

# Where have all the old cars gone? The role of the informal sector in handling end-of-life vehicles in Thailand<sup>1</sup>

Kriengkrai Techakanont\*; Tassanee Homklin; Thana Phamaranon

## 1. Introduction

Global car production and sales have increased over the past few decades. Awareness of the potential benefits of secondary resources and the social costs of improperly processing end-of-life vehicles (ELVs) seem to differ among countries. In high income nations, legislation initiatives on ELV recycling exist, such as in the EU, USA, Japan, Korea, China<sup>2</sup> and Taiwan. In contrast, in many developing countries where automobile ownership has been rapidly increasing, there seems to be a lack of formal recycling systems or policies. These countries lag in the establishment of legislation due to their economic and institutional circumstances. It is believed that trends in environmental awareness will increasingly drive them towards the sustainable management of ELVs.

In Southeast Asia, despite Thailand being the largest production hub for global car manufacturers and the second largest domestic market for automobile, there exists no formal policy concerning ELVs. New car registration and the accumulated number of vehicles have been growing rapidly in the past decade. The improper treatment of ELVs potentially results in undesirable social costs and environmental problems for a country. Establish a comprehensive framework and redesigning ELV management system is, therefore, crucial. However, only a limited number of research papers have been conducted on this issue in Thailand. Therefore, this research project attempts to examine how end-of-life vehicles have been treated and indicate how many economic factors are involved in the last stages of the lifespan of vehicles.

Since ELVs contain large amounts of potentially valuable secondary resources, it would be expected that market mechanisms would drive players along the value chain of ELV processing to recover as much of these components as possible. However, as those involved are driven almost exclusively by profit, rather than social, motives, they might lack sufficient incentive to deal with hazardous substances, such as refrigerant gases, mechanical oils, or lead batteries. This culminates in hazardous costs to both the society and the environment. Consequently, this study aims to contribute to the literature by examining the ELV treatment of existing players in the value chain and offering insight on the current status of initiatives on ELV in the public and private sectors.

To the best of our knowledge, no statistics exist concerning ELVs in the Thai Context. We started our project by tracing the data on registered cars in Thailand from 2007 onward using information from the Department of Land and Transport (DLT). To make thing simple, we focused on passenger cars, one-ton pickup trucks and vans only. The stock of cars in 2018 was about 16 million units, which was double the 2007 figure (see Figure 1). In addition, it was surprising to uncover that data on the number of old cars registered had disappeared, due to the lack of any DLT requirement for car owners to de-register. Instead,

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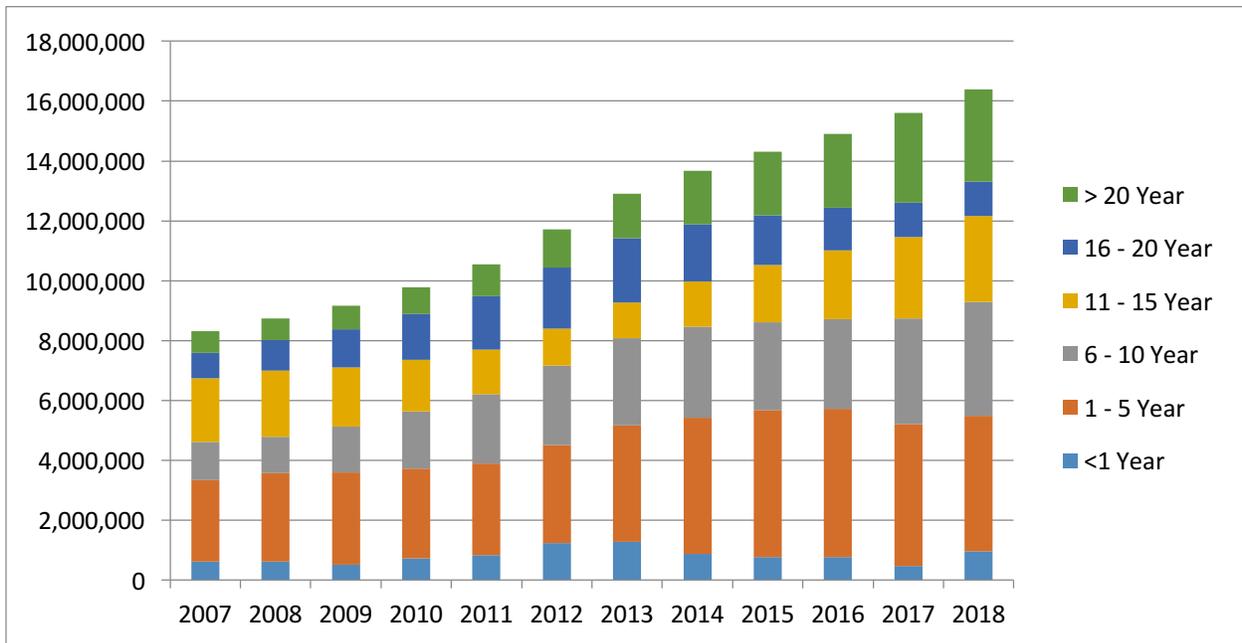
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\* Corresponding author, Email: [krieng@econ.tu.ac.th](mailto:krieng@econ.tu.ac.th)

<sup>2</sup> For EU see Schneider et al (2010), Japan see Hiratsuka et al (2014), Taiwan see Chen et al (2010). See Sakai et al (2014) for a review on comparative ELV recycling systems. For China, due to the large number vehicle registrations, the government enacted the End-of-Life Vehicle Recycling Regulations in 2001 (Hu and Wen 2015). The establishment of an ELV collection system was to prevent the potential accidents caused by the use of refurbished parts on old vehicles.

the DLT automatically deletes particular cars from the registration system after three years of failure to renew road taxes. Thus, the question of where have all the old cars gone is easy to ask, yet hard to answer.

