Appliance Penetration Analysis

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1. Introduction

Appliance penetration in Beijing, China, is driven by a multitude of factors, including household income, education level, household size, etc. The main drivers behind the adoption of each appliance also vary according to appliances' different value propositions to households. Based on a comprehensive household survey conducted in Beijing for 107 households, we have analyzed in detail the socioeconomic characteristics of our sample population as well as the penetration rate of major electric appliances in households.

In our initial literature review, we found that most of the existing research on appliance penetration is conducted using macro data. Our research is unique in that we examine the penetration of individual appliances by using micro level data collected through the detailed household level survey. It is a critical piece of groundwork research that will inform future endeavor on how households will behave given certain sets of household characteristics.

This paper is divided into the following sections: method and data will detail the survey results that our analysis is based on, as well as the methodologies that we chose to re-categorize the raw data and investigate potential relationship between socioeconomic status and penetration rates. Results and discussions focus on four areas: 1) exploratory analysis on the sample population, 2) an in-depth analysis on different penetration rates of common household appliances, 3) & 4) analysis on how household socioeconomic characteristics affect the number of ACs and PCs owned by surveyed families. Finally, the conclusion section will summarize our major findings.

2. Method and data

In this section, we describe raw data we used from the database, explain how we manipulated and created variables for the analysis and discuss methods that we used for the analysis.

Our research topic is analyzing the relationship between penetration rates of different appliances and household socioeconomic status, so we used survey data from spreadsheets "household_appl" and "socioeconomic". We looked into the following variables: quantity of appliances (water heating, cooking, light bulbs, refrigerator, clothes washer, TV and computers) and socioeconomic variables (household size, age, income, education) of all households (see Table 2.1 and Table 2.2 in Appendix).

Our first step before analyzing the data is to re-categorize and define variables. For the variable household size, we grouped observations in the following way: household size = 1 or 2 -- small household, household size = 3 or 4 -- medium household, household size = 5 or above -- large household. According to Beijing Municipal Bureau of Statistics, based on 2010 Population Census, the average household size in Beijing is 2.45[1]. Using this number as the cut-off, we grouped households that have two or less people as small households. On the other hand, after examining the distribution of household size in our sample, we found that the number of households drops by 10 when the household size increases from 4 to 5 (see Figure 2.1). Therefore, we decided

to categorize households with three or four people as medium-sized households and households with more than four people as large households. This categorization also matches common perception of household size in urban China. In Chinese culture, a household of three or four is considered to be a medium-sized household where two parents and one or two children live together. If elderly people live with mid-aged parents and their children, then the household size is usually five or even larger. This type of household is considered to be large. In cases where only one person or a couple live in the house, the household size is usually considered to be small.

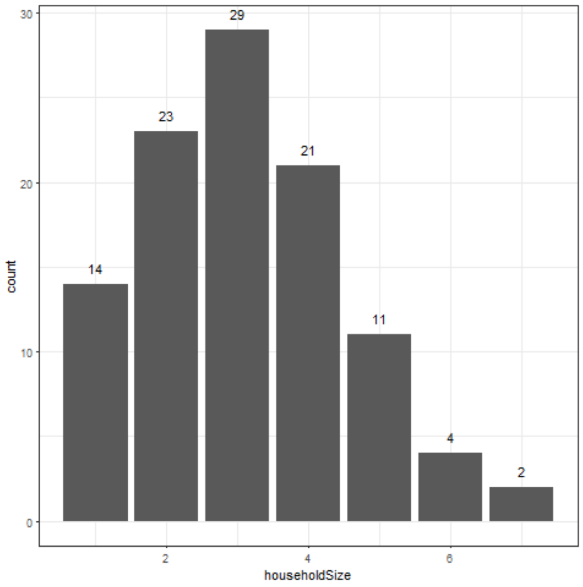

Fig. 2.1 Distribution of household size in the sample data.

For the variable age, we decided to summarize age features of a household by using these two variables: whether the household has people over 64 and whether the household has a pre-school child whose age is under 6. One of our hypotheses is that households with retired elderly people may have different penetration rates. In Beijing, the retirement age is 60 for males and 55 for females. However, instead of corresponding to retirement ages in Beijing, the ranges of age for old people in the survey are 55-64, 65-74, 75 or older. Therefore, we decided to define households with people who are either 65-74 or older than 75 as households with retired elderly people. Another one hypothesis is that households with pre-school children may have different penetration rates. In Beijing, under normal circumstances, a child goes to primary school at around seven years old. So we decided to use this cutoff and define households with people who are either under 3 or 3-6 as households with pre-school children.

For the income variable, we decided to regroup it into three categories to better facilitate analysis and interpretation of results. In the raw data, there are nine categories and after exploratory analysis, we realized that nine groups make it very difficult to find patterns. Although we first conducted analysis with income variable grouped in nine categories, we then grouped observations in the following way: income = 1 -- low income, income = 2 - 5 -- medium income, income = 6 - 9 -- high income. According to Beijing Municipal Bureau of Statistics, in 2016, the disposable personal income is 20204 for 20% lowest income households and 105425 for 20% highest income households[2]. Given that the average household size in Beijing is 2.45, we multiply the average number of people in a household and the disposable personal income for 20% lowest income households and got a number that's a little less than ¥50,000. Therefore, we decided that households with an income level one (income category 1: "¥0 - ¥49,999") are low-income households. We did the same

thing to find the cutoff for high-income households and decided that households with an income level six or above are high-income households. Note that being a low-income household in our analysis doesn't necessarily mean that, people in the household are poor because household size is critical to whether a household is considered low-income or not. We define low-income, medium-income, high-income from a household perspective. In other words, the variable household size and the variable income level are highly correlated.

