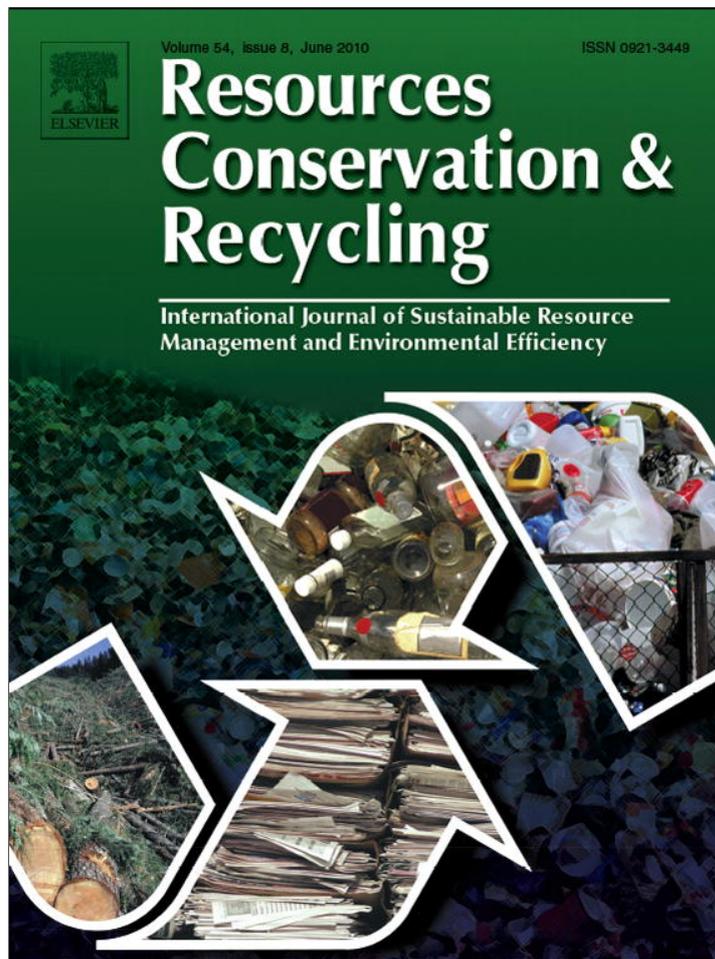


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## Adoption and disposition of new and used computers in Lima, Peru

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## ABSTRACT

The purpose of this study is to understand the importance of personal computers (PCs), new and used, as well as post-consumer management options in the residential sector in developing countries using Peru's capital, Lima, as a case study. Part of this study aims to understand how the growth of secondary markets for PCs satisfies demand of computer services in the residential sector. To achieve these goals a probabilistic survey was carried out in Metropolitan Lima. 600 households were interviewed in this survey. Households were divided into socio-economic levels (SEL) A–E, with A being the wealthiest and most educated and E being the least. Results show that ownership of computers in the residential sector is closely related to SEL, for example, for the highest SEL, SEL A, 93% of households owned a computer, however, only 1% of the households owned a computer in the lowest SEL, SEL E. Regarding the penetration of used computers in households, results show that for SEL A, B, C and D the ratio of used versus new computer ownership increases while SEL decreases. In addition, 68% of the households without a PC at home (HPC–) reported that economic constraint of expense is the main reason to not own one. The survey indicates that people in Lima are increasingly using computers for education, business and entertainment. In general people show a preference to buy a new computer but cost considerations have led to the diffusion of used computers in lower income groups. The penetration rate of used computers in Lima's residential sector is low at this time. People's negative perception of the reliability of used equipment and willingness to pay for new computers affects this penetration rate. Also, residents reported that landfills is the least chosen option, for end-of-life computers, monitors and electronics, with self-reuse and storage being the most selected.