**Figure 1 Number of registered vehicles in Thailand (2007 – 2018)**



Source: Compiled by the authors

Thai people use cars for several years, as indicated by the fact that the number of cars older than ten years in Thailand grew from 0.7 to 2.98 million units over the past decade. Techakanonont and Leelahanon (2015) explained that Thai people tend to use cars longer because the cost of ownership is cheaper. People in upcountry areas can get a cheaper price for used cars. On average, 70 percent of cars older than ten years are used in upcountry locations and these accounted for about 31 percent of total cars registered in Thailand in 2018 (a total of 16.39 million vehicles). It seems that older cars are sold in upcountry regions where people with lower incomes can afford them. Despite old cars needing regular repairs, garages and repair shops have established networks supplying spare parts to service their customers. Ultimately, old cars need to be dismantled and treated and this paper tries to uncover details of this process.

This paper is organized as follows; the next section concerns the conceptual framework and research methodology underpinning this research. The third section presents our research findings on the structure and roles of the players involved in treating the ELVs from in-depth interviews, questionnaire survey results from consumers' point of view, and SEM. The last section concludes our study.

## 2. Conceptual framework and research methodology

### 2.1 ELV treatment and players in the value chain

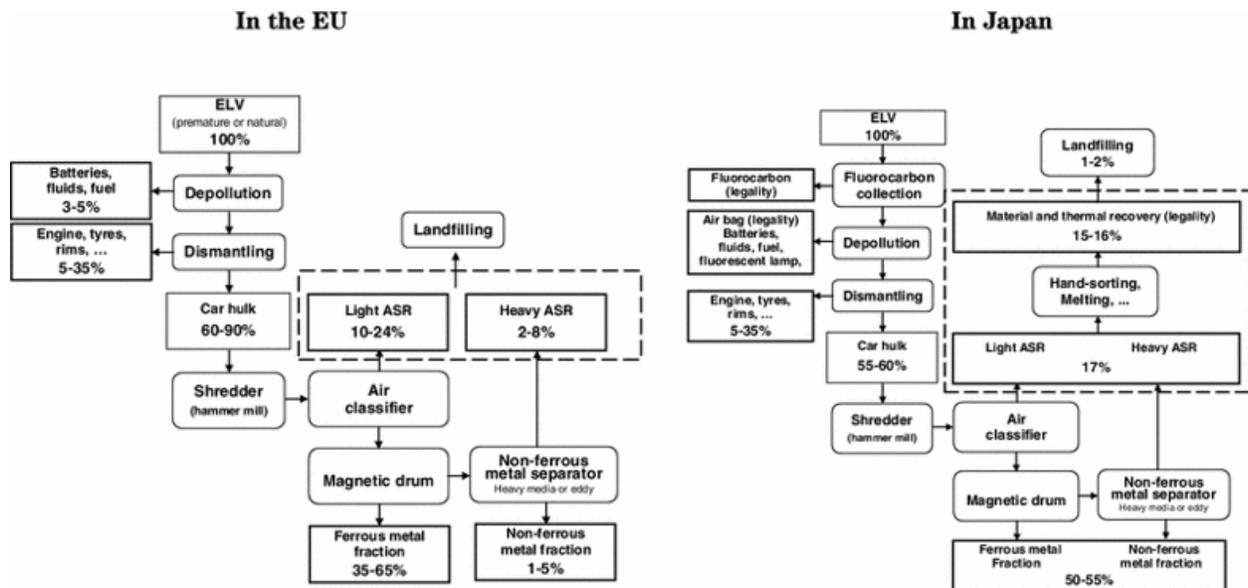
In developed countries, the management of processes concerning ELVs is efficiently organized. Although the processes, methods and regulations involved slightly differ, depending on the particular institutional, economic, and social conditions, their goals are to maximize the benefits accrued from recycling ELVs, retrieving useful material from old cars and minimizing the environmental impact of

improper treatments. Legislation has been imposed to ensure the recycling ELVs in EU countries, Japan and Taiwan.

In terms of material flow, stakeholders in the value chain in general play similar roles, but the steps in the dismantling process may be slightly different. For instance, Figure 2 shows that the processes in the EU and Japan are quite similar, but the Japanese system tries to recover a higher rate of reusable material from ELVs, especially ASR (Automobile Shredder Residue) which is treated with thermal recovery techniques to generate energy and reduce landfill needs. The ELV treatment process starts with depollution, dismantling and shredding, before classifying small ASR by air or magnetic processes.

In such processes, it is important to dismantle toxic, hazardous and dangerous parts from cars to avoid possible environmental problems. Then, all valuable parts, such as engines, wire harnesses, tyres and bumpers, are removed for repair and sold to the used car market. Car hulks then proceed to shredding and sorting to recover valuable materials, such as aluminum and steel, which are then sold to iron and steel makers as recycled materials. Any ASR materials are sorted to minimize the volume leftover which will finally go to landfill.

