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Cooling the Tropics Sustainably: Evidence from a Choice Experiment on Energy Efficient Air Conditioners in the Philippines

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Abstract

Energy efficiency of home appliances plays a crucial role in climate mitigation policies, especially considering the increasing energy consumption in developing countries. Particularly in countries with high temperatures such as the Philippines, switching to energy efficient air conditioners (ACs) can make a substantial contribution to both climate mitigation and sustainable development. We conducted a field survey among households with a choice experiment in the Philippines. We investigated the attributes that influence the decision to purchase ACs and to understand the variations in preferences among consumers in the tropics. Utilizing primary data with a broad range of socio-economic characteristics, we find that households have higher willingness-to-pay for energy efficient models. Moreover, in terms of preference variability, certain consumer groups such as AC owners, younger age segments, higher income brackets, and those with higher environmental awareness displayed higher willingness-to-pay. Furthermore, our survey reveals the potential for a significant rebound effect in AC use if households purchase an energy efficient model. Therefore, we emphasise the importance of combining the transition to energy efficient ACs with additional policy measures to reduce wastage and consume energy efficiently across other domains, as a country transitions to more sustainable and cleaner energy.

Keywords*: Appliance labelling; Energy-saving behaviour; Choice experiment; Air conditioner; Tropical climate; Philippines*

JEL: *D12; R11; Q56*

1. Introduction

Global temperatures are likely to be 1.5°C above pre-industrial levels in the 21st century, according to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2022). The average increase in temperature in the Philippines was 0.68°C from 1951 to 2015 and it is expected to be as much as 1.9°C higher under RCP 4.5 and 2.3°C higher under RCP 8.5 by the middle of this century (Climate change commission, n.d.). Along with this upward trend in temperatures, the increasing popularity of working from home[1] (Statista, 2022) and a growing economy will increase the ownership of air conditioners (hereafter, ACs) and the hours of use of AC. In fact, the AC market reached $8.45 billion in 2018 and is expected to grow at 4.55% annually until 2025 (Industry ARC, 2023). ACs are used continuously throughout the year because of the tropical climate in the Philippines. In fact, space cooling or air conditioning is the primary purpose of residential electricity use in the Philippines (Philippine Statistics Authority, 2011). Davis and Gertler (2015) state that the Philippines is ranked in the top 10 countries in terms of air conditioning potential. They also show that the increase in the use of AC contributes to electricity consumption, but advances in energy efficiency should mitigate the impact.

Given the growth in AC ownership and use, the choice of energy efficient AC is key. There is a growing number of studies using choice experiments that illustrate the importance of energy labelling to make people pay attention to energy-efficient appliances. For example, Lang et al. (2021) and Sammer and Wüstenhagen (2006) find that Swiss consumers have a higher willingness-to-pay (WTP) for higher energy efficiency ratings (such as “A, B, C”) of heating appliances and washing machines. In the US, Ward et al. (2011) find that WTP for ENERGY STAR ranged between USD 250 to 350. Furthermore, for South Korea, Jeong and Kim (2015) find that higher energy efficiency grades (such as ”1” and “2”) attract more consumers to energy efficient appliances compared with information on

[1] Approximately half of Filipino labour force is either partially or fully working from home (Statista, 2022).

annual operating costs. There are also a few studies for developing countries. For example, Shen and Saijo (2009) find that the China Energy Efficiency label significantly and positively impacts decision-making regarding AC and refrigerator purchases in China. Furthermore, Zha et al. (2020) and Zhou and Bukenya (2016) confirm the estimation results of Shen and Saijo (2009) with more recent data for fridges, washers and ACs. Other examples are Jain et al. (2021) and Jain et al. (2018) who find that consumers in India are more likely to purchase energy efficient home appliances (refrigerators or ACs) displaying energy star rating labels (such as "★" and "★★").

Overall, the literature suggests that energy labelling helps consumers understand the energy efficiency of appliances, which enables them to choose efficient appliances. However, the reactions to energy labelling and efficiency levels can be heterogenous depending on several factors such as socio-economic characteristics (Zha et al., 2020) and environmental awareness (Grankvist et al., 2004). Hence, it is important to understand the factors that are positively and negatively related to the preferences towards energy labels to promote energy efficient appliances. So far, the determinants of positive preferences to energy efficiency have not been fully investigated.

In this context, our objective is to understand consumer behaviour concerning energy-efficient appliances, namely ACs, in the Philippines which is a tropical climate country. Following a previous survey conducted in 2019 that focused on households with higher incomes in Metro Manila (Nakai et al., 2023), we conducted a face-to-face survey in three metropolitan areas of the Philippines. Using the survey data, we employ a mixed logit model to investigate which attributes are important among households. We estimate the corresponding WTP values and further examine the possible rebound effect when households choose energy efficient ACs.

We find that the households appreciate ACs with higher energy efficiency, as well as Philippine manufacturers. Convenient functions such as air purification and auto-cleaning could increase the probability of buying AC, which is not in line with the previous study (Nakai et al., 2023) possibly because the current survey was conducted in a broader range of socio-economic characteristics after the COVID-19. Notably, the WTP for higher energy efficiency levels extends beyond the price of current popular models, which clearly indicates that running costs can be considered as more important. Moreover, regarding the heterogeneity in households' preferences, we find that certain groups such as AC owners, younger age groups, and higher household income groups, exhibit higher WTPs for energy efficiency. However, our survey highlights the potential for a significant rebound effect in AC use. This emphasizes the necessity of combining the transition to energy efficient ACs with other policy instruments such as expanding renewable energy to effectively address climate change.

We contribute to the literature in three ways. First, our investigation into consumer behaviour towards energy efficient appliances in the Philippines contributes to the limited literature focusing on tropical countries, with the exceptions of the studies for India (Jain et al., 2021 and Jain et al., 2018). Biardeau et al. (2020) argue that booming AC sales are typically observed in developing economies in tropical climates, which can significantly increase total electricity consumption. Thereby, understanding household behaviours from such countries is critical given the increasing trend of AC sales. Second, we identify who would and would not appreciate the energy efficiency of ACs with socioeconomic information such as household income, age, and environmental awareness. This is particularly important from the perspective of promoting energy efficient technology, although it has not been fully investigated yet. Finally, we investigate the possible rebound effect after the replacement of energy efficient ACs. By doing so, we discuss whether promoting efficient ACs is sufficient to achieve climate mitigation goals, or whether supplementary policy measures are needed.

The remainder of this paper proceeds as follows. Section 2 presents our theoretical framework, methodology, and our survey design. We explain the results in Section 3, and a discussion follows in Section 4. Finally, we conclude and offer policy implications in Section 5.

2. Methodology

2.1 Survey Overview

We conducted face-to-face surveys in three metropolitan areas, namely Manila, Cebu, and Davao from 28th September to 7th October, 2022[2]. The surveys were conducted with the assistance of the Philippine Survey and Research Center (PSRC)[3]. The field interviewers visited households and administered screening questions via face-to-face interviews. Respondents in this study were 18 years old and above, decision-makers regarding large expenditures such as buying home appliances including ACs, and of any income classes. Monthly household income ranges from PhP 8,001 to PhP100,000 (equivalent of 142 USD to 1,775 USD as of January 2024), allowing us to investigate the determinants of AC purchases for a broader range of household incomes than the previous study (Nakai et al., 2023). There were 150 respondents in each of the three metropolitan areas; therefore, we have 450 respondents in total. The respondents were randomly sampled, but at the same time, they were recruited according to quotas for age, gender, and areas within each of the metropolitan areas.

The questionnaire consists of five parts. The first part includes eight choice experiment questions. This was followed by questions about energy consumption behaviour and ownership and use of space cooling appliances. Third, respondents were then asked questions about their energy saving behaviour.