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## 1. Introduction

The trade in used computers from developed to developing countries is frequently seen as a negative activity that needs to be banned. There are a number of arguments behind this view, in particular concerns over environment impacts and data security. The environmental concern, by far the most vociferous, is that informal electronic recycling in some developing countries, such as China, India, Ghana, Nigeria and others, causes serious environmental damages. Exposes of the problem from NGOs and the popular media have been confirmed by recent scientific research showing these activities are harmful to the environment and human health (BAN and SVTC, 2002; BAN, 2005; Wong et al., 2007a,b; Leung et al., 2006, 2007; Deng et al., 2006; Huo et al., 2007; Streicher-Porte et al., 2005; Keller, 2006; National Geographic, 2008; Toxics

Link, 2003). While the negative impacts of informal recycling are undeniable, one cannot generalize they are the only outcome of international trade in end-of-life electronics. In fact, reuse activities also motivate this trade, as noted by research and site visits in developing countries (Ingenthron, 2008; Kahhat and Williams, 2009). Moreover, the reuse of computers has environmental, social and economic benefits (Williams et al., 2008). The negative environmental impacts tied to the manufacturing phase of computers are significant when compared to the other phases of the life cycle (e.g., the operation phase) (Williams, 2004). As a result, extending the lifespan of computers by reusing them will favorably impact the environment by diminishing the demand for new equipment (Williams, 2004). Also, low income communities in developed and developing countries benefit from this trade due to the increased accessibility to technology that comes from the lower cost of used computers for small business and individual owners as well as the computers donated to schools, libraries, technology centers, and so on (Williams et al., 2008; Computers for Schools-Canada, 2008; CIA, 2007; Kahhat et al., 2008; BFG, 2009). In addition, this economic activity generates jobs and revenues along the chain of collection, refurbishment, transportation and sale in developed and developing countries (Williams et al., 2008; Streicher-Porte et al., 2005).

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Personal computers (PCs) are becoming an important part of society, and human dependency on them is significantly expanding to more activities, from business to entertainment to education (Rosenberg, 2004). Access to technology, especially PCs, has evolved from a privilege to a requirement in most societies. Moreover, the combination of PCs and Internet access expands the traditional domain for human contact, creating new modes for self-expression and fulfillment, e.g., *Second Life*, 2009. In this context residential PC ownership has increased dramatically in recent years, both in developed and developing countries (Cheeseman Day et al., 2005; INEI, 2008a). For example, computer ownership per household in the Peruvian capital of Lima increased 56% between 2005 (17%) and 2007 (26%) (INEI, 2008a). Moreover, this technology adoption trend in developing countries expands and opens the market not only for new but also for used PCs that are mostly imported from developed countries but are also generated domestically. With a vigorous secondary market, Peru is no exception to this trend (Williams et al., 2008; Kahhat and Williams, 2009).

The purpose of this paper is to understand the importance of computers and end-of-life management options in the residential sector of developing countries, using Lima as a case study. In addition, the growth of secondary markets for PCs opens the question of to what extent this used equipment is satisfying the demand for computers in the residential sector, so this study assess the diffusion rate and perception of used computers in Lima's residential sector. To achieve these goals a probabilistic survey was carried out in metropolitan Lima, the capital city of Peru, with more than 8 million inhabitants (around 30% of Peru's population) (INEI, 2008b).