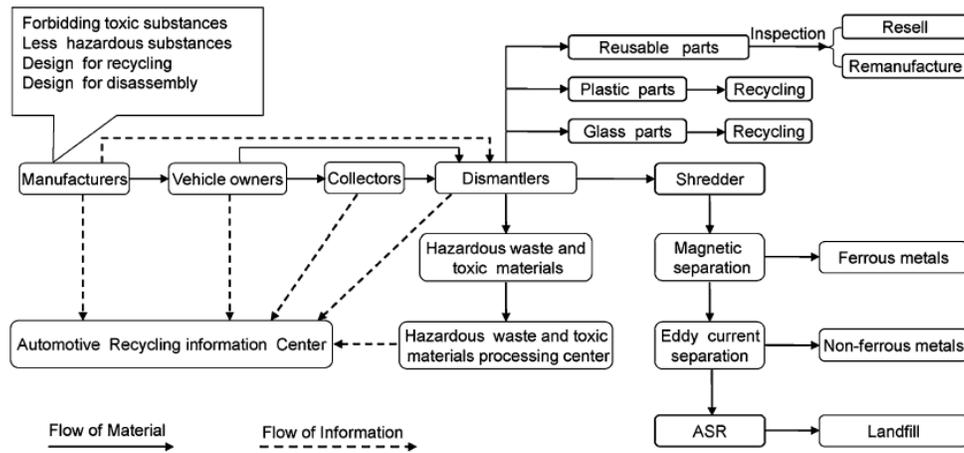
**Figure 2 Diagram of the typical processing of an ELV (EU and Japan)**



Source: Sakai et. al. (2014), Fig 1, page 4.

In each country, stakeholders in the ELV treatment process are numerous and their roles may differ. If we consider ELVs as a product, the owners of cars represent the ‘supply side’ and the recycling companies, as well as customers who want old parts, the ‘demand side’. It should be noted that the demand for ELVs comprises derived demand arising from valuable materials or parts from the ELVs concerned., Hence, firms in the recycling process (or waste management procedure) have a single goal to maximize their profits. If there are no regulations or standards, firms will have no incentive to bear the costs of treating substances that have no market value, such as CFCs or hazardous materials. The improper depollution processes of these substances would create negative externality and impose undesirable costs on society. The players involved in the value chain can be shown in Figure 3.

**Figure 3 Good practice in ELV management**



Source: Li J., Yu K., and P. Gao (2014)<sup>3</sup>

According to Li et. al. (2014), if all the players in the value chain have proper technical know-how and suitable equipment and facilities, the environmental problems from the improper treatment of ELVs can be mitigated. This might start at the upstream stage where cars are designed incorporating features such as less hazardous or toxic substances, more recycled materials and greater ease of disassembly and dismantling. Regarding car owners, in order to increase the recycle rate of ELVs, governments should design an easier process to deregister old cars and return ELVs to collectors. In addition, the information flow of registered cars from the beginning to the last stage of deregistration, depollution, recycling, and landfill allocation should be updated and monitored. This will enhance the effectiveness of tracing the flow of hazardous substances from the collection to depollution stage. Identifying how Thailand handles this represents the aim of this paper. The research method will next be outlined and explained.

## 2.2 Research methodology

This research aims to identify the flow of dealing with ELVs in Thailand in order to identify the roles of particular stakeholders in the process. The only way to accomplish this goal is to interview key players at all stages, from collection and dismantling, through to the recycling and waste management stages. After outlining this flow, we identify how old cars are processed when they become ELVs. In addition, we had to consult with consumers or the original car buyers in order to ascertain their preferences when buying a new car (either brand new or used) and what they did (or will do) to their old car.

We designed our questionnaires and administered them using approximately 200 respondents in Bangkok in 2018. The final set of questionnaires was completed in early 2019 and consisted of four main parts: 1) general information or demographic profiles, 2) information about respondent's current car (new or used) and what did they do with their old vehicle if they have changed to a new car, 3) their opinions on the problems experienced with old cars and improperly treated ELVs, knowledge concerning recycling ELVs, their perceived problems regarding ELVs, and what will be their decision if their car becomes an

<sup>3</sup> Li J., Yu K., and P. Gao (2014). Recycling and pollution control of the End of Life Vehicles in China. *Journal of Material Cycle and Waste Management* Vol. 16 pp.31-38.

ELV, and 4) their opinions on the two scenarios in the recycling program we would like to test, namely, if the government requires compulsory recycling fees and adjusts the annual vehicle tax from being a flat or regressive rate to be a progressive one.

The main purpose of the questionnaire is to cross check information concerning the route or flow of ELVs processed in Thailand. In addition, bearing in mind the potential environmental problem associated with ELVs, we would like to know how consumers consider the scenario that the Thai government will impose ELV laws and collect recycling fees. This is intended to reveal their perceptions concerning the problems ELVs potentially raise to society, their willingness to participate in recycling programs, who should be responsible for the fees incurred, and the possibility of Thai people in general participating in recycling programs. With respect to the last question, we utilize questionnaire survey results to run a structural equation model (SEM) in order to link the key factors important for higher participation rates in the program.