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[2] The survey area of Manila (NCR) covers Parañaque City, Valenzuela City, Quezon City, City of Manila (Tondo), Caloocan City, City of Manila (Santa Ana), Taguig City, Pasig City, Marikina City, and Las Pinas City. Similarly, Metropolitan Cebu in our survey includes Cebu City (Capital), Minglanilla, Balamban, Talisay City, Mandaue City, City of Carcar, Lapu-Lapu City (Opon), Consolacion, and Liloan, Cebu. Finally, the survey of Metropolitan Davao covers Davao City, Hagonoy, Davao del Sur, Santa Cruz, Davao del Sur, and Digos City (capital).

[3] PSRC was responsible for programming our questionnaire on to tablets and undertaking fieldwork in preparation for the interview. The enumerators were aided by a tablet. The survey was conducted in both English and the local dialect in the region, e.g., Tagalog, and Bisaya.

Fourth, questions about environmental awareness and economic preferences such as risk aversion and patience were asked. The final part asked about their socio-demographic characteristics.

2.2 Design of Choice Experiment

Our choice experiment design is based on Nakai et al. (2023), which was developed through focus group discussions[4], pre-tests, interviews with officials from the Department of Energy (DOE), Philippines, and Manila Electric Company (Meralco), and related literature. While window-type ACs are still dominant in the Philippines (The Japan Refrigeration and Air Conditioning Industry Association, 2022)[5], this study focuses on split-type ACs as it has been growing strongly in recent years. Thus, one can expect that split-type ACs will be as popular as window-type ACs in the near future. Moreover, investigating the determinants of purchasing split-type ACs is warranted.

In the survey, the respondents were asked to assume that (i) they were about to purchase a new split-type AC for their bedroom that is one horsepower covering 14–17m^2, (ii) there is no installation cost, and (iii) the ACs' characteristics, other than the four attributes, are the same between the two products. Table 1 summarises the attributes and their levels of the ACs in the choice experiment questions, which are purchase price, country of manufacturer, additional functions, and energy star rating (energy efficiency).

The most important attribute in our study is energy efficiency measured using one to five stars. Energy efficiency increases with the number of stars, which mimics the new energy label[6] introduced

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[4] Focus group discussions were conducted to determine the potential attributes and levels of choice experiment settings. We observed their views and attitudes regarding energy and its consumption in general and ACs through participants' discussions. See Nakai et al. (2023) for more details.

[5] Approximately 62% of room ACs in the Philippines are window-type ACs.

[6] For details of the new Philippine energy label, see https://www.doe.gov.ph/pelp/philippine-energy-label?q=pelp/philippine-energy-label

in 2020 (DOE, 2020). Nakai et al. (2023) find energy star label could bring the highest possibility to motivate consumers in Metropolitan Manila to choose energy efficient AC among the labels with EER[7] and with running cost information. For the reasons above, this survey follows the design of the current label. Purchase price indicates the price of a split-type AC. There are five price levels that cover the majority of the one-HP split-type ACs sold in the Philippines. Country of manufacturer has four levels which were also established based on the market research. There are four additional functions' categories: "no additional functions", "auto-cleaning", "air purification", and "smart function". ACs with an auto-cleaning function can automatically clean their air filters. Therefore, it can reduce the frequency of AC cleaning and, thus, the amount of harmful materials that exist in a room from the AC. An auto-cleaning function is an advanced function in the Philippine market, but it is the most popular function in Japan.[8] As there are many ACs from Japanese manufacturers available in the Philippines, this function could also be one of the most popular functions in the country. An air purifier function removes certain harmful materials from a room, such as dust, pollen, bacteria, mould, and PM2.5. Therefore, it can reduce the risk of some sicknesses. Finally, ACs with smart functions enable households to monitor their electricity consumption and turn the unit on and off via a mobile phone or tablet using Wi-Fi. During the survey, we also told respondents that smart functions require Wi-Fi in the home.

[7] For the Philippines, the label called 'energy guide' was used to be issued by DOE and attached for window-type ACs without inverter as the energy efficient indicator. The EER (energy efficiency ratio) was shown on 'energy guide'.

[8] In July 2017, MyVoice Communications conducted a representative "Questionnaire Survey on Household Air Conditioners" in Japan. The survey found that the most popular additional function of ACs is an auto-cleaning function.

Table 1: Attributes and Levels for Split ACs

Attributes	Levels				
Purchase price	PhP 25,000	PhP 30,000	PhP 35,000	PhP 40,000	PhP 45,000
Country of manufacturer	Philippines	Japan	Korea	United States	
Additional functions	No additional function	Auto-cleaning	Air purification	Smart functions	
Energy Star Rating (energy efficiency)	★	★★	★★★	★★★★	★★★★★

We created an efficient experimental design using the dcreate command in STATA 16, which leads to 48 scenarios (3 alternatives * 8 questions * 2 blocks) including a status-quo option. The status-quo option is an alternative under which neither AC 1 nor AC 2 with differing attributes is chosen. The respondents were split into two groups, with half of the respondents assigned to each group. An example of a choice experiment set in our study is shown in Table 2.

Table 2: Example of Choice Set

	AC 1	AC 2	
Purchase price	PhP 25,000	PhP 30,000	**I purchase neither AC 1 nor AC 2**
Additional functions	Noise reduction	Smart functions	
Country of manufacturer	Philippines	Japan	
Energy star rating	★★	★★★★	
Choose one			

2.3 Econometric Strategies

The purpose of this study is to identify the attributes that influence the decision to purchase an AC, with a specific focus on how energy efficiency affects the decision-making process. To achieve this, we refer to the standard random utility theory (McFadden, 1974; 1984), and define U_{njt} as an individual n's latent utility for alternative j in choice situation t, which is decomposed into a deterministic component V_{njt} and an unobserved stochastic component ε_{njt} which is independently and identically distributed as a Gumbel distribution. That is,

$$U_{njt} = V_{njt} + \varepsilon_{njt} \cdot\cdot\cdot (1)$$

We assume that a respondent *n* chooses alternative *j* if and only if $U_{njt} > U_{nit}$ for any *j*≠*i* in choice situation *t*. In this study, each respondent chooses an alternative from a set of three alternatives, including two types of ACs and status quo (not purchasing either) ($j \in 1,2,3$) eight times ($t \in 1,2,\ldots,8$). Each type of AC is described by four attributes. Therefore, the deterministic component of the utility is described as follows:

$$V_{njt} = status\ quo + \boldsymbol{\beta_n^E EnergyStarRating_{ijt}} + \beta_n^p Price_{ijt} + \boldsymbol{\beta_n^C Country_{ijt}} + \boldsymbol{\beta_n^A AdditionalFunctions_{ijt}}, \cdot\cdot\cdot \quad (2)$$

where $\boldsymbol{EnergyStarRating_{ijt}}$ is a vector of energy efficiency indicators for each energy star rating from 2 to 5, $Price_{ijt}$ is a continuous variable that indicates the price of an air conditioner, $\boldsymbol{Country_{ijt}}$ is a vector of dummy variables that indicates the country of manufacturer, and $\boldsymbol{AdditionalFunctions_{ijt}}$ is a vector of dummy variables that indicates additional functions. As the base category, for $\boldsymbol{EnergyStarRating_{ijt}}$, $\boldsymbol{Country_{ijt}}$, and $\boldsymbol{AdditionalFunctions_{ijt}}$, , we set an energy efficiency level of 1, the manufacturer as the Philippines, and the case of no additional functions, respectively. *Status quo* implies a status-quo option. $\boldsymbol{\beta_n}$ ($\boldsymbol{\beta_n^E}$, $\boldsymbol{\beta_n^C}$, $\boldsymbol{\beta_n^A}$, $\boldsymbol{\beta_n^p}$) are parameters to be estimated and can vary across respondents (Train, 2009). Following the standard in the literature, we assume that these parameters are normally distributed except that of price, which is assumed to be fixed (Schleich et al., 2022).

