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Comparative analysis of average time of use of home appliances

Jordi Cravioto[a]*, Reika Yasunaga[b] and Eiji Yamasue[a]

[a]Ritsumeikan University, Kusatsu Shiga 525-8577 Japan
[b]Graduate School of Energy Science, Kyoto University Kyoto University, Sakyo-ku Honmachi, Kyoto 606-8314, Japan

* Corresponding author. Tel.: +81 077-561-4866; fax: +81-077-561-4866. E-mail address:jordi-c@gst.ritsumei.ac.jp

Abstract

Greater appliance penetration has been associated with economic advancement, sophisticated lifestyles, improved safety, health and several environmental benefits. However, recent studies suggest that easier appliances acquisition also push reductions in the total time of appliance use, regardless of the gains achieved by technological advancement. With this respect, estimation of the total time of use of appliances is the first important step towards understanding such a trade-off. This study reports a summary of the average age of appliances in developing countries from Southeast Asia, Mexico and some developed countries, as well as a discussion of the relationship between income level and age of appliances using scatter plots of the summarised data. Six categories of appliances (personal computers, mobile phones, washing machines, refrigerators, air conditioners and TVs) were summarised from the literature, and the observed differences in the average age were hypothesised to have connection with income level and the appliance penetration rates. Average appliance age in a greater scale of income (using GNI per capita, PPP) also showed two main trends. Namely, a U-shaped and linear pattern in which the six appliances could be categorised.

1. Introduction

Worldwide, the number of middle-income economies with mature markets for consumer appliances are rising. Refrigeration and cooking are the main industry targets, but even less essential appliances (coffee machines, juice extractors, mini ovens, etc.) have reported high growth rates from increasing popularity.

Promoting greater penetration of appliances, understood as the percentage of possession in households, has resulted in several positive effects: improved communication, health benefits, higher safety and lower environmental impacts from more efficient use of key resources (energy and water).

Despite all this, the level of appliance manufacturing in recent years has been linked with global shortage of material supply to keep pace with increasing consumption rates, because easier appliances acquisition has pushed reductions in the service lifetime of appliances [1]. Longer lifetime of appliances achieved by technological advancement is being overshadowed by faster consumption. In other words, there is a direct trade-off between the amount of resources used during operation and the resources used during manufacturing and disposal.

To make a comprehensive assessment of this trade-off, the first crucial step is to understand the time of use of consumer appliances, because it is the primary information for assessments regarding the resources needed when possession spans reduce from new appliance acquisition. Nevertheless, studies on appliance age especially in developing countries are scarce and summaries of those existent not available.

Appliance age analyses are mostly carried out in industrialised nations, given the better availability of data. Research on lifetime of appliances have been found for Norway [2], Austria [3], Spain [4], the United States [5] and Japan [6]. Some studies have even taken such information to evaluate the optimal utilization of household commodities' through a life cycle approach [7][8][9]. In contrast, most economically developing countries lack of systems to collect similar information, resulting in a considerable smaller share in the

literature. From the developing country context, one study reports that in Vietnam, the average years of use of a washing machine (11.5 y) and refrigerators (11.5 y) is quite comparable to Japan (10.5 and 11.5 respectively) [1]. This study also found that the lifetime of these appliances became about half in 6 years.

Information is less accessible for other countries, suggesting the need for a more detailed literature review. Because of their size and recent economic growth levels, Asian nations are important case studies here, in particular Southeast Asian countries as they have observed important rise in income levels in the past 10 years and are expected to increase appliance penetration further in the next future. Thailand, Malaysia, Indonesia and the Philippines are within this group.

At the same time, middle-income economies in Latin America, although experiencing less growth than Southeast Asia can be good examples of regions with a mature markets for appliances within the developing world. Two countries in this region probably have the most comprehensive socio-economic databases: Chile and Mexico [10][11]. However, in both cases specific information about appliances age is also scarce and rather diverted from such a concern [12][13].