### **3. Results**

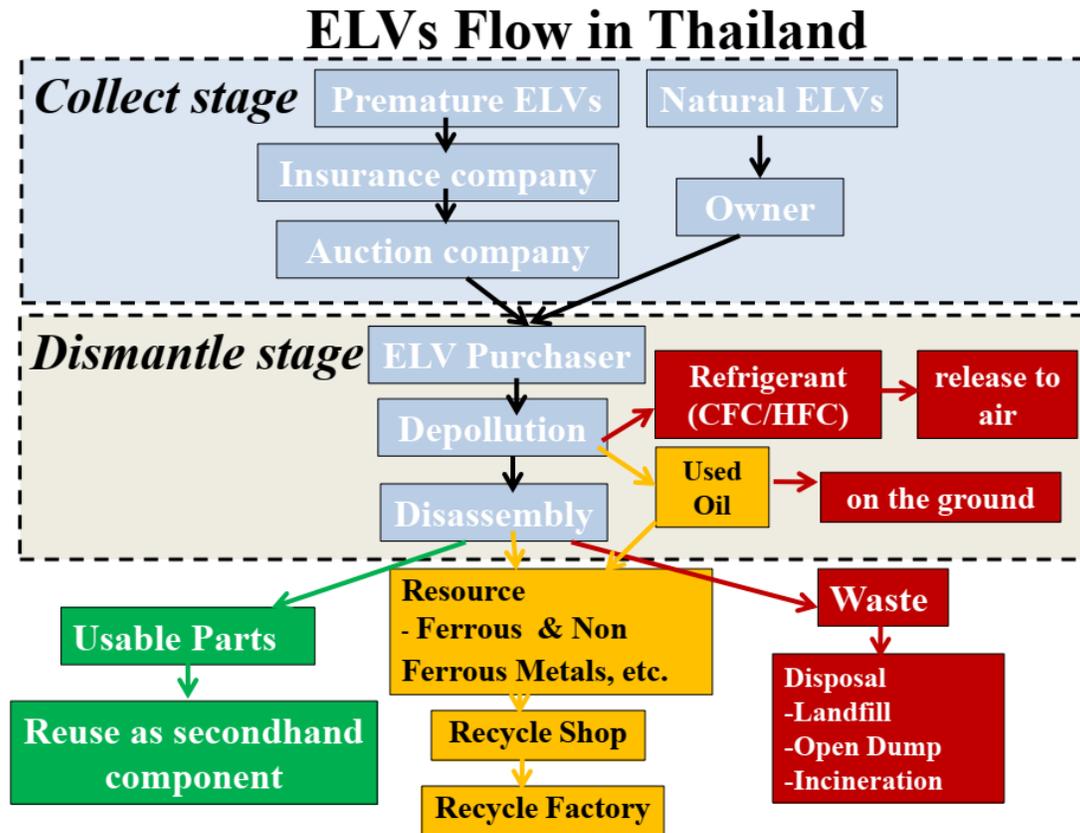
This section is divided into three parts. In the first part, we outline the flow, or value chain, of ELVs in Thailand, based on interviews with key players in the process. In the second we reveal the questionnaire survey results from consumers and provide general information concerning their income and the types of car they currently use, together with their reasons for changing to a new car (the current one), their willingness to participate in both free-of-charge ELV recycling programs and recycling programs wherein the government charges a small fee. In the third section we try to combine these factors and test if some variables will be significant in promoting participation in ELV recycling programs.

#### **3.1 ELV value chains in Thailand**

This research aims to identify stages in the flow of ELVs in Thailand in order to identify the roles of stakeholders in the process. The project started with interviews with public sector representatives, including respondents from the Department of Land and Transport, the Pollution Control Department, and the Commission of Insurance Association. We then interviewed key players in the ELV value chain. Regarding the ELV collection stage, we interviewed a leading insurance company representative, who shed light on the role of the main source of premature ELVs for sale at auction. Then, we interviewed a leading auction company representative, whose company includes a specific area for the auction of ELVs. Auctions place act as a market place for ELVs, where sellers and buyers conclude transactions. Subsequently, we sought the cooperation of an ELV buyer, suggested by the auction company, in order to learn about the practices of dismantlers and how they conduct business. We also carried out a field survey of several players in the supply chain in order to identify their particular roles in the collecting, dismantling, and recycling stages.

Based on the field and questionnaire surveys, this research revealed that the informal sector has played important roles in reusing, recovering and recycling old cars. However, they lack suitable technology and equipment and consequently their treatments of end-of- life vehicles endanger the environment and incur social costs for Thai society. In order to understand their roles in treating ELVs, we can compile a flow chart of ELV treatments in the informal sector in Thailand. See Figure 4

Figure 4 Value chain of ELVs in Thailand



Source: By the authors

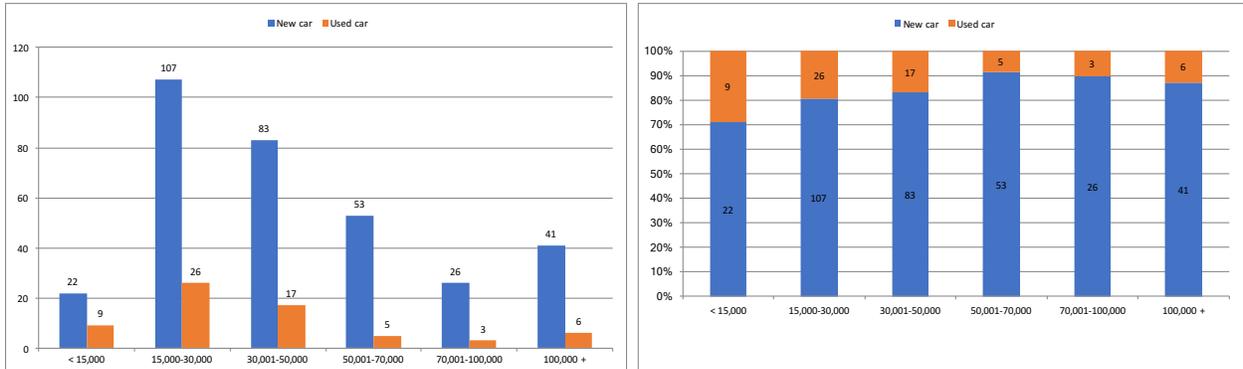
### 3.2 Results from questionnaire survey

From our questionnaire survey conducted between February and April 2019, we obtained 403 complete sets of responses. In conducting this survey, we sought the opinion of car owners who had bought a car and subsequently used it. Thus, we limited the age of respondents to be over 25 years old. Respondents were from all regions of the country because we would like to see if there is any regional effect on ELV perceptions. Income inequality is observed among our sample. The average income of the respondents in Bangkok and vicinities is highest, followed by respondents in the central and eastern part of Thailand, with the northeastern region representing the lowest.