Based on these assumptions, a respondent n's logit probability of alternative i from the observed sequences of choices in a total of T can be specified as follows.

$$L_{ni}(\beta_n) = \prod_{t=1}^{T} \frac{\exp(V_{nit})}{\sum_{j=1}^{J} \exp(V_{njt})} \cdot \cdot \cdot (3)$$

Using $f(\beta|\theta)$, which is the density function of β, where θ is the parameter of β's distribution, the unconditional probability that a respondent n chooses alternative i based on the mixed logit model (Revelt and Train, 1998; McFadden and Train, 2000) can be obtained as follows.

$$P_{ni}(\theta) = \int L_{ni}(\beta) f(\beta|\theta) d\beta \cdot \cdot \cdot (4)$$

Moreover, the corresponding log-likelihood function $LL_i(\theta)$ can be written as follows.

$$LL_i(\theta) = \sum_{n=1}^{N} \ln P_{ni}(\theta) \cdot \cdot \cdot (5)$$

As there is no closed-form solution for this equation, we obtain the parameters by simulated maximum likelihood estimation with 1,000 Halton draws (Train, 2009).

3. Data and Stylized Facts

3.1 Descriptive Statistics

We present the descriptive statistics for all respondents in Table 3. Our respondents are relatively young and only 10% live alone. Approximately 70% of respondents are married or common-law married and live with their children who are younger or not yet in junior high school. We also find that most live in an urban area. Slightly more than half of the respondents are full-time workers, including full-time employees and self-employed. A relatively high percentage of respondents own their home. The New Ecological Paradigm (NEP) scale, developed by Dunlap et al. (2000) is widely used to measure individual environmental attitudes. It comprises 15 items where eight are framed as pro-environmental statements and the remaining seven are framed as anti-environmental statements. Respondents were asked to indicate the extent to which they agreed with each item. The most pro-environmental response is given the score of five, while the most anti-environmental response is given a score of one. We then sum the scores for each 15 items, so that the NEP value ranges from 15 to 75 where higher values indicate stronger environmental attitudes. The mean of NEP among respondents is 44.81 out of 61, which is lower than for developed countries (e.g., Gutsche et al., 2021).

The differences in the descriptive statistics among the three metropolitan areas are shown in Table A1. The table shows similar characteristics among the subsamples for age, NEP scale, ratio of females, working full time, and living with children. We find that metropolitan Manila has the highest household monthly income and Davao has the lowest. The same trend is observed for the ratio of university degree completion. However, the married ratio in Manila is much lower than in the other two areas. The proportion of those living alone is the highest in Cebu. Whereas all respondents in Manila live in the key cities, some participants in the other two areas live in surrounding towns, too. Finally, the ratio of homeowners in Manila is much lower than in the other two areas, which could be related to the fact that all respondents in Manila live in the urban area, thereby, owning their home is likely to be more expensive than in Cebu and Davao.

Table 3: Summary Statistics

	No. of Respondents	Mean	SD	Min	Max
Age	450	38.19	12.81	18	78
Female	450	0.5	0.50	0	1
Household monthly income in PhP	450	23,490	16,837.85	5,000	180,000
University Degree	450	0.10	0.31	0	1
Married	450	0.69	0.46	0	1
Living alone	450	0.10	0.30	0	1
Living with children	450	0.66	0.48	0	1
Living in urban area	450	0.87	0.34	0	1
Working in full time	450	0.58	0.49	0	1
Homeowner	450	0.72	0.45	0	1
NEP	450	44.81	5.07	27	61

3.2 Ownership of Space-cooling and Use

Table 4 summarises the trend in ownership of space-cooling appliances, their use, and monthly electricity fee[9]. We find significant differences between the ownership of ACs and fans. Although only 19% of respondents own an AC, almost everyone owns at least one fan. Figure 1 shows that the majority of AC owners have only one AC[10]. We also find that the average AC use per day is 8.40 hours, which is consistent with the survey responses in the Manila Metropolitan Area (Nakai et al., 2023). However, non-owners expect to use ACs for a slightly shorter time, 7.54 hours per day. Figure 2 also

[9] We included Table A2 in the Appendix to show the descriptive statistics of Electricity Consumption, Ownership of Space-Cooling Appliances, and Usage by the three metropolitan areas.

[10] Ownership rates by AC type are shown in Appendix Figure A1.

shows that AC owners tend to use ACs more than the expected AC use by non-owners. We also asked respondents how often they (expect to) use an AC in a year. Figure 3 shows about 60% of non-owners declare that they want to use AC everyday throughout the year, whereas only 30% of owners responded the same way. The most popular answer among AC owners is “about half” suggesting that the majority of owners expect the electricity fee would be too expensive if they use an AC nearly every day.

Table A2 shows electricity consumption, ownership of AC, and its use by the three different areas. We find that about 20% of respondents in Manila and Cebu own their ACs, whereas only 10% own an AC in Davao. Regarding AC use during summer, AC owners in Manila and Cebu use their AC about nine hours per day, whereas those in Davao use it less. These differences in AC ownership and use may be partially related to income differences. However, we do not see any significant differences in expected AC use per day among non-AC owners regardless of where they live.

Table 4: Electricity Consumption, Ownership of Space-Cooling Appliances, and its Use

	No. of Respondents	Mean	SD	Min	Max
AC Ownership	450	0.19	0.40	0	1
AC use per day during summer (owner)	87	8.40	4.26	1	24
Expected AC use per day during summer (non-owner)	363	7.54	5.47	1	24
Monthly electricity fee in PhP during summer	450	2,273.29	2,204.70	100	18,000
Monthly electricity fee in PhP during summer (owner)	87	4,334.16	2,911.63	1,000	18,000
Monthly electricity fee in PhP during summer (non-owner)	363	1,776.92	1,654.44	100	11,000
Electricity fee/Household Income	450	0.11	0.12	0.0015	0.88