For the education variable, we chose to use the highest education attainment in each household to represent the education level. After plotting the distribution of the highest education attainment in households (see Figure 2.2), we realized that our sample is highly concentrated with well-educated households. Given the lack of heterogeneity of highest education level in our sample, we didn't explore much about how education level influences penetration rates. Moreover, we recognize that all conclusions that we find from survey data only applies to households in which at least one person is highly educated.

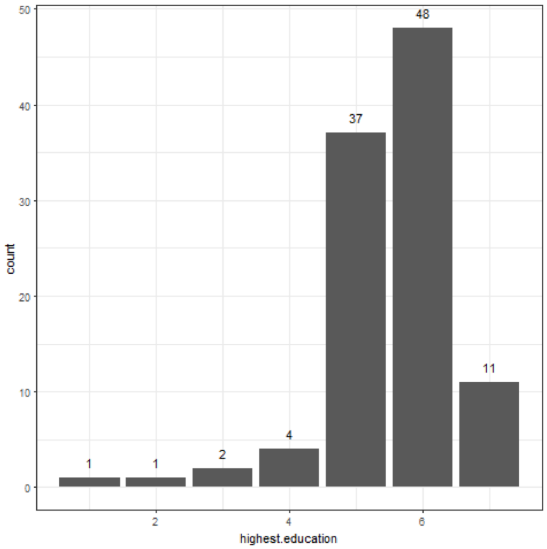

Fig. 2.2 Distribution of the highest education attainment for each household in the sample data.

After categorizing socioeconomic variables, we attempted several ways to analyze how different household attributes impact appliance penetration rates. Methods that we attempted to use but failed include logistic regression model, k-means and hierarchical clustering method. After intensive exploratory analysis, we found that what influences penetration rates most is a combination of different aspects of house characteristics instead of a single variable we defined above. In addition, all variables we have are categorical variables, so we can't capture the quantitative influence of each variable very well. That's why regression models don't work very well for our data. On the other hand, we tried to use clustering methods, but results are arbitrary and hard to interpret. In the end, we decided to go with the two-way tables to find and present patterns as it's the cleanest and most efficient way to investigate potential patterns and show our findings. We also applied ANOVA tests and t tests to back up our findings statistically.

Note that because of missing data, in our analysis, there are 104 observations in total.

3. Results and Discussions

In this section, we divide our results into four sections: household and socioeconomic characteristics, current common electric appliance ownership rate, determinants for AC quantity, determinants for PC quantity.

3.1 Household and socioeconomic characteristics

In our sample, 37 (35.58%) households have small household size, 50 (48.08%) households have medium household size, and 17 (16.34%) households have large household size. 88 (84.62%) households have people over 64 years old while 16 (15.38%) don't. 78 (75%) households have pre-school children while 26 (25%) don't. 4 (3.84%) households are categorized as low-income households, 50 (48.08%) households are categorized as medium income households, and 50 (48.08%) households are categorized as high-income households. Below, we list four major findings among these variables.

Finding 1: Households with pre-school kids tend to be larger in household size.

The average household size for households with pre-school children is 4.55 and the average household size is 2.47. We used ANOVA test and found that households with pre-school children and households without them have significantly different average household sizes (see Figure 3.1.1).

```
             Df Sum Sq Mean Sq F value   Pr(>F)
young         1  20.51  20.513   70.59 2.73e-13 ***
Residuals   102  29.64   0.291
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 3.1.1 ANOVA test output. Group "young" are households with pre-school children and the other group are households without pre-school children. Household size is the dependent variable.

There's a trend that having a pre-school child results in a larger household size (see Table 3.1.1). This finding corresponds to Chinese cultural norms that in many households, grandparents help parents take care of pre-school children. It's often seen that three generations live in one apartment because young parents are too busy with work to raise their pre-school children and thus invite their parents to help out with that. Note that in our sample size, there's no family in which only one adult is responsible for the pre-school child.

Table 3.1.1

Numbers and percentages of households that have pre-school children under different types of household sizes.

Household size	**No. of households**	**No. of households with pre-school children**	**Percentage of households with pre-school children**
Small (1-2 people)	37	0	0.0%
Medium (3-4 people)	50	11	22.0%
Large (5 and more people)	17	15	88.2%
All cases	104	26	25.0%

Finding 2: Households with people over 64 years old tend to be larger in household size.

Among households that have old people, the average household size is 4.0625 while the average household size is 2.9432 among households that don't have old people. We applied ANOVA test and found that

households with old and households without old have statistically significant difference in average household sizes (see Figure 3.1.2).