**2. Methodology**

A probabilistic survey was performed in the residential sector of metropolitan Lima. During August 2008, 600 houses were interviewed. A face-to-face interview method was used for the questionnaire. The survey had a confidence level and interval of 95% and 5%, respectively, and was randomly stratified based on socio-economic levels (SEL) in metropolitan Lima. The SEL is the most commonly used indicator to characterize population. In Peru, this socio-economic indicator considers the following aspects of the household: educational level, type of work and type of health insurance of the head of household, primary construction materials used to build the house, and electronic appliances owned by the household, among others (APEIM, 2008). The five SEL are: SEL A, the high and upper middle class; SEL B, the middle class; SEL C, the upper low class; SEL D, the lower low class; and SEL E, the marginal class. The survey sample distribution was based on the SEL found in an extensive study performed in Lima by the Peruvian Business Association of Market Research (APEIM, 2008). Households were divided in two groups, those with and without a computer at home, HPC+ and HPC-, respectively. The survey included 13 general questions and 25 or 13 specific questions for the groups with and without computers, respectively. All questions were close-ended. Participants with computers at home (HPC+) were asked questions regarding their purchase, use and disposal of PCs. Participants not owning a PC (HPC-) were asked about their computer use outside work (e.g. Internet kiosks) as well as about the factors that are important for them to be able to purchase a desirable computer. The computer-owning group included 214 houses, or 36% of the interviewed homes, and the second group contained 386 houses (64%). The survey questions also required a minimum level of computer literacy from at least one member of the household. Table 1 shows the stratified population chosen for this survey divided by SEL and computer ownership. It also includes the SEL from which this sample was created.

**Table 1**  
Distribution of surveyed households by socio-economic level.

Socio-economic level (SEL)	Households	Survey sample	Population from which sample was taken	HPC+	HPC-
SEL A	29	4.8%	5.3%	27	2
SEL B	103	17.2%	15.7%	68	35
SEL C	168	28.0%	28.7%	77	91
SEL D	201	33.5%	33.9%	41	160
SEL E	99	16.5%	16.4%	1	98
	600			214	386

HPC+: households with a PC at home; HPC-: households without a PC at home.

**3. Survey results**

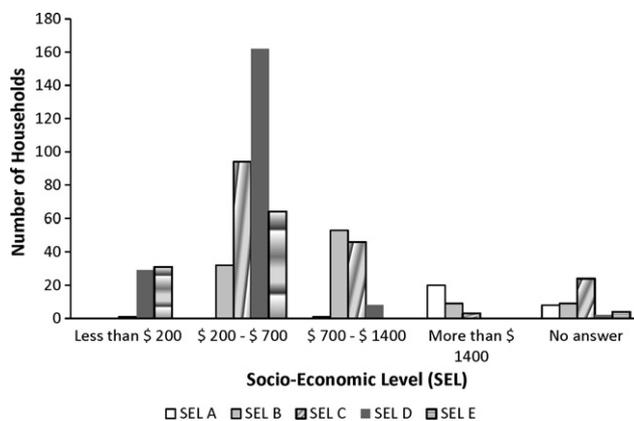
The most common (30%) size of a household was 4 persons, while 72% of the interviewed households contained 4–6 persons. The monthly income profile by household per SEL is shown in Fig. 1. As seen, around 59% of the households reported an income of US\$ 200–700, 10% less than US\$ 200, and only 5% above US\$ 1400. Most of the households in SEL A, 69%, had an income of more than US\$ 1400, incomes of US\$ 200–700 and US\$ 700–1400 were mostly seen in SEL B and C households, and incomes of less than US\$ 200 and US\$ 200–700 predominated in SEL D and E.

Of the interviewed households, 36% had one computer and 8.5% had more than one computer at home. Fig. 2 shows the computer ownership trend per socio-economic level. About 43% of respondents paid between US\$ 230 and US\$ 600 for their computer, while 38% paid US\$ 601–1000. Only 6% of the computers had a price greater than US\$ 1000 and 4% below US\$ 230.

Fig. 3 shows the age distribution for purchased (new and used) computers. Almost 31% of the owned computers were purchased in the previous 0–1 years, 58% in the previous 1–2 years and only 7% of the computers were purchased more than 5 years prior to the time the survey was done. A similar trend is seen in the age distribution of new computers. In addition, 61% of the owned computers were the first computer in the household. These results show that computer adoption in Peru is in its infancy. The major technical causes for replacement of owned computers were that the computer was too slow (30%) and that the hardware did not run with emerging applications (16%).

Additionally, around 27% of the households had upgraded their computer. The most switched parts were: RAM memory (42%), hard drive (30%), DVD device (13%) and processor (3%).