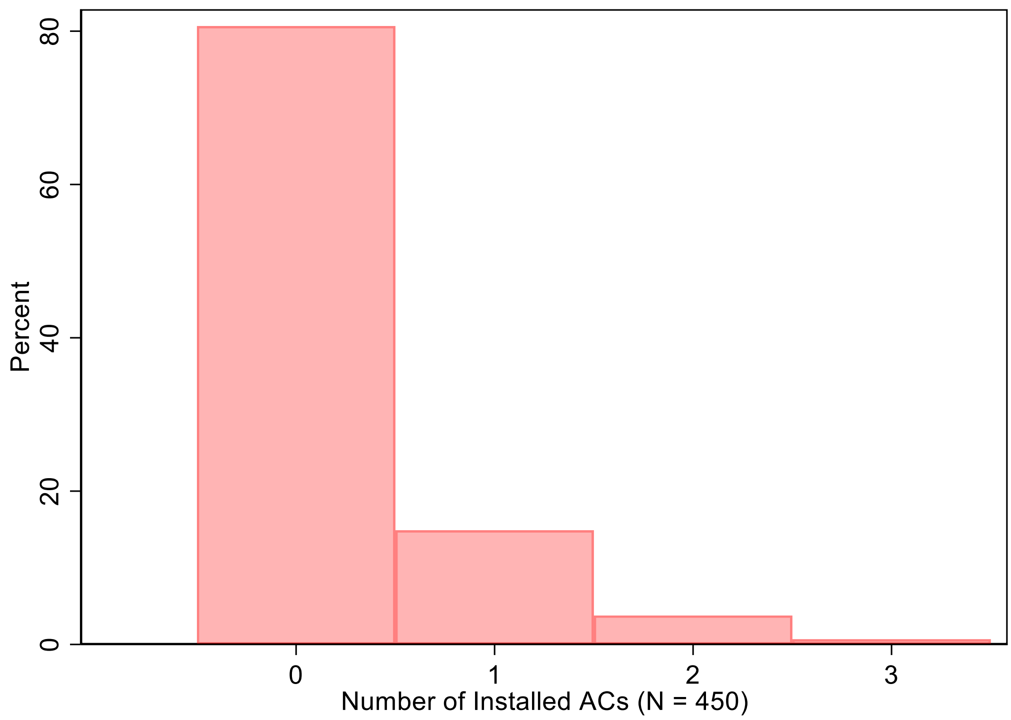

Figure 1: Ownership of AC

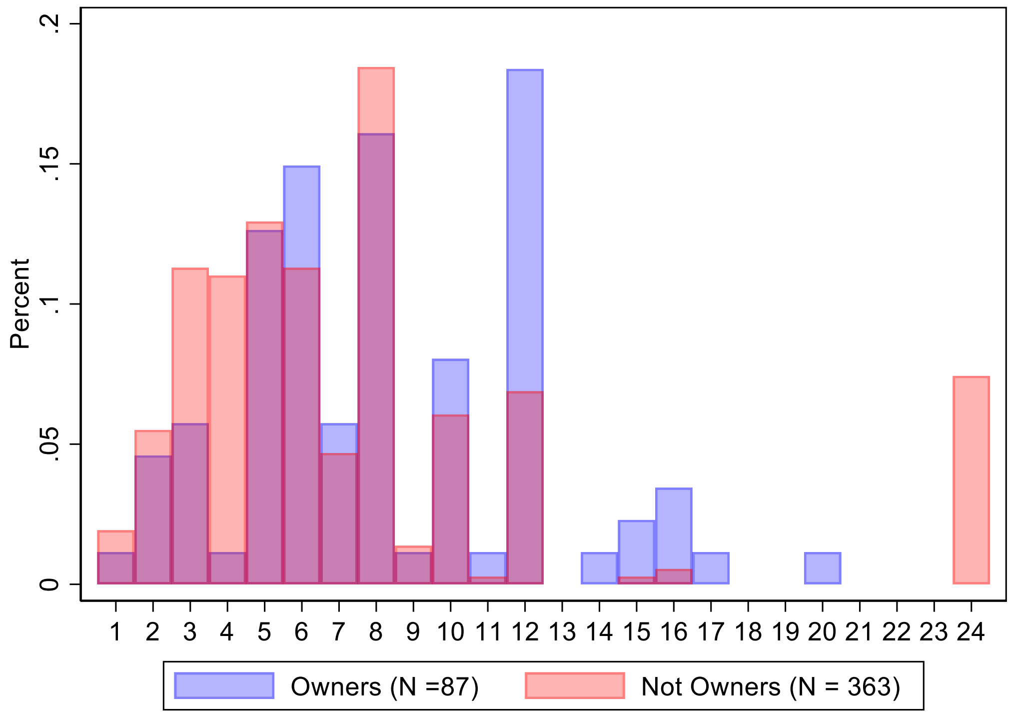

Figure 2: Daily (Expected) AC Use during Summer, 2022

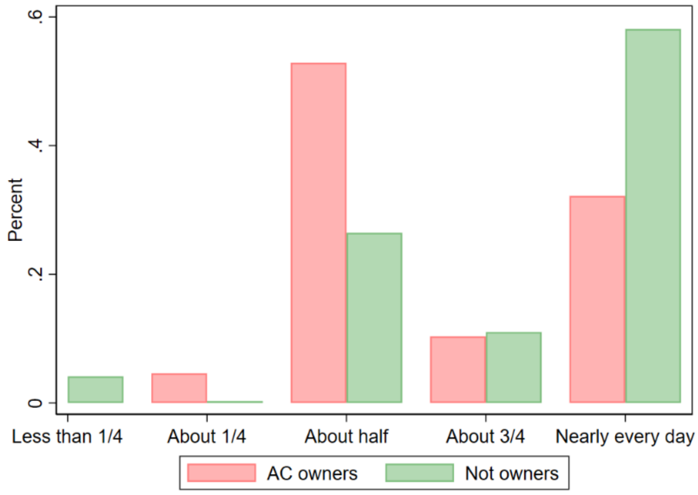

Figure 3: Yearly (Expected) AC Use

Electricity prices in the Philippines are high by regional standards (Ravago, 2023). Our survey data show how electricity fees impose a heavy burden on households in the Philippines. The monthly electricity fee during summer is approximately 10% of the household income. The ratio of the electricity fee to household monthly income is a surprising 17% in Manila (see Table A2). Furthermore, the table shows that the average monthly electricity fee in Manila is much higher than in Cebu and Davao, which could be because more people work from home in Manila. Income differences are another important factor as it is natural to assume that households with more income are likely to spend more on electricity.

Figure 4 illustrates the distribution of monthly electricity fees by AC ownership, showing that the distribution of non-owners is more left-skewed. Along with the findings in the graph, Table 4 also shows that AC owners pay a monthly electricity fee that is approximately 2.5 times higher than non-owners.

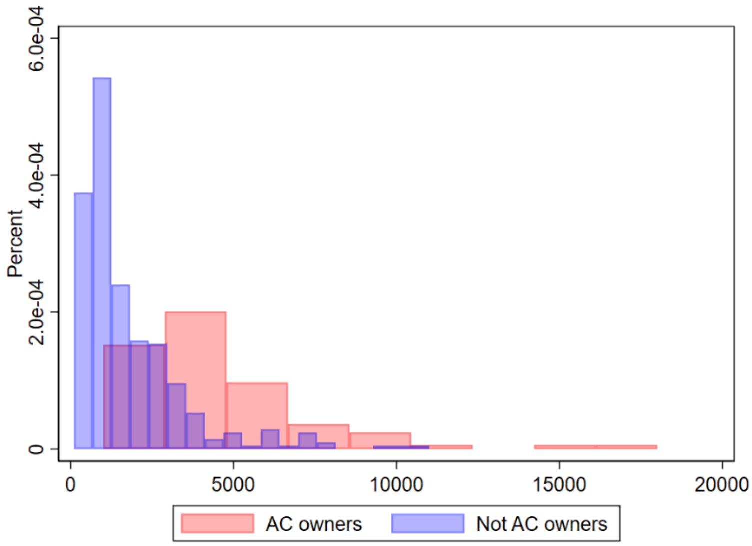

Figure 4: Electricity Fee (in PhP) during Summer by AC Ownership

4. Results and Discussion

4.1 Estimation Results from Mixed Logit Model (MXL)

We interpret the estimation results from the MXL model. We assume that the coefficient of price is fixed and the other coefficients are random. The main results are summarized in Table 5. The results of Model 1 are reported in columns (1) and (2) with specifications following equations (1) to (3). Columns (3) and (4) show the result of Model 2, where we treat the Energy Star Rating as a continuous variable. Columns (1) and (3) display the mean coefficient of each attribute and alternative-specific constant, while columns (2) and (4) show standard errors of the mean coefficient. If the standard error is statistically significant, it implies the possibility of heterogeneity in the effect of variables among respondents.

In terms of the Energy Star Rating, all coefficients of the indicator are statistically significant at the 1% level regardless of the specification (Model 1 or Model 2). Our results reveal that respondents, on average, prefer energy efficient ACs. Moreover, the size of these coefficients is larger for higher energy efficiency rating levels, suggesting a stronger preference for higher energy efficiency.

The coefficient of price is statistically significant at the 1% level and has a negative sign. It is consistent with economic theory that suggests an increase in price leads to a decrease in demand. Regarding the alternative-specific constant, its coefficient is negative and strongly significant at the 1% level, indicating that respondents, on average, do not appreciate the status quo option (not purchasing either AC).

Regarding preferences for country of manufacturer, we find that the coefficients of all country indicators are negative and statistically significant at least at the 5% level, except for Japan. This means that respondents, on average, prefer ACs manufactured in the Philippines compared with those from other countries.

As for additional functions, we find that all additional functions such as air purification, auto cleaning, and smart functions have positive and statistically significant coefficients at the 1% level. It is intuitive that respondents appreciate more convenience on average, and there is no statistically significant heterogeneity in the preferences among respondents for each of the functions.