```
            Df Sum Sq Mean Sq F value  Pr(>F)
old          1   3.70   3.699   8.123 0.00529 **
Residuals  102  46.45   0.455
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 3.1.2 ANOVA test output. Group "old" are households with people over 64 years old and the other group are households without old people. Household size is the dependent variable.

There is a trend that having an old person results in a larger household size (see Table 3.1.2). As mentioned in the previous paragraph, this finding corresponds to Chinese cultural norms that in many households, grandparents help parents take care of pre-school children. However, in our sample size, there are cases where one old person lives in the household alone.

Table 3.1.2

Numbers and percentages of households that have old people over 64 years old under different types of household sizes.

Household size	No. of households	No. of households with old people over 64 years old	Percentage of households with old people over 64 years old
Small (1-2 people)	37	3	8.1%
Medium (3-4 people)	50	6	12.0%
Large (5 and more people)	17	7	41.2%
All cases	104	16	15.38%

Finding 3: Household size for households with either a pre-school kid or an old tends to be four or larger.

We created a new variable "old_child", which is one if a household size has a pre-school child or an old person, zero otherwise. The average household size for households with either a pre-school child or an old is 4.33. We applied ANOVA test to see if there's a statistically significant difference between mean household size for the group with children or old and the group without children and old. The low p-value rejects the null hypothesis and we reach the conclusion that households with either a pre-school child or an old have four or more people in the household (see Figure 3.1.3).

```
             Df Sum Sq Mean Sq F value   Pr(>F)
old_child     1  18.60  18.598   60.12 6.96e-12 ***
Residuals   102  31.56   0.309
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 3.1.3 ANOVA test output. Group "old_child" are households either with people over 64 years old or with pre-school children and the other group are households without old people and pre-school children. Household size is the dependent variable.

Finding 4: Households with lower overall income don't have pre-school children or old people.

It's possible that this result is particular to our data set since we only have four households that are categorized as low-income households. One or two people households are likely to be recent graduates from colleges or newly-weds who have yet to establish a well-paid career. Poor households in urban Beijing are also composed of migrant workers from less developed cities who are living apart from their core families.

3.2 Current common electric appliances penetration rate

In our descriptive analysis section for the ownership rate of household common electric appliances, we examined

1. Type of water heating system and percentage (e.g., proportion of households with electric water heater)
2. Type of cooking system and percentage
3. Type of light bulbs and percentage
4. Amount of appliance ownership per household, including refrigerator, clothes washer, TV, and laptops (also called PCs).

We plotted distribution graphs of all above appliances (see Figure 3.2.1 – Figure 3.2.7 in Appendix) and below is a summary of the penetration rate of each appliance in the households we surveyed.

Water Heating System: More households use natural gas than electricity or solar. Almost all households only have one water heating system.

Cooking system: All households have at least one cooking system, dominated by those powered by natural gas. There is one household using coal and no household that uses wood. This is mostly an urban characteristic because rural families in China still uses wood to prepare food.

Light Bulbs: There are 12 groups within the light bulb ownership types, grouped based on their types and locations in the house. The range in number of light bulbs owned per household is much larger than other appliances, presumably this number is highly correlated with income and type of dwelling. Average total number of light bulbs owned by households is 12 while the median is 8. The minimum is 0, which likely is a survey error, and the maximum is 94.

Fridges: Most households now own one fridge.

Washing machines: Most households now own one washing machine.

TVs: Most households now own one TV.

Laptops: Most households now own one to two laptops.

3.3 Cooling system and house characteristics

We conducted in-depth analysis on two electric appliances – AC and PC – to set up a framework for future research effort on the determining the key drivers behind ownership of different electric appliances. This section details our findings on the penetration rate of AC.

From the distribution of the number of ACs owned by households, we can see that most households have one to four AC units. Four households do not have AC and two households have above four ACs (see Figure 3.3.1).

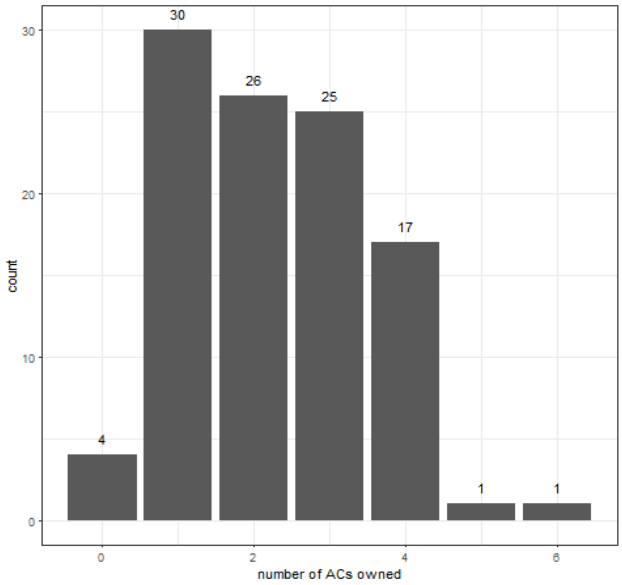

Figure 3.3.1 Distribution of the number of ACs owned by households

Because the type of AC owned affects the number of overall ACs in a household, we subsequently looked at the most common types of AC owned by Beijing households. Only eight households have centralized AC system, while most own window AC split system and most others own mini AC window units. We then examined the household characteristics associated with those that own central AC units (see Table 3.3.3 in Appendix) and found that all of these households are of the middle to upper income class. This result is expected because only the new and upscale apartments in Beijing are equipped with central AC units.

The type of AC has influence on the overall number of ACs that a household owns (see Table 3.3.1). For households that own central AC systems, there is no need for multiple ACs whereas mini ACs have more limited cooling power.

Table 3.3.1