The main constraint to own a computer at home was the expense of purchasing and taking care of a computer (e.g., software, maintenance, etc.). However, the majority of participants agreed that they would like to purchase a PC in the future to help them with their work and educational activities.



**Fig. 1.** Household income per socio-economic level (SEL).

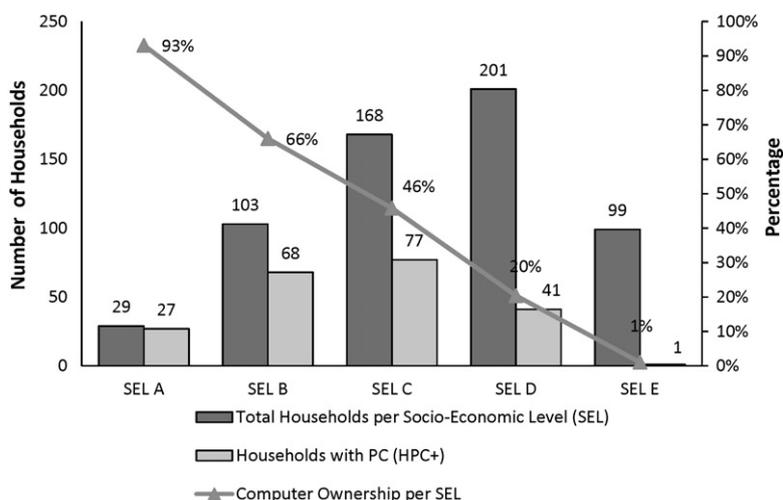


Fig. 2. Socio-economic level and computer ownership of interviewed household.

When asked how much money they were willing to spend to buy a computer, more than 75% were willing to spend more than US\$ 230, more than the cost of a used non-mobile personal computer (nmPC) with a Pentium 4 processor (2.4 GHz), 40 GB hard drive and a RAM memory of 512 MHz (around US\$ 170), and more than the minimum Peruvian monthly salary (around US\$ 180) (MTPE, 2009). Fig. 4 shows the willingness of households to pay for a computer at home per SEL, excluding SEL A. In addition, in two separate questions, HPC– were asked about the preferred computer they will like

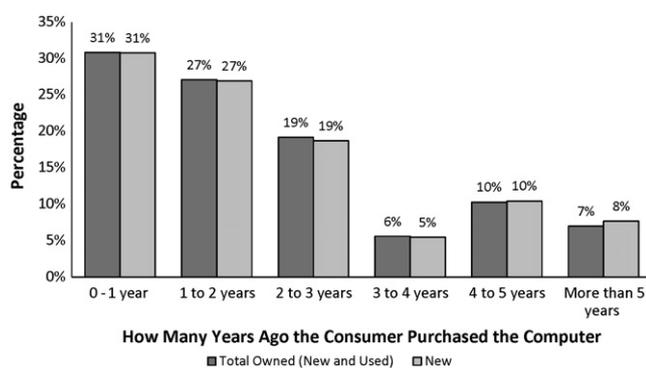


Fig. 3. Age distribution of owned (new and used) and new computers.

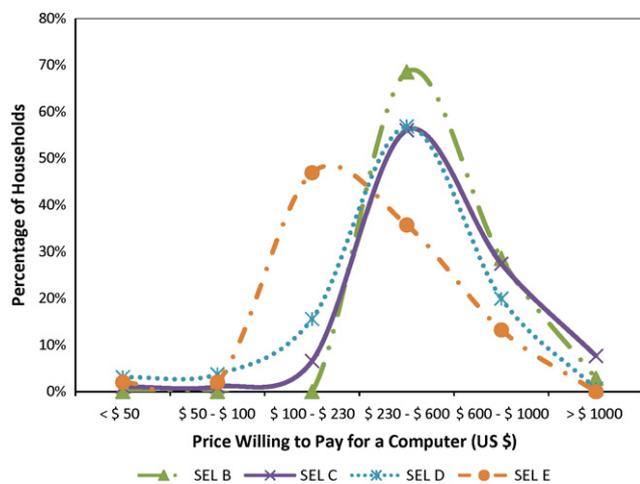


Fig. 4. Willingness to pay for a computer at home for non-computer owners (HPC–).

to purchase as well as the willingness to consider buying a used computer. Only 11% preferred to buy a used computer, although 47% would consider it.