The high economic growth in Southeast Asia and the rather mature appliances markets of the Latin America make them both regions informative to sketch a pattern of appliance age transformation by industrialisation level until more comprehensive analysis are able to explain such a relationship.

Based on all the previous, this study presents a summary of reviewed literature on the average age of home appliances focusing on Southeast Asia and Mexico. It also presents two estimations of appliance age in Mexico using data surveyed in two locations, and finishes with a discussion of the relationship between income level and age of appliances using scatter plots of the summarised data.

2. Method

An overall examination of relevant literature from 2000-2016 using Scopus, Web of Science and Google Scholar was first carried out to retrieve the available estimations of average time of use of appliances in Southeast Asia, Mexico and other countries in the economically developed world. The study focused particularly on six categories: Personal computers (PC), mobile phones (mobile), washing machines (WM), refrigerators, air conditioners (AC) and TV sets, given that these were the appliances associated with the highest time reductions [1].

Additionally, for the case of Mexico appliance age data in households of two locations surveyed in March 2011 is also reported. The two sites correspond to a rural community and an urban location. The urban setting is one of the sixteen boroughs in Mexico City (Cuauhtémoc) and the rural location is a community to the southwest of Mexico City in the highlands of the state of Puebla (Zoquitlán). The data was collected using an interviewed survey conducted in randomly selected households. The obtained sample consisted of 98 questionnaires: 40 from Zoquitlán and 58 from Cuauhtémoc.

Finally, using data from the World Bank on gross national income (GNI) per capita controlled for purchasing power parity (PPP) [14], the relationship between income level and age of appliances is analysed using scatter plots of the summarised and the surveyed data. This allows to elaborate a discussion on appliance classification based on the trend of appliance age.

3. Results and discussion

The appliances, country and the year of publication in the relevant literature found are shown in table 1. A total of 13 studies have been selected and reported from more than 100 with possible relevant information. Table 2 shows a summary of the data retrieved from these published works and through the surveyed locations in Mexico. In table 2, a diagonal line means that data was not reported; the blank cell corresponding to AC in Zoquitlán means that no respondent used the appliance in this location.

Table 1. Previous studies reporting age of appliances

Country	Year	Appliances
Austria[3]	2011	WM, Refrigerator
Indonesia[15]	2011	WM, refrigerator, AC, TV
Japan[6]	2007	All
Malaysia[16]	2007	PC, mobile, WM, refrigerator, AC, TV
Mexico[12]	2009	Refrigerator
Mexico[13]	2012	Refrigerator, AC
Norway[2]	2007	Refrigerator
Philippines[16]	2006	WM, Refrigerator, AC, TV
Thailand[17]	2004	PC, mobile, WM, refrigerator, AC, TV
Thailand[18]	2004	WM, refrigerator, AC, TV
Thailand[19]	2006	AC
Spain[4]	2008	Refrigerator, TV
USA [20]	2007	PC, WM, Refrigerator, AC

3.1. Comparison of appliance age by region and income levels in Southeast Asia and Mexico.

As shown in table 2, the average time of use of appliances varied among regions and incomes within the same country. It was found that for some appliance categories the hypothesis of reduction in time of utilisation held as income increased, but in others it appears to be less clear.

In the case of Indonesia, for example, the survey taken by Wijaya and Tezuka from the two largest ethnic groups (Javanese and Sundanese) [21] showed that ACs and TV sets were used longer among cultural groups more identified with consumerism, whereas for WM and refrigerators the opposite was found. Although the reason for the variation is not entirely clear, the authors attribute it to cultural aspects that reflect the way in which people use electrical appliances. It can be considered that the results partly support the idea that the appliance utilisation time is reduced from increased purchasing power.