Different types of AC systems owned.

Types of AC	Spacecool 1	Spacecool 2	Spacecool 3	Spacecool 4	Spacecool 5	Spacecool 6
Central AC	8	0	0	0	0	0
Window AC split unit	89	70	42	19	2	1
Portable AC	2	0	1	0	0	0
Others	1	0	1	0	0	0

There are four households in our sample that do not own any type of AC. Looking at the characteristics of these households (see Table 3.3.4 in Appendix), we found that all households without AC are single person families having medium income (one of which is a senior living by him/herself). They live without AC most likely because of their own preferences.

We then looked at the average number of ACs owned by households grouped according to their income levels, household size, and whether they have seniors or babies at home (see Table 3.3.5, 3.3.6 in Appendix). Inspecting values from the table, we noticed that holding the size of the household constant, there is an observable pattern that the average number of ACs increases as a household's income increases, specifically within the group where there is no babies at home.

Next, we performed a series of statistical tests to test the hypotheses of whether there are significant differences between families with different attributes (income, household size, and demographics). To test whether household income and size are significant determinants of the number of ACs owned by households, we conducted a two-way ANOVA test to test both variables as well as their interactions. As shown in the ANOVA output table (see Table 3.3.2), only household size makes a statistical difference in the average number of ACs owned by the different types of households, while income does not correlate with the number of ACs owned.

Table 3.3.2

Two-way ANOVA results of whether household size and income are significant determinants in the number of ACs owned by households.

	Sum_sq	**df**	**F**	**PR(>F)**
Size	21.708583	2	8.739968	**0.000326**
Income	4.683824	2	1.885728	0.157296
Size * Income	7.431663	4	1.49601	0.209476
Residual	119.223772	96	/	/

This finding is rather expected because AC is increasingly considered as a necessity and after income reaches a certain threshold, every household will purchase as many AC as sufficient to cool the house. The type of AC owned, however, is more determined by income level because central AC system is an uncommon amenity that only comes in the newer luxury apartments in Beijing.

Then, we looked at whether there are statistical differences between households that have either seniors or babies and those that have neither by performing two t-tests. Neither household attributes contributed to statistically significant differences in average number of ACs owned (see Python code 3.3.1, 3.3.2 in Appendix). This finding again contributes to supporting our hypothesis that AC is becoming a necessity that is used beyond protecting the more vulnerable members of the household.

3.4 PC and house characteristics

In our sample, the average quantity of PC per household is 1.74 and the mode quantity of PC is 1. Most households have one (44 households, 42.31% of the sample) or two PCs (29 households, 27.88% of the

sample). We first created two-way tables of average PC quantities under different combinations of income levels and household sizes for all households and subset households (see Table 3.4.2 – Table 3.4.7 in Appendix) to explore underlying patterns. Then, we used ANOVA tests to investigate statistical differences of average PC quantities between two or more groups. Below, we list six major findings about the relationship between socioeconomic factors and the quantity of PCs.

Finding 1: Household sizes, income levels, having an old or not, having a pre-school child or not, are not statistically significant determinants for different quantities of PC.

We applied ANOVA test to test if the following four variables are determinants for PC penetration rates and found that none of these variables are significant (see Figure 3.4.3 – Figure 3.4.6 in Appendix).

Finding 2: At 10% significance level, households that have an old or a pre-school kid and households with no old and children have statistically significant different quantities of PC.

We first used ANOVA and found the difference of PC quantities between households that have an old or a pre-school kid and households with no old and children significant (see Figure 3.4.1). The average PC quantity for households that have an old or a pre-school kid is 1.444 and the average PC quantity for households with no old and children is 1.926. Having an old or a pre-school child in the household leads to a smaller penetration rate of PC. It's possible that both old people and young children don't use PCs, so this type of households have a smaller average PC quantity. It's also possible that in order to protect the old and the young from radiation of PCs, households intentionally adopt fewer PCs.

```
             Df Sum Sq Mean Sq F value Pr(>F)
old_child     1   5.47   5.469   3.497 0.0643 .
Residuals   102 159.52   1.564
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 3.4.1 ANOVA test output with "having old or young" and "no old and young" as different groups and PC quantity as the dependent variable.

Finding 3: After sub-setting households with no old and pre-school children, we found that household size is a statistically significant determinant for PC quantity.

We first made the two-way table to present the average PC quantity for households with different household sizes and income levels (see Table 3.4.1). We can see the pattern that in each income level, as the household size increases, the average PC quantity per household also increases.

Table 3.4.1

Average PC quantity for households with no old or young people and of different household sizes and income levels.

	Small households	**Medium households**	**Large households**
Low-income	1.33 (3)	2 (1)	N/A
Medium-income	1.286 (21)	2.615 (13)	N/A
High-income	2.1 (10)	2.15 (20)	N/A

Note: the number in the bracket in each cell is the sample size in that category.

