some obsolete but still functional equipment, other treatment options such as reuse, repair and refurbishment should be incorporated into the post-collection stage of the program. The second reason is not about the buy-back mechanism per se. The program might gain public support simply because it will offer households a proper, standard way to dispose of WEEE which is currently missing in Thailand. The survey shows that some people are not concerned about the financial return on WEEE and might just want to do the right thing for society and the environment. The key to win their participation is by improving the convenience of disposing WEEE. This can be done, for example, by using (part of) the buy-back money to organize a routine pick-up service and/or by requiring retailers and convenience stores to accept WEEE from their customers, all in addition to the standard buy-back offers at the local-governments' drop-off locations.

More research is needed to confirm our findings and to further investigate households' disposal decision making. Our analysis shows that households evaluate disposal options based on particular properties such as financial incentives, convenience and the trustworthiness of waste collectors. Further work can employ choice modeling to elicit their willingness to pay for improvements of these factors. It would also be interesting to examine the influence of values, attitudes, and demographic factors as determinants of disposal behavior and preferences. Future surveys should also cover disposal behavior and preferences of households in rural areas. Last but not least, additional research is needed on the collection of WEEE in developing countries as to how to lessen pollution and other environmental impact caused by its recycling.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resconrec.2012.08.014.

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