In Figure 5, we classified respondents according to monthly income and found that people in the lower income group tended to purchase more used cars. We anticipated this finding, which is consistent with data from the DLT indicating that 70 percent of old cars were used in upcountry regions. From our sample, 243 persons had experience of changing to a new car so we asked what were their main reasons behind this decision and what did they do with their old car. Our survey results indicate two main reasons; on the one hand, they changed to a new car because they wanted to experience new technology, or their utilization change. On the other hand, other respondents reported that they changed because their cars were

no longer functional. This involves the group of vehicles approaching their final end-of-life stage. (see Figure 6)

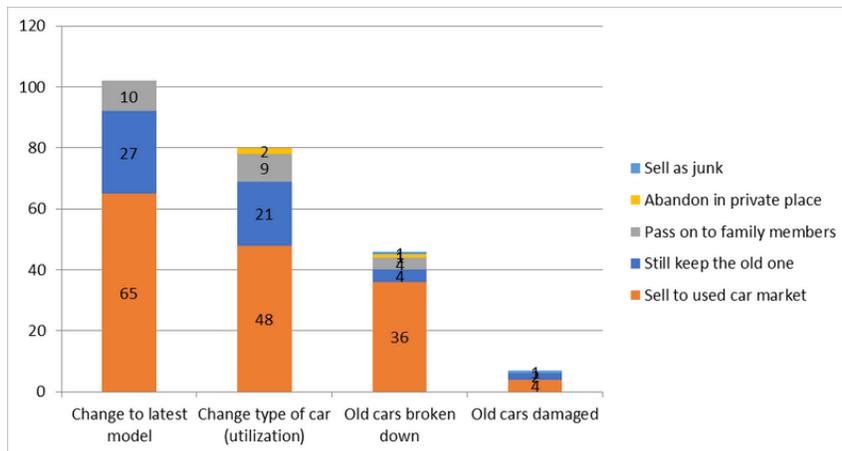
**Figure 5 Income level and type of the currently used car**



Source: from questionnaire survey by the authors

It is interesting to ascertain how they handle their old cars. As discussed in the previous section, in Thailand the used car segment is large and there are many players, such as auction companies, garages and repair shops, all of which play important roles in reviving the near-end-of-life cars to prolong their lifespan. Our survey results indicate that 65 percent of old cars were sold on the used car market, including broken cars, see Figure 6. It is possible to profit from fixing broken cars with spare parts from other vehicles and selling the repaired car on the used car market. It is obvious that an asymmetric information problem exists, so car buyers would have the unfortunate relatively high probability of buying a ‘lemon’. This finding confirms that such old cars will again return to the market by profit-driven firms.

**Figure 6 Reasons to buy a new car and what happened to the disused vehicles (n=243)**



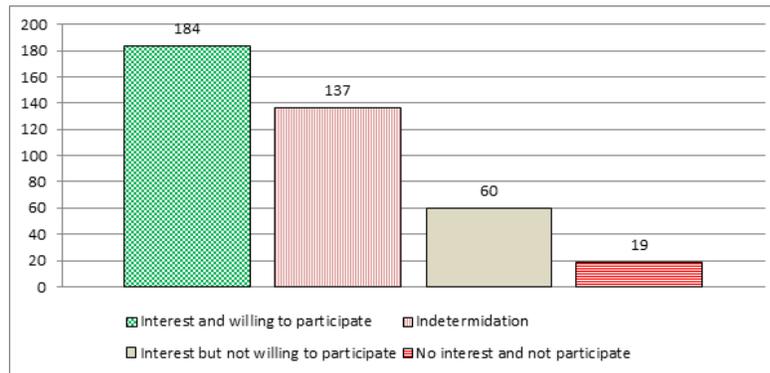
Source: from questionnaire survey by the authors

There were some fraudulent cases involving selling a car rebuilt from ‘total loss’ cars. Some of these cars had damage from serious accidents and the insurance company or owners sold them to garages.

This happens because the cars still have valid registration status. When garages buy broken cars and revive them with key parts from other broken cars, they can renew their annual tax automatically if the car is not older than five years old (the DLT requires car to have checkups after five years). Thus, consumers are worse off from such a loophole that players in the value chain take advantage of.