We also applied ANOVA test and concluded that within households with no old and children, household size is a statistically significant determinant for PC penetration rate (see Figure 3.4.2).

```
            Df Sum Sq Mean Sq F value Pr(>F)
size_new     1  10.72  10.721   6.438 0.0135 *
Residuals   66 109.91   1.665
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Fig. 3.4.2 ANOVA test output with household size as the independent variable and PC quantity as the dependent variable.

Finding 4: Income is not a statistically significant determinant for average PC quantities in households.

We applied ANOVA test to investigate whether income is a determinant of PC penetration rate for households with no old or children (see Figure 3.4.7 in Appendix). We also tried to lump together low income level and medium income level together and test against high income level households (see Figure 3.4.8 in Appendix). Neither of the above tests says that the income variable is a significant determinant for quantity of PC. Nowadays, because PC is no longer a luxury, people can buy it as long as they want it. So income level is not a constraint for PC purchases.

Finding 5: Households that have no PCs are either households with young or old or small-sized households.

We subset households that have no PCs and tried to use variables that we have to explain the reason behind having no PCs at home. Some households have young or old within family. Others only have one or two people within family. Only one household with three people has no PCs at all.

Finding 6: There's no significant and consistent pattern for households that have more than two PCs.

While most households in the sample have only one or two PCs, some have more than two. We tried to summarize characteristics of those households, but didn't find any consistent patterns. It's possible that reasons for owning more than two PCs are not explained in variables we have here. For example, particular job types may require more laptops than others. It's also possible that households with more than two PCs don't actually use more than two PCs. They own more than two PCs just because they didn't bother to get rid of old laptops. Some of PCs that they have might be old and outdated.

4. Conclusion

This paper is a deep dive into Beijing households' electric appliances ownership rate through examining household survey data that we conducted in Beijing, China. After summarizing statistics on our sample population, we found that our sample is biased toward the highly educated households in Beijing and thus the results we derived cannot be extrapolated to represent the entire Beijing population. Our income data also represents household data and thus there is ambiguity in the actual per capita income level within a household. To facilitate analysis, we re-categorized our income and household size groups into three broader categories.

We conducted a broad analysis on the penetration rate of common electric appliances in households. Most of the appliances range from one to three per household. Lightbulbs have the largest range in numbers owned per household, from a minimal amount to almost a hundred per household. From this observation, we deduce that most of the other appliances are necessities, so the ownership of one to two per household is sufficient. Lightbulbs, however, are both necessities and symbols of wealth, in which quantity translates to wealth.