Table 5: Estimation Results with Mixed Logit Model

	Model 1		Model 2	
	(1)	(2)	(3)	(4)
VARIABLES	Mean Coefficient	S.D.	Mean Coefficient	S.D.
AC Price	-6.14e-05***		-6.17e-05***	
	(1.69e-05)		(1.32e-05)	
Status-quo	-4.554***	4.239***	-4.084***	4.528***
	(0.555)	(0.351)	(0.533)	(0.383)
Energy Star Rating (Continuous)			0.585***	0.544***
			(0.0432)	(0.0467)
Efficiency level 2	0.424***	0.0877		
	(0.127)	(0.353)		
Efficiency level 3	0.986***	0.0129		
	(0.133)	(0.205)		
Efficiency level 4	1.537***	0.0627		
	(0.128)	(0.503)		
Efficiency level 5	2.067***	-1.428***		
	(0.164)	(0.155)		
Japan	-0.191*	0.589***	-0.129	0.685***
	(0.114)	(0.116)	(0.0995)	(0.117)
Korea	-0.810***	0.689***	-0.812***	0.680***
	(0.118)	(0.143)	(0.115)	(0.161)
US	-0.300**	-0.379*	-0.294**	0.703***
	(0.117)	(0.202)	(0.114)	(0.150)
Air purification	0.714***	-0.0502	0.696***	0.298
	(0.0930)	(0.522)	(0.0935)	(0.288)
Auto cleaning	0.848***	0.0930	0.831***	0.0379
	(0.120)	(0.179)	(0.112)	(0.323)
Smart function	0.692***	0.0380	0.657***	-0.0214
	(0.112)	(0.192)	(0.111)	(0.239)
Observations	10,800	10,800	10,800	10,800

*** 0.01<p, ** 0.05<p, * 0.1<p. Standard errors are in parentheses.

Table 6: Summary of WTPs

	(1)	(2)
Variables	WTP	
Energy Star Rating (Continuous)		9477.77***
Efficiency level 2	6903.73***	
Efficiency level 3	16054.86***	
Efficiency level 4	25040.17***	
Efficiency level 5	33668.15***	
Japan	-3109.97	-2094.47
Korea	-1.3e+04***	-1.3e+04***
US	-4885.42***	-4759.28***
Air purification	11637.42***	11279.77***
Auto cleaning	13812.18***	13466.20***
Smart function	11274.55***	10647.76***

*** 0.01<p, ** 0.05<p, * 0.1<p.

We also compute the WTP for each attribute, reported in Table 6. Except for the WTP for Japanese manufacturers, we find that all the WTPs are statistically significant at the 1% level. We can see that the WTP for Korean manufacturers is around PhP –13,000, while that of the US is around PhP –4,900. Regarding additional functions, the point estimates of WTP for air purification, auto cleaning, and smart functions are around PhP 12,000, PhP 14,000, and PhP 11,000, respectively. The WTP for an auto cleaning function is relatively higher than the three other functions. This result is different to Nakai et al. (2023), which could not find any statistical significance for auto cleaning and air purification functions using data from a choice experiment in the Philippines for August 2019. One possible reason for the difference is that the COVID-19 pandemic may have increased preferences for such functions.

Regarding the WTP for the Energy Star Rating, Figure 5 displays the WTP for each energy efficiency level from 2 to 5, compared with the baseline of level 1. The results indicate that respondents are willing to pay around PhP 6,900 more for energy efficiency level 2 (★★) compared with the baseline level. The WTP increases for higher energy efficiency levels, with the WTP for level 4 (★★★★) and level 5 (★★★★★) being PhP 25,000 and PhP 34,000, respectively. These WTPs are higher than some lower- or medium-priced ACs in our choice experiment design.

Based on these WTPs, the potential adoption of ACs with energy star ratings of 4 or 5 is conceivable in the Philippines. In 2023, the typical price of an AC with an energy star rating of 5 (one horsepower) ranged between PhP 30,000 and PhP 60,000 in the Philippines. The price range for an AC with an energy star rating of 1 (one horsepower) is between PhP 10,000 and PhP 30,000[11]. Given the estimated WTPs, it is possible that some respondents would purchase a higher energy efficiency model.

However, our data show that the mean value of average monthly income is about PhP 23,000 (PhP 32,000 for AC-owners and PhP 21,000 for non-AC owners). These statistics suggest that even if they were willing to purchase an energy efficient model, the purchase decision would not be straightforward. Therefore, it is pertinent to investigate which demographic groups are more likely (or less likely) to engage in this purchase decision. In the next sub-section, we analyse the socio-economic attributes associated with the purchase decision to identify effective policy instruments for support.

[11] We surveyed the price of AC using several e-commerce websites such as SM appliance, ABENSON, Lazada, and Shopee, all of whom sell home appliances in the Philippines.

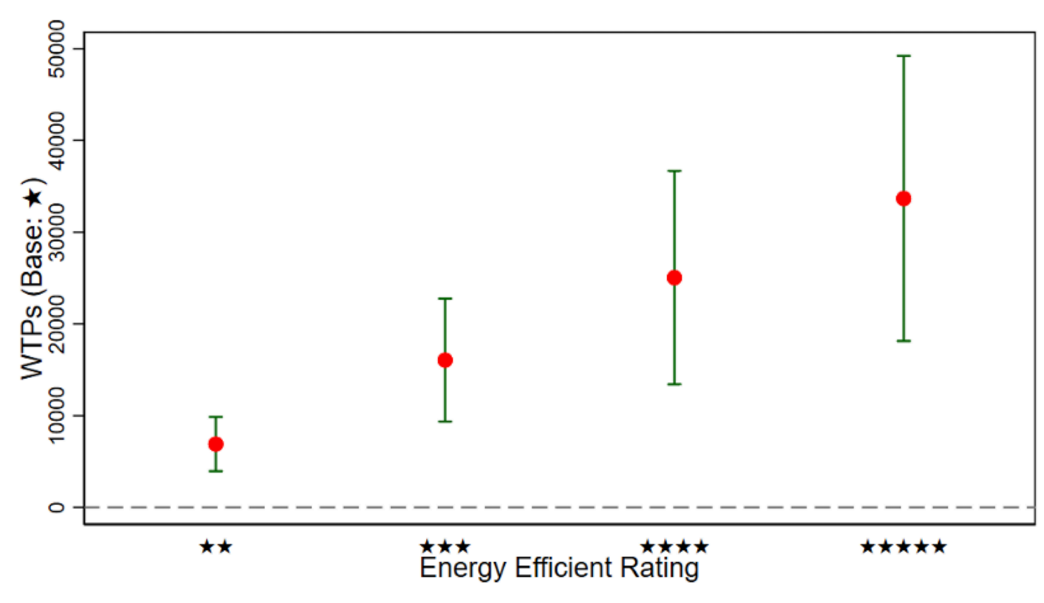

Figure 5: WTPs for energy efficiency

4.2 Who appreciates energy efficiency?

To investigate how to effectively promote the decision to purchase an energy efficient AC, we computed the marginal willingness-to-pay (MWTP), associated with an increase in the energy star rating with respect to various individual characteristics, namely socio-economic information and environmental awareness. Specifically, using the equation (2), we added several interaction terms between individual characteristics and the continuous energy star rating.

Figures 6 to 8 present the point estimates and 95% confidence intervals of MWTPs for an increase of the energy star rating based on various socio-economic characteristics and environmental awareness. Figure 6 summarises the MWTPs corresponding to educational backgrounds, whether respondents have ACs or not, and environmental awareness. We note that each MWTP is from a different estimation.

According to Figure 6, we find that the MWTPs for energy efficient ACs are higher for respondents who have ACs. Moreover, we reveal that respondents with higher than average NEP scale tend to have a higher WTP for energy efficiency. However, we fail to find any significant differences in the WTPs by graduation from university.

Figure 7 presents the MWTPs for an increase in the energy efficiency rating by age group. We find that the MWTPs are negative and statistically significant, except for the age group between 30 and 39. This result implies that respondents who are older than 40 do not understand the benefits of owning efficient ACs, compared with respondents under 30. Finally, Figure 8 shows the MWTPs for an increase in the energy efficiency rating by household income, with the baseline being under PhP 12,500. We find that only the MWTPs of respondents with incomes over PhP 35,000 are positive and statistically significant. This result indicates that respondents with higher household incomes have a higher preference for energy efficient ACs, compared with the income group under PhP 12,500.