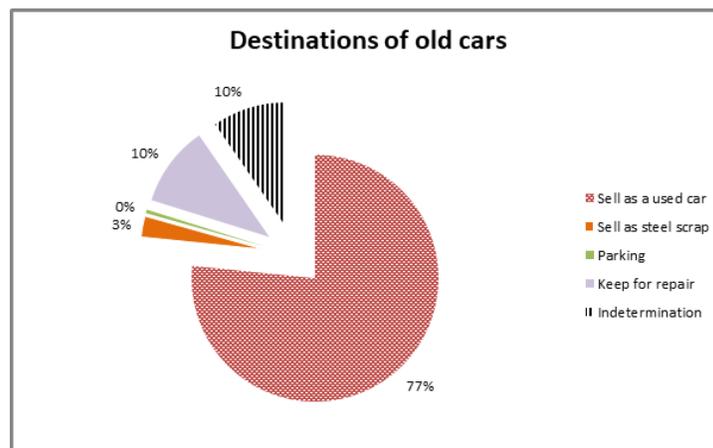
Many people sell their cars to used car markets or garages, this might be due to the lack of regulations or recycling laws concerning ELVs in Thailand. Respondents were asked if the government launched a free-of-charge ELV recycling program, would they be willing to participate? Among 400 respondents, only 184 (46 percent) were willing to participate, the rest were not sure what to do and not willing to participate in such a program (see Figure 7). For those who were not willing to participate in the recycling program, we further asked what they would do with their disused vehicles. There were 219 answers to this question with 77 percent of respondents indicating they would sell their vehicles on the used car market and ten percent saying they would either keep the vehicle for repair in the future or could not decide on an action. Thus, it is clear that the destination of old cars will eventually be to return to the used car market, see Figure 8.

**Figure 7 Willingness to participate in free-of-charge ELV recycling programs (n = 403)**



Source: from questionnaire survey by the authors

**Figure 8 What will people do with their old cars?**

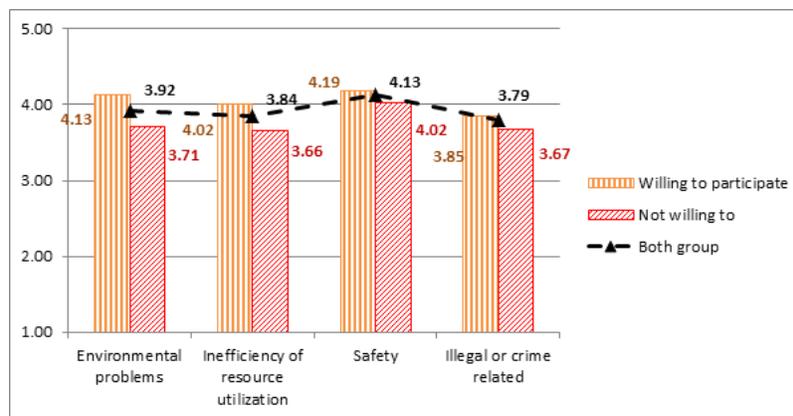


Source: from questionnaire survey by the authors

Note: (n = 219 from those not willing to participate in free-of-charge recycling programs)

Thai people are familiar with old cars and it often seems they do not think cars have any limitation on their lifespans. We asked respondents to specify the degree of seriousness of problems arising from old cars in terms of environmental issues, safety issues, inefficient use of resources, and illegal or crime related activities. In Figure 9, we show two aspects of the findings derived concerning both the average degree of problems arising from ELVs and respondents' willingness to participate in free-of-charge recycling programs. On average, the group showing an interest in participating in such programs identify a higher degree of problems across all issues than the 'not willing to participate' group. The perception of ELV problems may differ between the two groups. The possibility exists to make people participate if the government wants to promote recycling programs for ELVs.

**Figure 9 Perceptions towards problems concerning ELVs for all respondents (classified by willingness to participate in recycling programs)**

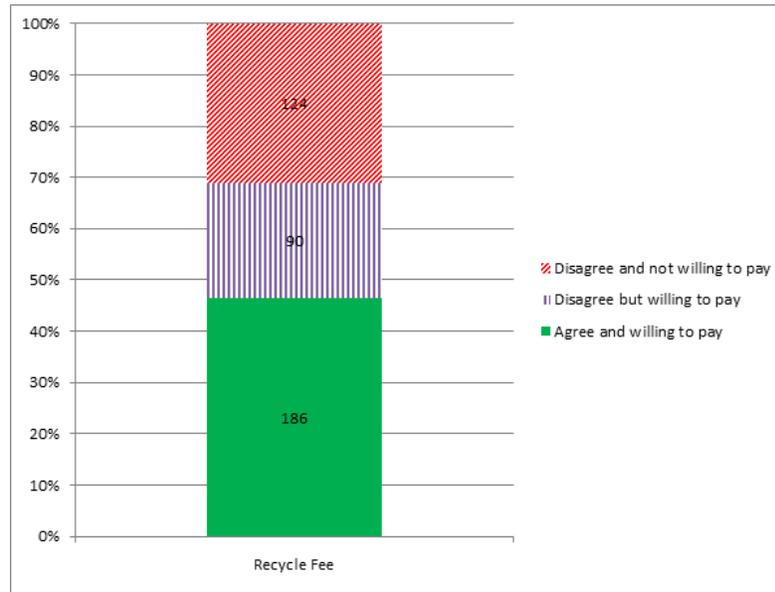


Source: from questionnaire survey by the authors

Note: (Willing to (n = 184) and Not willing to (n = 219))

Subsequently we asked about peoples' perceptions towards the problems involved with ELVs if improperly treated. The majority of respondents thought that ELVs would cause problems, but this raised the issue of who should be responsible for this. The answer is unclear, but the respondents thought either users or buyers should share recycling costs. Then we probed their ideas on recycling programs concerning whether if governments passed a law charging a small amount of money, would they agree with such a policy and would they be willing to pay. Our findings show that more than half of the respondents agreed to pay the fee in principle (even though some of them did not agree, they would cooperate in practice) see Figure 10. Therefore, our findings suggest that people who would like to participate in recycling programs perceived more serious problems concerning ELVs over all of the aspects outlined. Hence, their knowledge on the potential problems of ELV may transmit to their concerns regarding society and the environment.