Key findings within the AC analysis include that there is currently a low penetration of central AC system whereas AC window split units are much more common. Household size is the only statistically significant predictor of the number of AC units owned, but only middle to higher income households are equipped with central AC system. Households not equipped with AC are all single person households, and the decision to not purchase an AC seems to be one based on personal preference rather than financial constraint. Whether the households have seniors or babies also has no influence on AC ownership.

For our PC analysis, we found that at 10% significance level, households that have an old or a pre-school kid and households with no old and children have statistically significant different quantities of PC. Household size is also a statistically significant determinant for PC quantity if we solely look at households with neither seniors nor pre-school children. Income, as in the case of PC, is also not significantly correlated with the average PC quantity in households.

Reference

1. http://www.bjstats.gov.cn/zt/rkjd/zbjs/201603/t20160322_340748.html
2. http://www.bjstats.gov.cn/tjsj/yjdsj/jmsz/2016/201701/t20170122_367579.html

Appendix

2.1 Electric Appliance Penetration Rate Graphs and Tables

Table 2.1

Variables that we used in the spreadsheet “household_appl”.

Sheet name	Variables	Definition of the variable
waterheating	waterh_solar_qty	solar water heating devices ownership per household
waterheating	waterh_electricity_qty	electricity water heating devices ownership per household
waterheating	waterh_ng_qty	natural gas water heating devices ownership per household
waterheating	waterh_other_qty	other water heating devices ownership per household
cooking	cook_lpg_qty	LPG cook devices ownership per household
cooking	cook_ng_qty	NG cook devices ownership per household
cooking	cook_coal_qty	Coal cook devices ownership per household

lighting	light01_qty	light bulb 01 ownership per household
lighting	light02_qty	light bulb 02 ownership per household
lighting	light03_qty	light bulb 03 ownership per household
lighting	light04_qty	light bulb 04 ownership per household
lighting	light05_qty	light bulb 05 ownership per household
lighting	light06_qty	light bulb 06 ownership per household
lighting	light07_qty	light bulb 07 ownership per household
lighting	light08_qty	light bulb 08 ownership per household
lighting	light09_qty	light bulb 09 ownership per household
lighting	light10_qty	light bulb 10 ownership per household
lighting	light11_qty	light bulb 11 ownership per household
lighting	light12_qty	light bulb 12 ownership per household
refrigerator	fridge_qty	Refrigerator ownership per household
washingmachine	wash_qty	Washing machine ownership per household
tv	tv_qty	tv ownership per household
pc	pc_qty	PC ownership per household

Table 2.2

Variables that we used in the spreadsheet “socioeconomic”.

Sheet name	Variables	Definition of the variable
economic	income_annual_category	1 "¥0 - ¥49,999", 2 "¥50,000 - ¥99",999", 3 "¥100,000 - ¥149,999", 4 "¥150,000 - ¥199,999", 5 "¥200,000 - ¥299,999", 6 "¥300,000 - ¥399,999", 7 "¥400,000 - ¥499,999", 8 "¥500,000 - ¥599,999", 9 ">= ¥600,000"