Table 2. Summary of appliance's age

Method	Country	GNI cap [US$]	Income level	Region	Year	PC [yrs]	mobile [yrs]	WM [yrs]	Refrigerator [yrs]	AC [yrs]	TV [yrs]
Literature review (SE Asia)	Indonesia	8,610	Javanese (low)	Yogyakarta	2011			7.71	11.54	11.10	9.86
	Indonesia	8,610	Sundanese (high)	Bandung	2011			7.68	9.96	12.45	10.16
	Malaysia	18,460	Low	all	2007	1.30	3.10	7.60	10.80	5.70	9.90
	Malaysia	18,460	Middle	all	2007	4.70	3.10	5.70	8.10	5.20	9.20
	Malaysia	18,460	High	all	2007	5.20	2.90	8.70	8.20	9.20	10.80
	Philippines	5,710	mean	all	2006			10.00	10.00	10.00	8.00
	Thailand	9,130	mean	all	2004	7.00	2.00	12.00	14.00	9.00	18.00
	Thailand	9,130	mean	all	2004					9.24	
	Thailand	10,570	mean	all	2006			11.90	15.10	9.05	18.60
	Mexico	14,050	mean	all	2009					10.00	
	Mexico	15,790	mean	all	2012				13.20	10.90	
Survey	Mexico	14,740	Low	Zoquitlán	2011	2.73	5.21	8.33	8.33		10.63
	Mexico	14,740	Middle	Cuauhtémoc	2011	3.00	7.49	4.35	5.73	5.21	3.56
Literature review (developed countries)	Japan	34,650	mean	all	2010	6.72	3.83	11.28	12.17	12.55	7.82
	Norway	56,680	mean	all	2007				14.60		
	Austria	44,170	mean	all	2011			12.00	14.00		
	United States	48,420	mean	all	2007	4.14		10.50	11.50	12.50	
	Spain	32,820	mean	all	2008				11.00		12.00

For Malaysia, the results found were reported in three different income levels (high: 5,000 RM per month; middle: 1,200 ~ 4,999 RM per month; and low: < 1,999 RM per month) [16]. Only mobile phones and PCs showed a consistent trend of average age increasing with income level, which disproves the idea that as income increase appliances are used in shorter times. For other appliances the shortest age was reported at middle incomes, supporting the hypothesis that an income rise will reduce appliance use time, but also disproving it as longer average age was also found among lower incomes. The Malaysian results on PC and AC were also noted for being surprisingly short. This might be explained by the fact that the penetration of PC and AC were 37.7% and 26.2 % at the time of publication of these results. In contrast, mobiles and refrigerators had a higher penetration rate, 121.32% and 84.8%, being more similar to the other countries in the table.

The case of Vietnam is similar to Malaysia. As mentioned before, Yamasue et al. [1] found that the total lifetime of TV, refrigerators, WM and AC shortened from 2007 to 2013. Using data presented in table 3, the difference could probably be because of a relationship with the penetration rates. Higher levels of penetration seem to be associated with shorter lifetime. In any case, it is still not clear if lower incomes could have been unable to access these appliances, resulting in the short time of use, and such a hypothesis might be interesting for further examination.

In the Philippines, AC, WM, refrigerator and TV age did not observe important changes to the other countries in the region, whereas for Thailand refrigerators and TVs showed a considerably longer age compared to the other countries.

Finally, the results reported in the literature and obtained through survey in Mexico (table 2) showed certain variations. Refrigerators and particularly AC reported a decrease in the age from a previous study and the survey results. Similar to Malaysia and Vietnam, the households surveyed in Cuauhtémoc and Zoquitlán also reported differences in the appliance saturation levels. According to Cravioto et al. [23], this rate corresponds to 80% among households in Cuauhtémoc, compared to 50% in Zoquitlán (for a detailed result refer to [23]). Given this, the results in Mexico also support the pattern of reduction in appliance age associated to higher penetration rates for certain categories (TV, refrigerators and washing machines). Information-related appliances (PCs and mobiles), on the other hand, showed an opposite trend, being used for a longer time among higher incomes.