**Figure 10 Willingness to participate in government ELV recycling programs with application of a small fee**



Source: from questionnaire survey by the authors

### 3.3 Structural equation modeling

#### 3.3.1 The preliminary factors

From the questionnaire survey of this study, 12 items were used to analyze the causality of people who would like to participate in ELV-related recycling programs in Thailand. These items were classified into four factors including individual characteristics—their region of living (Bangkok or non-Bangkok), type of vehicle (1 = passenger car, 2 = van, and 3 = pickup truck), new or used car and the price of their car, their knowledge of ELVs, their perceptions concerning ELV problems and their willingness to participation in ELV recycling programs. The preliminary factors, their related items and the scale of data are listed in Table 1.

**Table 1: List of preliminary factors and items**

Preliminary factors	Code	Item	Scales
Individual characteristics			
-Price of Car	Dummy		1 = ≤ 800,000 Baht 0 = > 800,000 Baht
-1 <sup>st</sup> Type of Vehicle	Dummy		1 = Passenger car, 0 = otherwise
-2 <sup>nd</sup> Type of Vehicle	Dummy		1 = Van, 0 = otherwise
-Region of Living	Dummy		1 = Bangkok Metropolitan Region 0 = Others
-New or Used Cars	Dummy		1 = New Car, 0 = Used car
Knowledge of recycling ELV	1	Knowledge of ELV	Three-point Likert scale (1 = None, 2 = partly, and 3 = Very well)

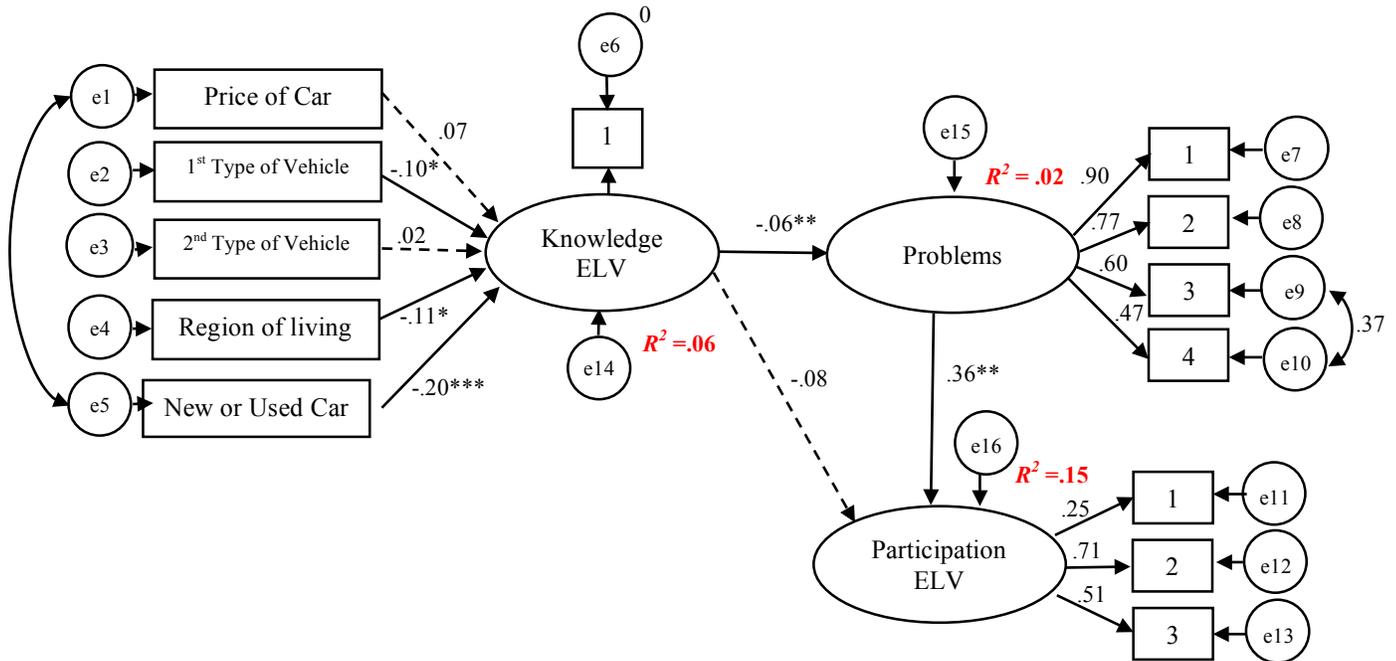
Preliminary factors	Code	Item	Scales
The perceived problem of ELVs	1	Environmental problems from waste of vehicle	Five-point Likert scale (1 = not at all to 5 = extremely high)
	2	The problem of waste of resources from auto parts that can be recycled.	
	3	Road safety problems	
	4	Illegal or crime-related problems	
The participation ELV project	1	If the public sector has initiated a project to bring the old into the recycling process without charge.	Three-point Likert-try scale (1 = not participated, 2 = uncertain, and 3 = participate the project)
	2	If the public sector has the law of recycle to impose a fee for handling and recycling of car wastes.	
	3	If the public sector has annual tax changes for personal cars at the progressive rate based on vehicle lifetime	

### 3.3.2 Data analyses

We used AMOS 21.0 for multivariable analysis. Structural equation modeling (SEM) was used for multivariable data analysis (Kline, 2011) by using maximum likelihood (ML) estimation. In this model, goodness of fit was assessed using the chi square  $\chi^2(61) = 186.829$ , the comparative fit index (CFI) = 0.849, the adjusted goodness-of-fit index (AGFI) = 0.905, the root mean square error of approximation (RMSEA) = .072, the standardized root mean square residual (SRMR) = 0.069, the chi square/degree of freedom (CMIN/df) = 3.063, the Tucker-Lewis index (TLI) = 0.807, and the Bollen's incremental fit index (IFI) = 0.852. Thus, the fitness of the overall model represented a good model fit.