The main concerns about buying a used computer were guarantee (with 85% and 70% in HPC+ and HPC–, respectively) and reliability (with 86% and 68% in HPC+ and HPC–, respectively) issues. In addition, although people prefer to own new computers, they think that used computers are better priced and can suit their needs.

Following the survey discussed the main computer applications used by the residential sector as well as their purposes, such as entertainment, education or work. For HPC+, the questions pertained to the use of the main computer they own at home. For HPC–, the questions were about any computer they (members of the household) use in for example, Internet kiosks, friend’s house, or others, with the exception of those used at work.

In general, the main purpose of all home computer applications was entertainment (57%), followed by education (22%) and work (21%). The major applications used were (1) word processing and other “office” applications (86%), (2) Internet browsing (61%), (3) e-mail (58%), (4) chatting (54%), (5) digital photographs (48%), and (6) watching videos (45%). Applications were perceived to run well on home computers, indicating that they were capable of satisfying the demand for these applications. It is important to note, however, that 30% of the households did not have an Internet connection but some of the applications included in the survey require one. For HPC–, the purpose of computer use results is similar: entertainment (56%), followed by education (25%) and work (19%). The main applications used were: (1) Internet browsing (84%), (2) e-mail (80%), (3) chatting (76%), (4) word processing and other “office” applications (55%) and (5) watching videos (47%). Similar figures were found in a recent study in Ireland, where Internet browsing (80%) and word processing and other “office” applications (60%) were the predominant applications (Hickey and Fitzpatrick, 2008).

In addition, 80% of HPC– accessed the Internet via Internet kiosks, 11% using their work computers, 6% using the computers of friends or family, and 3% using computers found at their university/college/school. Internet kiosks are found in all neighborhoods of Lima and are a perfect solution for accessibility to a computer and the Internet for those that cannot afford a computer at home (De Althaus, 2007).

Furthermore, the survey assessed the post-consumer practices for computers and monitors (computer owners) and electronics (non-computer owners). When asked about the opportunity to sell their own computer in the used computer market, more than 50% of the participants were concerned about losing information/data

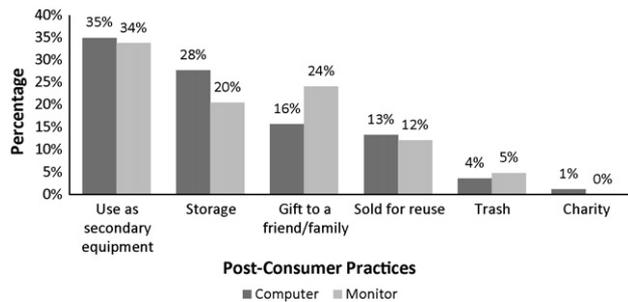


Fig. 5. Post-consumer practices for computers and monitors.

not properly stored in another storage device and about information/data security if accessed by the refurbisher or next user. In addition, 60% were not sure about a fair price for a used computer.

Fig. 5 shows the computer and monitor post-consumer management options chosen by households. However, it is important to note that 61% of the computer and monitor-owning households reported currently owning their first computer/monitor, so a relatively small number had experience dealing with the post-consumer options for these devices. As seen, prior “main” computers are mostly used as secondary machines (35%) or kept in storage facilities (28%); only 4% of the households hand thrown away their equipment into the municipal solid waste stream, where scavengers or informal street buyers collect obsolete equipments (Kahhat and Williams, 2009). The average storage time for computers was around 1 year. The trend for monitors is very similar to that for computers, with 34% of the monitors used as a secondary device, 24% in storage, and 20% given to a friend/family. Only 5% trashed the device. Moreover, 78% of the households indicated a belief that there is an environmental risk when landfilling a computer or monitor.