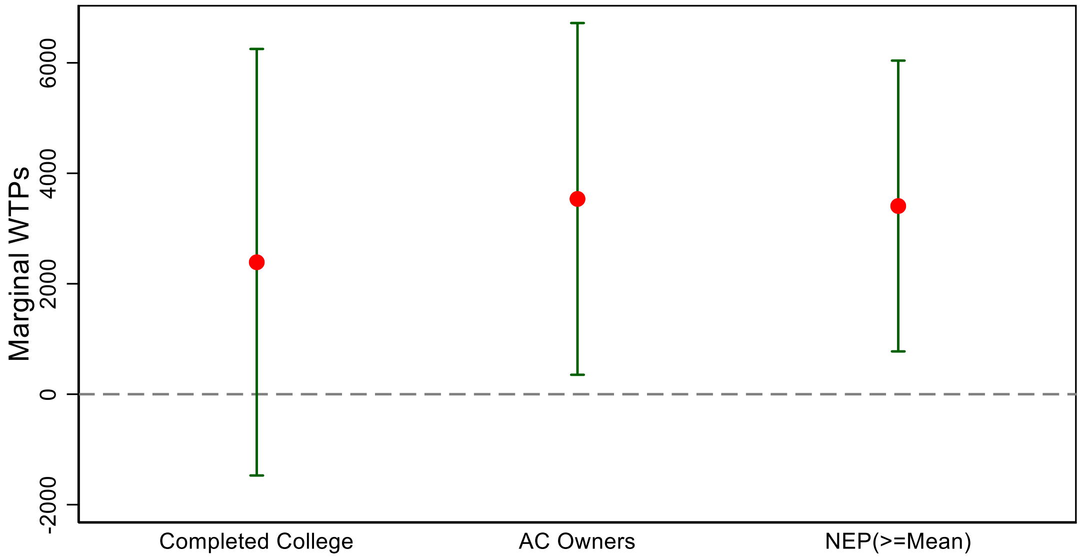

Figure 6: MWTPs for an increase in the energy star rating by socio-economic characteristics and environmental awareness (NEP)

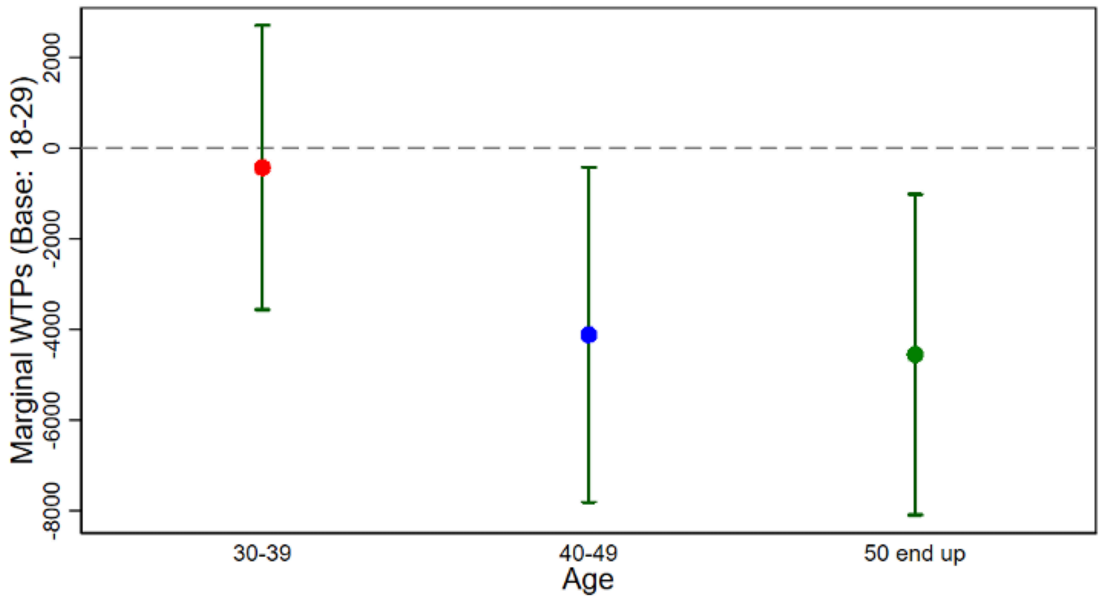

Figure 7: MWTPs for an increase in the energy star rating by age

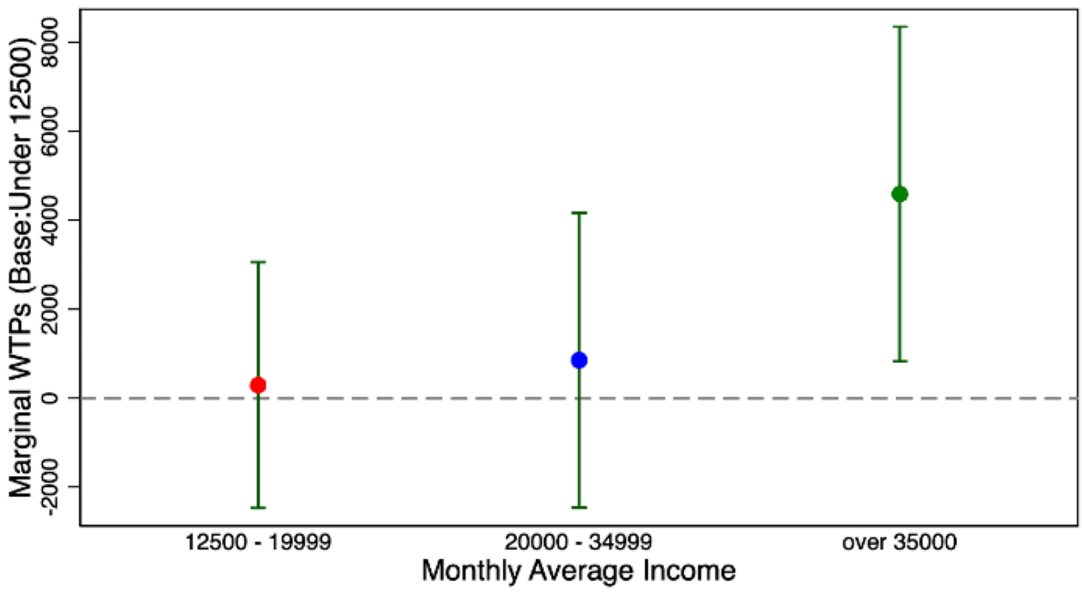

Figure 8: MWTPs for an increase in the energy star rating by monthly household income

One important implication of our analysis is the presence of an information gap in the Philippines. Our results reveal that once individuals begin using an AC, they are willing to purchase a more energy efficient model, suggesting an understanding of its benefits. A lower WTP among elderly groups compared with younger groups may also reflect such a lack of information. These findings suggest the need for an information campaign to bridge the gap in understanding regarding the benefits of ACs, especially, energy efficient ones.

In addition, enhancing environmental awareness can be effective. While our analysis did not find a statistically significant relationship between university degrees and WTPs, as discussed in the literature (Damigos et al., 2021; Schleich et al., 2016), it is also natural to expect that an increase in education level can help address the energy efficiency gap. Therefore, it is important to promote environmental awareness in not only educational institutions, but also lifelong education for adults.

Another effective policy instrument is a subsidy for purchases of ACs. When focusing on differences in preferences for energy efficient ACs by income levels, our finding implies that the WTP for ACs mainly reflects the preferences among a high-income group. It emphasizes the potential for an energy efficient model to become more popular as economic growth increases income levels and through subsidies for low-income groups.

4.3 Possible Rebound Effect

So far, we have shown the potential for transitioning towards energy efficient ACs and effective strategies to promote the decision to purchase them. However, it is crucial to consider the potential consequences, such as rebound effects, even if individuals opt for energy-efficient models. The phenomenon of "rebound effects" involves increased energy consumption because of efficiency measures that reduce energy costs. Thus, the rebound effect results in lower energy savings than expected (Sorrell, 2009 and Khazzoom, 1980). Many empirical studies show that a rebound effect related to home appliance use may occur in various countries, including developing countries. In tropical regions such as the Philippines, the potential of a rebound effect may be particularly significant.