The results of the SEM-analyses indicated that the demographic characteristics which included respondents' region of living, first type of vehicle (passenger cars) and whether they drove a new or used car were negatively related to their knowledge concerning ELVs ( $\beta = -0.10$ ,  $p < .05$ ,  $\beta = -0.11$ ,  $p < .05$  and  $\beta = -0.20$ ,  $p < .001$ , respectively). However, the effects of the price of a car and the second type of vehicle were not a significant predictor of any knowledge of ELVs ( $\beta = 0.07$  and  $0.02$ ,  $p > .05$ , respectively). The findings also revealed that region of living, first type of vehicle and whether they had a new or used car explained 6.0 per cent of the variance of knowledge concerning ELVs. All of the variables, the problems concerning ELVs, explained 15.0 per cent of the variance of participation of ELVs directly and/or indirectly (see Figure 11). Furthermore, bootstrapping offers multiple advantages over traditional mediation analysis approaches. Therefore, all of the variables on the structural model were based on  $N = 5000$  bias-corrected bootstrap samples in Amos and estimated 95% confidence intervals (CI), which correspond to a two-tailed test with  $\alpha = 5\%$  (Preacher et al., 2010). In our mediation analysis we report on the indirect effects because the recent literature on mediation assumes that a significant total effect is not necessarily a prerequisite for investigating mediation relationships (Rucker et al., 2011). The indirect effects of knowledge of ELVs on participation ELV as outcome through the received of ELV's problems ( $\beta = -.056$ ,  $p < .01$ ) was significant (Table 2). Thus, our results support a full-mediation model in that the received of ELV's problems mediated the effect of knowledge of ELV on participation ELV.

**Figure 11 Structural Equation Model (SEM)**



Note: \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ ;  $N = 399$ .

**Table 2 Indirect effects on participation ELV as outcome (N = 399)**

Mediating effect of study engagement	$\beta$	95% Confidence interval	
		Lower end	Upper end
Knowledge ELV $\longrightarrow$ Problems $\longrightarrow$ Participation ELV	-.056**	-.114	-.018

Note: \*\*  $p < .01$

In sum when considering ELVs in Thailand, in terms of participation in ELV projects through knowledge of ELVs and their perceived problems, we predict that people who have less knowledge of ELVs, but a clear perception of the problems arising from ELVs, will be more willing to participating in ELV projects than those who have significant knowledge concerning ELVs, but limited perception of the problems ELV may cause to society and the environment.

#### 4. Conclusions

We envisage end-of-life vehicles will increasingly become a serious problem for emerging economies. This paper takes Thailand as a case study. Thailand has been chosen as a production and export hub of many global car manufacturers. The number of cars sold is the second largest in Southeast Asia, after Indonesia, thus, problems arising from ELVs will potentially soon endanger the environment, the economy and society in general.

Field surveys conducted by the authors uncovered the roles of stakeholders in the informal sectors in ELV treatments. The value chain of ELVs shows that several parts of the process potentially cause social or environmental problems. In Thailand, it is quite normal for Thai people to use their cars more than ten years because the cost of ownership of old cars is low and we have a vast number of players in the ELV supply chain engaged in reviving and extending the lifespans of old and broken cars. This is perhaps similar to the case of China, wherein respondents think that their cars have market value, so they might seek to sell their broken cars to buyers to receive money (Hu and Wen 2015, 2017). This is because the price mechanisms and market-driven entrepreneurs in the ELV supply chain allow them to make profit. However, consumers are aware of the pollution emanating from old cars and will conform if there is clear, intelligible legislation on ELVs in Thailand.

Our SEM analysis suggests that the perceived problems of ELVs played the important role of mediation in predicting participation in recycling programs. More specifically, people who perceived the more serious problems concerning ELVs across all aspects were more willing to invest the effort and time for deriving knowledge regarding ELVs and, thus, will feel more involved in recycling programs. As a starting point, the government should provide information on the impacts of ELVs to people in Thailand leading to an improvement in their knowledge and an increase in the overall motivation of the population to participate in recycling programs.

Recently, the increasing number of ELVs and the negative impact of continuing to run old cars have led to an initiative to develop a framework for establishing end-of-life vehicle management systems in Thailand. The Pollution Control Department (PCD), under the Ministry of Natural Resources and Environment, has formed a steering committee to tackle the ELV issue in Thailand. This committee consists of private sector, public sector and university participation to help promote best practice ELV processors in Thailand, suggest policy recommendations to the Thai government to encourage a licensing system for dismantling companies, an improved deregistration system, and technology transfer to local firms in the ELV supply chain. This research helps shed light on both the ongoing process of this initiative and the status of the ELV management in Thailand. Lessons from Thailand may benefit other developing countries in managing the associated waste in this particular value chain and help mitigate the social problems derived from the prolonged use of old vehicles.

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