Table 3. The penetration and the average time of use in Vietnam [1] [15] [22]

		TV	Refrigeration	WM	AC
2007	Lifetime (y)	10	9	9	15
	Penetration (%)	86.8	31.5	13.1	4.4
2013	Lifetime (y)	7	7	8	10
	Penetration (%)	90.1	53.9	23.6	10.8

In sum, the summary above and the survey results suggest that average appliances' age could be influenced by various factors, such as culture, income, region and the judgement of how essential the appliance is for daily living. In addition, for some categories, the quality of the appliance might determine

its average age, given that most developed countries in table 2 observe longer use of WM, AC and refrigerators. In contrast, TVs, mobile phones and PC do not seem to have considerable differences. The results also point to believe that low income households have a tendency to use appliances as long as possible. As for the appliances essential for living in these developing countries, it is likely that the average time of use become shorter with increased rates of ownership (appliance penetration).

A final concern is that table 2, although a good starting point, cannot reflect the rate of appliances that have been imported from and the possession span of each owner until the total lifetime of the appliance. According to two reports [24] [25], in Thailand most of all used PC (97.6%) is imported from Japan, and the number of it is increasing annually. Furthermore, Thailand exports some of these used PC to neighbouring countries such as Indonesia and Vietnam. In other words, PC and mobile phones are distributed in Southeast Asian markets several times. In Mexico this might also happen as some appliances find their way from the neighbouring USA and Canada, and extend after from Mexico into Central American countries.

3.2. Cross-sectional analysis of appliance age and income level

In addition to differences within countries, an examination of appliance age by income level in a wider scale was conducted. Taking GNI per capita, PPP and the average appliance age of data summarised in table 2, it was found that through scatter plots appliances could be grouped by a trend in the plot. First, figure 1 presents the positive U-shaped relationship between income and average use. In this example, AC age gets shorter as income increase, probably due to a developing industry of appliances increasing efficiency and penetrating the local market. However, once economic growth reaches a certain level in which the market has become mature, the average time of use might turn around getting longer, such as observed for the case of Japan and USA. Refrigerators and WM age was also found within this category.

Another reason to find these trends might be also related to policy of replacement to more efficient appliances as a part of an energy saving policy. Energy Efficiency Standards and Labelling for main consumer appliances, such as MEPS (Minimum Energy Performance Standards), HEPS (High Energy Performance Standard) has been developing in some of these regions. Because old appliances consumed a large amount of energy, the replacement of appliances essential for living such WM, TV, refrigerator and AC is promoted by the government. As a result, the average time of use of WM, AC and refrigerators gets shorter with economic growth and higher GNI per capita.
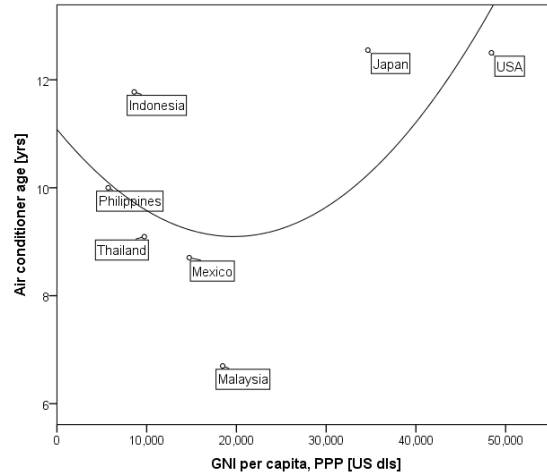