In the survey, we asked the following question to respondents who have at least one AC (N = 87): "If you purchased a more energy efficient air conditioner, would you want to use it more per day?". We also asked, "How many hours more would you have used an AC per day?" to any person who answered "yes" to the previous question. These questions allow us to examine possible rebound effects if energy efficient ACs are more popular in the future in the Philippines.

Table 7 summarizes the summary statistics of possible rebound effects and total AC use, including rebound effects. Meanwhile, Figure 9 illustrates the distribution of total AC use with and without possible rebound effects. Among the 87 respondents, 85 of them expressed their intention to use their ACs more if they purchase energy-efficient models. The average number of additional hours they want to use their ACs is around seven hours, indicating that the total expected use could almost double.

As demonstrated in Figures 3 and 4 in Section 4.2, AC owners tend to have a better understanding of the energy cost associated with AC use compared with non-AC owners. Surprisingly, this group of AC owners is even more willing to increase their use if they switch to energy-efficient models. These statistics suggest that their current AC use might be constrained by their household income despite the extreme temperatures in the Philippines.

Table 7: Summary Statistics of AC use including rebound effects

	N	Mean	S.D.	Min	Max
AC use in September 2022	87	6.67	2.95	1.00	14.00
Daily AC Use - owner (April-May 2022)	87	8.26	3.93	1.00	20.00
Rebound Effect – # of hours	85	7.44	3.60	1.00	18.00
Total Expected AC use in September	85	14.13	5.71	2.00	24.00
Total Expected AC use in April to May	85	15.74	6.39	2.00	24.00

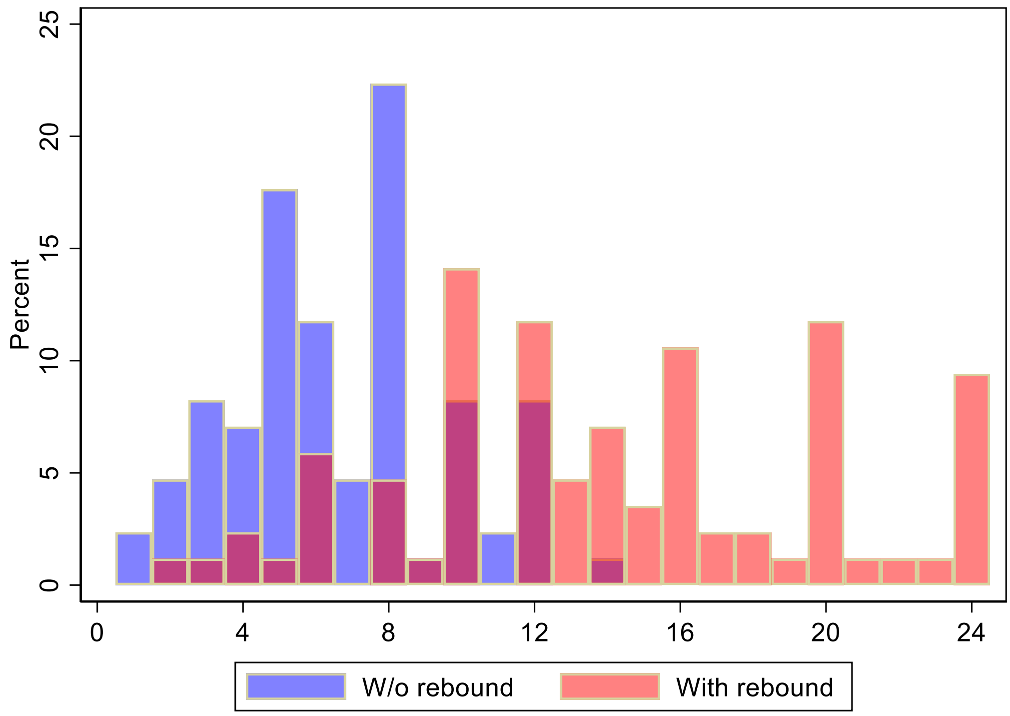

Figure 9: AC use with and without possible rebound effects based on AC usage in September

To examine which demographic attributes are related to extra hours of use, we conduct an OLS regression. Our selected covariates to explain the number of hours of extra use are as follows. As continuous variables, we include NEP, ratio of electricity bill in September to average household income, number of owned ACs and daily AC use in September. Moreover, we include an interaction between daily AC use in September and a dummy variable that takes the value of 1 if their daily AC use in September is greater than its sample mean of around 6.7 hours. We also add an indicator for a university degree, whether the respondent lives with family, and age group dummies. Finally, we include a dummy variable of impatient that takes the value of 1 if a respondent answers "very impatient" or "rather impatient". Region fixed effects are also included.

Our results are summarized in Table 8. We reveal that the impatient dummy variable and number of ACs are statistically significant at the 10% level. The ratio of electricity bill to household income is also statistically significant at the 5% level. Daily AC use and its interaction are not significant itself, however, they are jointly significant at the 1% level.

These results provide several implications. Basically, respondents consider the burden of their electricity bill when they use an AC (as expected), however, if their income increases in the future and the electricity rate is fixed, in other words, disposable income increases, their AC use is likely to rise. This tendency can be pronounced for those who have been using AC more frequently, particularly for individuals who use AC more than around 6.7 hours.

As discussed in Section 4.2, the amount of the WTPs for the energy label is substantial. Moreover, the WTP is relatively higher in a higher income group. However, the discussions in this section suggest that the size of the rebound effect is seriously high, notably evident in a high (disposable) income group. More to the point, it is likely to become increasingly severe as economic growth occurs, and average income levels in the Philippines increase.

Table 8: OLS regression results

VARIABLES	OLS # of extra hours
Impatient dummy	4.136*
	(2.265)
NEP	0.00435
	(0.0729)
Family	1.323
	(0.898)
Completed college	-1.159
	(0.805)
Daily use in September	0.600
	(0.366)
Daily use in September * D (daily use is higher than its sample mean value)	0.0464
	(0.217)
Number of ACs	1.465*
	(0.771)
Ratio of electricity bill in September to average household income	-0.0651**
	(0.0295)
Age group dummy 1 (30-39)	0.385
	(0.851)
Age group dummy 2 (40-49)	-1.395
	(1.016)
Age group dummy 3 (50>=)	-1.147
	(0.959)
Region Fixed effect	Y
F test	0.00***
Observations	85
R-squared	0.429

*** 0.01<p, ** 0.05<p, * 0.1<p. Robust standard errors are in parentheses. "F test" implies the F test for the null hypothesis that the coefficient of daily use in September and its interaction are jointly zero. We only show the p-value from this test.

5. Conclusion and Policy Implications

Energy efficiency plays a pivotal role in climate mitigation policies, particularly given the rise in energy consumption in developing countries. Specifically, for countries characterised by high temperatures, such as the Philippines, transitioning to energy-efficient ACs can significantly contribute to climate mitigation efforts and sustainable development.

We conducted a field survey with a choice experiment for the Philippines in 2022 to investigate the attributes that influence the decision to purchase ACs, as well as WTP for each attribute. While a previous study (Nakai et al., 2023) examines potential AC purchasers in Metro Manila, this study includes respondents who have a broader range of household incomes, electricity consumptions, and ownership of cooling space appliances in three metropolitan areas in the Philippines.

Our key objective is to examine how energy efficiency affects decision making for AC purchases. Therefore, we included an energy efficiency rating in the number of stars from 1 to 5, following the New Philippine Energy Label in our choice set. The other attributes of ACs are price, country of manufacturer (the Philippines, US, Korea, and Japan), and additional functions (no functions, air purification, auto cleaning, and smart functions).