demographics	household_size	Number of people in a household
demographics	person0#_age (1-7)	1 "under 3", 2 "03-06", 3 "7-11", 4 "12-17", 5 "18-24", 6 "25-34", 7 "35-44", 8 "45-54", 9 "55-64", 10 "65-74", 11 "75 or older"
demographics	person0#_edu (1-7)	1 "Elementary School", 2 "Middle School", 3 "High school", 4 "Bachelor's degree", 5 "Master's degree", 6 "PhD", 7 "Technical Training", 8 "Not started yet", 9 "No education"

3.2 Electric Appliance Penetration Rate Graphs and Tables

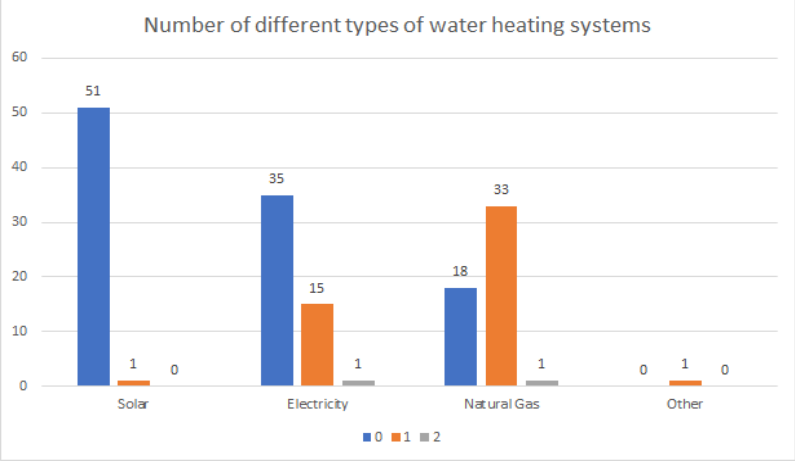

Fig. 3.2.1 Distribution of types of water heating systems.

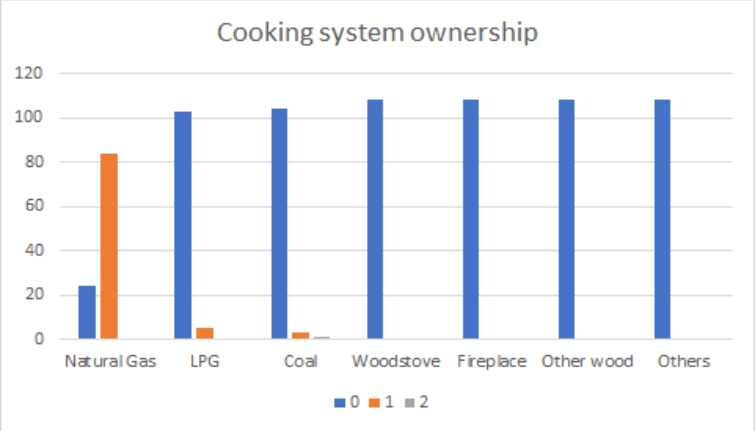

Fig. 3.2.2 Distribution of types of cooking systems.

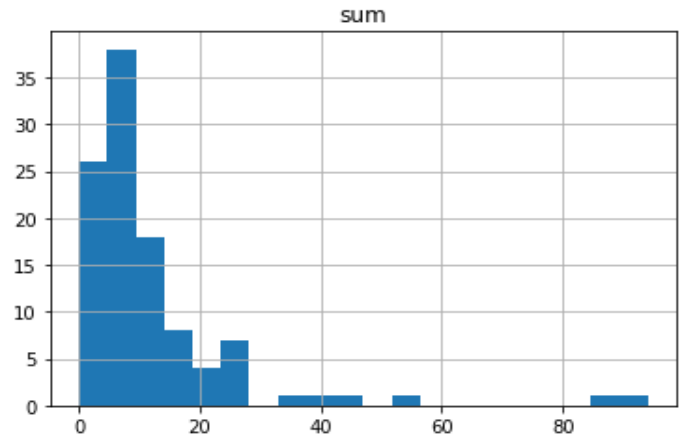

Fig. 3.2.3 Distribution of total number of lightbulbs owned.

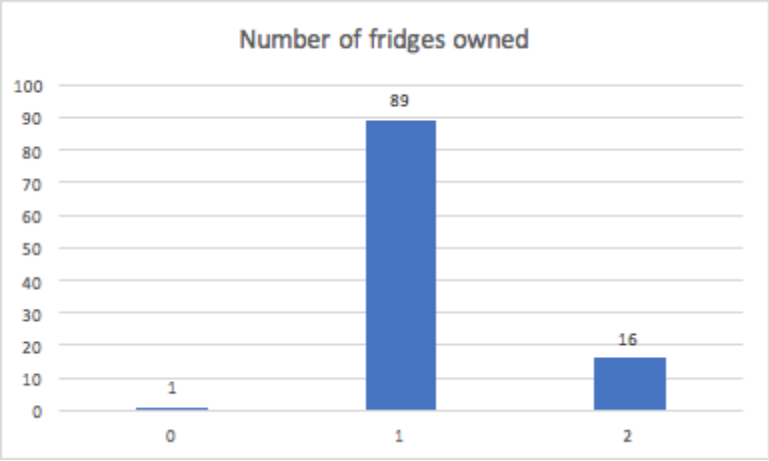

Fig. 3.2.4 Distribution of number of fridges owned.

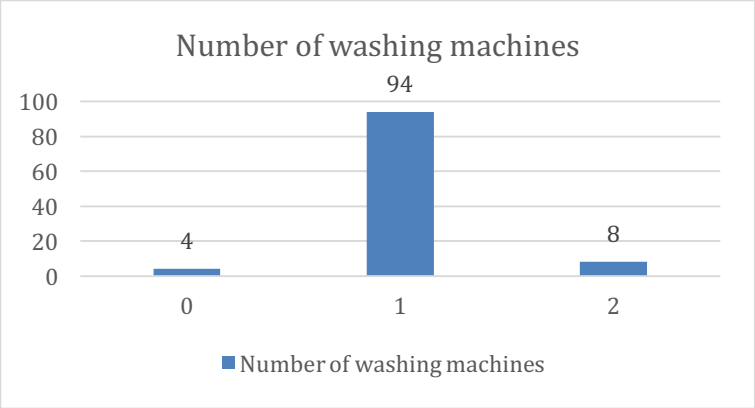

Fig. 3.2.5 Distribution of number of washing machines owned.

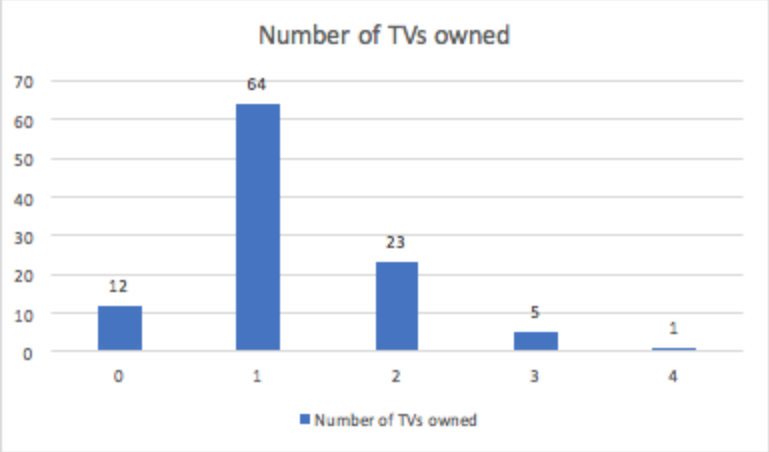

Fig. 3.2.6 Distribution of number of TVs owned.

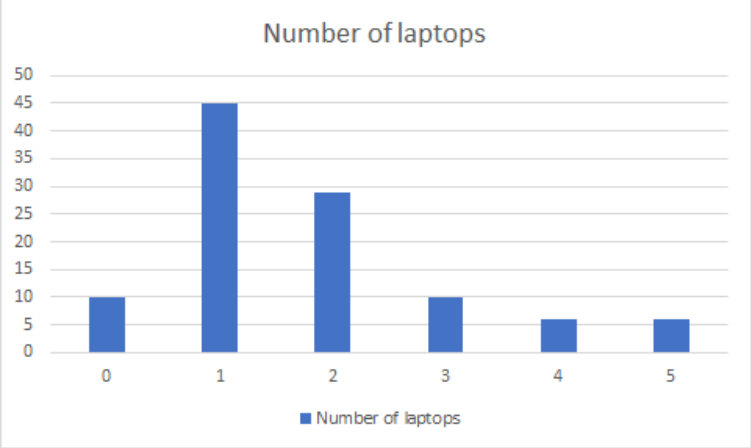

Fig. 3.2.7 Distribution of number of laptops owne.

3.3 AC Analysis Graphs and Tables

Table 3.3.3

Characteristics of the eight households with central AC units

Household	Income	Size
1	2	1
2	3	3
3	3	2
4	3	2
5	3	1
6	3	3
7	3	1
8	3	3

Table 3.3.4

Characteristics of the four households without ACs

Household	Income	Size	Have Baby?	Senior?
1	2	1	0	1
2	2	1	0	0
3	3	1	0	0
4	2	1	0	0

Table 3.3.5

Three-way table of average number of ACs owned by households in each income and household size groups, differentiated by whether they have babies at home.

Size	Income	No Baby	Have Baby	All
Small (1-2 people)	Low income	1	/	1
Small (1-2 people)	Medium income	1.583333	/	1.583333
Small (1-2 people)	High income	1.6	/	1.6
Medium (3-4 people)	Low income	1	/	1

Medium (3-4 people)	Medium income	2.6875	3.5	2.85
Medium (3-4 people)	High income	2.909091	2.428571	2.793103
Large (5 and more people)	Medium income	/	2.5	2.5
Large (5 and more people)	Low income	2.5	2.222222	2.272727
All cases		**2.179487**	**2.538462**	**2.269231**

Table 3.3.6

Three-way table of average number of ACs owned by households in each income and household size groups, differentiated by whether they have seniors at home.

Size	**Income**	**No old**	**Have old**	**All**
Small (1-2 people)	Low income	1	/	1
Small (1-2 people)	Medium income	1.52381	2	1.58
Small (1-2 people)	High income	1.6	/	1.6
Medium (3-4 people)	Low income	1	/	1
Medium (3-4 people)	Medium income	2.823529	3	2.85
Medium (3-4 people)	High income	2.769231	3	2.79
Large (5 and more people)	Medium income	2.6	2	2.5
Large (5 and more people)	Low income	2.2	2.333333	2.27
All cases		**2.227273**	**2.5**	**2.27**

Python Code 3.3.1

T-test on whether there is significant difference between families with babies and without. Insignificant due to large p-value.

ttest_ind(young['AC'],no_young['AC'])

Out[206]: Ttest_indResult(statistic=1.2903061936162585, pvalue=0.19986178490693315)

Python Code 3.3.2

T-test on whether there is significant difference between families with seniors and without. Insignificant due to large p-value

ttest_ind(old['AC'],no_old['AC'])

Out[207]: Ttest_indResult(statistic=0.81285222823048986, pvalue=0.41819601605672574)

3.4 PC Analysis Graphs and Tables