Figure 1. Average age of AC at households and GNI per cap, PPP

A second trend is a linear relationship between appliance age and income level. This was seen in scatter plots of mobile phone, TV and PC age. In the case of TV and PC, the relationship was negative (figure 2), whereas in the case of mobiles the trend was positive (figure 3). These trends might reflect that certain electronic appliances do not observe drastic changes in the average use despite increases in income level possibly due to the globalisation of their penetration. TVs, PCs and mobile phones might fall into this category suggesting that despite the differences observed in section 3.1, by income level increase there seems to be no observable trend.
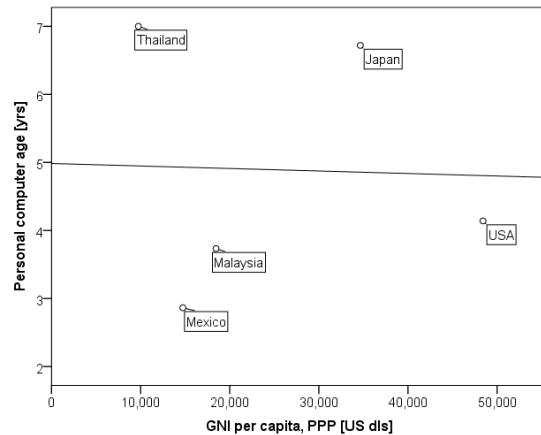

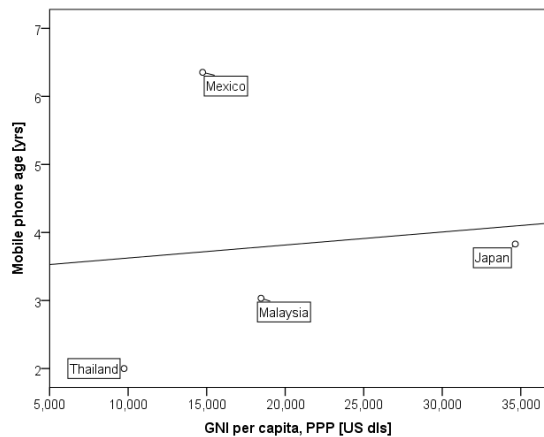Figure 2. Average age of PCs at households and GNI per cap, PPP

Figure 3. Average age of mobile phone and GNI per cap, PPP

In sum, taking a single average time of appliances utilisation and comparing in greater scale using economic measures showed that there are differences noticeable in U-shaped and linear trends. The average time of use of appliances essential for living (WMs, ACs and refrigerators) get shorter with increasing economic growth, changing tendency when it reaches a certain level. The average time of use of mobile, TV and PC, on the other hand, might remain fairly similar in the long run despite market expansion.

As a final note, the readers should consider the discussion elaborated above as a starting point, provided the inherent limitations associated to the small size of the summarised data in section 3.1. The trends analysed in section 3.2 might present changes using more comprehensive datasets. Nevertheless, the hypothesis that appliance age is categorised by such trends can be a fertile ground for further research, as such results might be informative for several purposes related to more sustainable production and consumption. The primary concern that easier appliances acquisition has pushed reductions in the service lifetime of appliances seems to have subtle differences depending on the appliance in question.

4. Conclusions

This study summarised the information of the average age of 6 categories of appliances in Southeast Asia and Mexico from relevant literature and a two-location survey conducted in Mexico. Possible reasons for differences found in these results were also discussed.

It was found that the difference in the average time of use observed within countries is influenced by income and possibly the penetration rate. People of low income have a tendency to use appliances longer. As for appliances considered more essential for living (WM, TV, Refrigerator and AC) it is also likely that the average time of use of appliances become shorter with increase of the penetration.

The average time of use of appliances was also different by economic level in a greater scale. The relationship between the average time of use of appliances and GNI per capita suggested that the average time of use of WM, refrigerator, and AC follows a U-shape, reducing and then increasing above a

threshold as income rise. In contrast, the average time of use of information appliances such mobile phones, PCs and TVs observe a more linear trend.

These preliminary comparisons suggest that it is relevant to conduct future research with a more comprehensive collection of data on appliance age. In addition, examination of the hypothesis of longer lifetime of appliances comes at the expense of faster consumption would be another application of the results here presented.

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