Our main findings are as follows. First, households in the Philippines prefer a domestic manufacturer rather than a foreign manufacturer. Second, in terms of AC functions, households appreciate all additional functions. Finally, households are more likely to purchase ACs with a higher energy efficiency level than the base of level 1. Significantly, the WTPs for higher energy efficiency levels, specifically for levels 4 (★★★★) and 5 (★★★★★), amounting to PhP 25,000 and PhP 34,000, respectively, surpass the price of several popular models available in the Philippines.

While the WTPs for energy efficiency are high enough, constraints related to income also pose challenges in deciding to purchase an energy efficient model. Therefore, we investigated which socio-economic groups are more (less) likely to purchase such a model. We found that households who are

AC owners, younger (between 18 to 29), higher income earners, and with higher environmental awareness, displayed higher MWTPs for higher energy efficiency.

These findings provide insights into promoting the purchase of energy-efficient AC units and climate mitigation in the Philippines. Our results indicate that households, particularly those with higher household incomes, are willing to pay more for energy efficient ACs, suggesting a potential shift towards these models as the economy grows and income levels rise. However, the prices of some current popular models exceed average household incomes. This emphasizes the importance of expanding subsidies for purchasing energy efficient ACs. Our analysis also shows that higher environmental awareness could help raise the support for higher energy efficiency, suggesting that environmental education or any information campaigns for the general public should be considered.

However, we found that an information gap is a significant barrier to the adoption of energy efficient ACs in the Philippines. The descriptive statistics indicate that individuals without ACs lack comprehension regarding the costs associated with AC use. This challenge is more serious in older age groups, whose WTPs for energy efficiency are relatively smaller among all age groups. However, we discovered that households who already own ACs have a higher WTP for energy-efficient alternatives. To address this, it is crucial to provide information about tangible energy costs and energy efficient AC use, such as the estimated annual electricity fee and savings compared with some older models.

Even if it could effectively encourage a transition to energy efficient ACs, concerns about a potential rebound effect in AC use arise. This study reveals that households would use their ACs more if they had energy-efficient models, potentially resulting in nearly doubled energy consumption. By examining the relationship between rebound effects and demographic attributes, we find that the size of the rebound is larger at higher disposable income levels. It is particularly notable among individuals who use ACs longer, exhibit impatience, and own ACs.

An illustrative policy instrument aimed at promoting the acquisition of energy-efficient appliances was the “Eco-point Program” implemented in Japan between 2009 and 2012. Under this initiative, a financial incentive, referred to as the “eco-point,” was offered for the purchase of TVs, refrigerators, or ACs with the highest and second highest energy saving level on the label, as determined by the Agency for Natural Resources and Energy, Japan. These “eco-points” could then be redeemed in the form of electronic funds or vouchers. The Ministry of the Environment, Japan, has reported a staggering 45 million applications submitted for this program, culminating in an estimated total of 2.6 trillion Japanese Yen in sales for these three categories of home appliances (Ministry of the Environment Japan, 2011). However, the Board of Audit Japan has reported that an unintended consequence of this program, resulting in an increase in CO_2 emissions, was an increase in the use of these appliances (Board of Audit of Japan, 2012). The lessons from this program further emphasize the necessity of addressing the rebound effects of AC use in the Philippines.

Finally, we discuss several limitations of our study. First, we only had 150 respondents per region. For future research, it would be desirable to include a larger number of participants from each region. Second, when investigating the possibility of rebound effects, we asked respondents directly about their likely AC use if they owned an energy efficient AC. However, it might be beneficial to provide actual model information to make it easier for respondents to consider actual energy costs. Finally, how purchase intentions would be affected by governmental support such as subsidies or loans should be examined in future analysis.

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Appendix

Figure

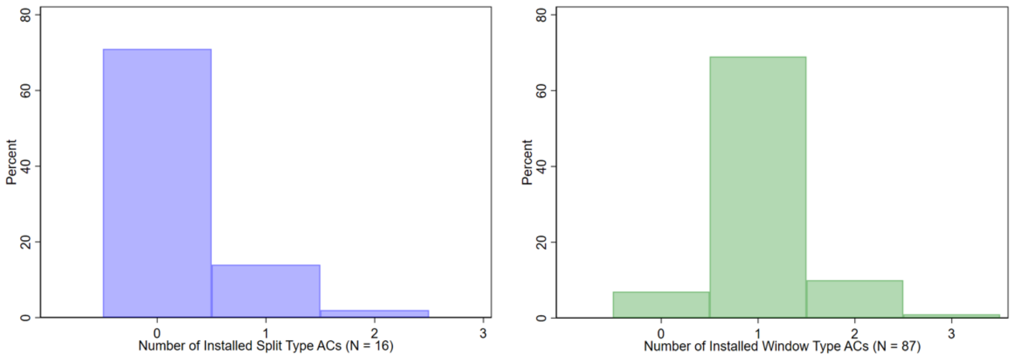

Figure A1: Ownership of AC by type

(lefthand-side: Split type, righthand-side: Window type)

Tables

Table A1: Summary Statistics

	Manila (n=150)		Cebu (n=150)		Davao (n=150)	
	Mean (SD)	Min-Max	Mean (SD)	Min-Max	Mean (SD)	Min-Max
Age	38.89 (13.65)	18-78	37.73 (11.27)	18-78	37.95 (13.43)	18-72
Female	0.5 (0.51)	0-1	0.5 (0.50)	0-1	0.5 (0.50)	0-1
Household monthly income	26,253.99 (24,837.99)	5,000-180,000	23,010.00 (11,217.12)	5,000-70,000	21,205.99 (9,920.74)	5,000-50,000
University degree	0.15 (0.36)	0-1	0.1 (0.30)	0-1	0.06 (0.24)	0-1
Married	0.57 (0.50)	0-1	0.78 (0.42)	0-1	0.71 (0.46)	0-1
Living alone	0.09 (0.28)	0-1	0.18 (0.39)	0-1	0.04 (0.20)	0-1
Living with children	0.43 (0.50)	0-1	0.51 (0.50)	0-1	0.49 (0.50)	0-1
Living in urban area	1 (0)	1	0.73 (0.44)	0-1	0.87 (0.34)	0-1
Working in full time	0.57 (0.50)	0-1	0.53 (0.50)	0-1	0.63 (0.48)	0-1
Homeowner	0.61 (0.49)	0-1	0.81 (0.39)	0-1	0.75 (0.43)	0-1
NEP	46.03 (4.03)	33-56	45.92 (5.01)	27-61	42.47 (5.28)	29-56

Table A2: Electricity Consumption, Ownership of Space-Cooling Appliances, and their Use

	Manila (n=150)		Cebu (n=150)		Davao (n=150)	
	Mean (SD)	Min-Max	Mean (SD)	Min-Max	Mean (SD)	Min-Max
AC Ownership	0.25 (0.43)	0-1	0.23 (0.42)	0-1	0.11 (0.31)	0-1
Fan Ownership	0.99 (0.08)	0-1	1 (0)	0-1	0.98 (0.14)	0-1
AC use per day during summer (owner)	8.51 (3.88) [n=37]	3-20	9.12 (3.90) [n=34]	2-17	5.88 (3.34) [n=16]	1-12
Expected AC use per day during summer (non-owner)	7.05 (4.95) [n=113]	1-24	7.59 (5.02) [n=116]	1-24	7.90 (6.23) [n=134]	1-24
Monthly electricity fee during summer	3,244.86 (2,806.05)	150-18,000	1,927.18 (1,584.20)	300-9,089	1,647.82 (1,673.00)	100-15,000
Monthly electricity fee during summer (owner)	5,438.05 (3,226.80) [n=37]	1,000-18,000	3,550.12 (1,883.80) [n=34]	1,200-9,089	3,501.88 (3,266.61)	1,200-15,000
Monthly electricity fee during summer (non-owner)	2,526.74 (2,240.31) [n=113]	150-11,000	1,451.49 (1,107.43) [n=116]	300-8,000	1,426.44 (1,212.13)	100-7,000
Electricity fee/Household Income	0.17 (0.16)	0.02-0.88	0.09 (0.06)	0.01-0,4	0.09 (0.08)	0.01-0.42