```
             Df Sum Sq Mean Sq F value Pr(>F)
income_new    1   2.44   2.438    1.53  0.219
Residuals   102 162.55   1.594
```

Fig. 3.4.3. ANOVA test output with income level as the independent variable and quantity of PCs as the dependent variable.

```
             Df Sum Sq Mean Sq F value Pr(>F)
young         1   2.34   2.337   1.465  0.229
Residuals   102 162.65   1.595
```

Fig. 3.4.4. ANOVA test output with having a young or not as the independent variable and quantity of PCs as the dependent variable.

```
             Df Sum Sq Mean Sq F value Pr(>F)
old           1   3.78    3.78   2.392  0.125
Residuals   102 161.21    1.58
```

Fig. 3.4.5. ANOVA test output with having an old or not as the independent variable and quantity of PCs as the dependent variable.

```
             Df Sum Sq Mean Sq F value Pr(>F)
size_new      1   1.34   1.338   0.834  0.363
Residuals   102 163.65   1.604
```

Fig. 3.4.6 ANOVA test output with household size as the independent variable and quantity of PCs as the dependent variable.

```
             Df Sum Sq Mean Sq F value Pr(>F)
income_new    1   2.44   2.438    1.53  0.219
Residuals   102 162.55   1.594
```

Fig. 3.4.7 ANOVA test output for households with no children or old people, three income levels as the independent variable and quantity of PCs as the dependent variable.

```
             Df Sum Sq Mean Sq F value Pr(>F)
income_two    1   2.48   2.477   1.555  0.215
Residuals   102 162.51   1.593
```

Fig. 3.4.8 ANOVA test output for households with no children or old people, two income levels (low income and medium income levels are lumped together) as the independent variable and quantity of PCs as the dependent variable.

Table 3.4.2

Average PC quantity for households with old people.

	Small household	**Median household**	**Large household**
Low income	/	/	/
Median income	0.3333 (3)	1 (3)	2 (1)
High income	/	1 (3)	2 (6)

Note: the number in the bracket in each cell is the sample size in that category.

Table 3.4.3

Average PC quantity for households with no old people.

	Small household	Median household	Large household
Low income	1.333 (3)	2 (1)	/
Median income	1.286 (21)	2.412 (17)	1.4 (5)
High income	2.1 (10)	2.115 (26)	1 (5)

Note: the number in the bracket in each cell is the sample size in that category.

Table 3.4.4

Average PC quantity for households with young people.

	Small household	Median household	Large household
Low income	/	/	/
Median income	/	1.75 (4)	1.5 (6)
High income	/	1.714 (7)	1.222 (9)

Note: the number in the bracket in each cell is the sample size in that category.

Table 3.4.5

Average PC quantity for households with no young people.

	Small household	Median household	Large household
Low income	1.333 (3)	2 (1)	/
Median income	1.167 (24)	2.3125 (16)	/
High income	2.1 (10)	2.091 (22)	3 (2)

Note: the number in the bracket in each cell is the sample size in that category.

Table 3.4.6

Average PC quantity for households with either old or young.

	Small household	Median household	Large household
Low income	/	/	/

Median income	0.3333 (3)	1.429 (7)	1.5 (6)
High income	/	1.667 (9)	1.545 (11)

Note: the number in the bracket in each cell is the sample size in that category.

Table 3.4.7

Average PC quantity for all households.

	Small household	**Median household**	**Large household**
Low income	1.33 (3)	2 (1)	/
Median income	1.167 (24)	2.2 (20)	1.5 (6)
High income	2.1 (10)	2 (29)	1.545 (11)

Note: the number in the bracket in each cell is the sample size in that category.