A similar question was asked to HPC— regarding post-consumer management for the electronics they own (e.g., radio, TV, phone, cell phone, DVD player, and so on). Results show that the most common post-consumer management option was waiting to be sent for repair or been repaired for future reuse (50%), followed by sold (14%) and given to a friend/family member (13%). Only 6% reported throwing the equipment into the municipal solid waste stream. In addition, 70% of the households believed that there is an environmental risk when placing electronics in landfills.

## 4. Discussion

### 4.1. Penetration of used computers

As seen in Fig. 2, ownership of computers in the residential sector is closely related to socio-economic level; for example, in SEL A, 93% of the households owned a computer; however, only 1% of the households in SEL E owned a computer. In addition, the number of computers per 100 inhabitants was 34, 19, 10, 4 and almost zero in SEL A, B, C, D and E, respectively. Moreover, 15% of the computer-owning households overall had a used computer. Ownership of used computer increased with decreasing income, with percentage of household with used as opposed to new computer of 8%, 17%, 18%, and 24% for SEL A, B, C and D respectively. So despite the preference for new computers noted in Section 3, cost considerations have led to diffusion of used computers in lower income groups.

The perception of consumers in Peru for used computers (53% in HPC— unwilling to buy used) is favorable when compared with developed countries. In Ireland for example 76% of survey respondents were unwilling to buy used computers (Hickey and Fitzpatrick, 2008). Still, many lower income consumers do not own

a computer due to not considering purchasing used. So it is important to consider why some consumers avoid used computers. One possibility is that users evaluate used computers as offering poor performance compared to new machines. At least for users who already own a used computer, this does not seem to be the case. The survey assessed the satisfaction of consumers with their computer and no significant difference was found between those with new versus used computers. It may be that used computers are underestimated by consumers. It is worth noting that the major commercial operating systems (OS) such as Windows Vista require more hardware resources compared to open source OS such as the freely available Linux-based Ubuntu (<http://www.ubuntu.com/>). Linux systems deliver excellent performance for most functions even on older machines, thus dissemination of Linux-based OS could expand the range of utility of used computers.

Peru's being in the early stages of computer adoption (recall Fig. 3) may pose an obstacle to used computer adoption. The survey results indicate a lack of consumer awareness regarding used computer markets. For example, households expect to pay high prices for computers and ignoring the affordable prices of used computers, an issue that can delay the ownership of a home computer, especially in the middle and low socio-economic classes. As knowledge relating to Information Technology diffuses through Peruvian society, consumer attitudes regarding what they want from computers and whether they would consider purchasing a used machine may change rapidly.

In summary, computer ownership in Lima's residential sector is low when compared with developed countries, but has been growing rapidly in recent years, as evidenced by the high percentage rates and age distribution of first-purchased computers. Moreover, the survey indicates that people in Lima are increasingly using computers for entertainment, education and business. Word processing and other “office” applications and Internet browsing were the most common applications used at home and at Internet kiosks. These applications do not require a computer with cutting edge technology, indicating that used computers could easily fill the need in Lima's residential sector. Ownership of used computers is low at this time; the residential sector could easily take advantage of their affordable prices; however, the reliability and guarantees of used equipment needs to be addressed to improve perceptions of used PCs.

### 4.2. Computer, monitors and electronics post-consumer practices

Residents reported that landfills is the least chosen option, for end-of-life computers, monitors and electronics, with self-reuse and storage being the most selected. The storage management option has also been reported in other countries, such as United States, Japan and Ireland, where the known “closet effect” occurs for a long period of time before consumers decide to proceed with the next disposition option: donation, recycling, or trash (U.S. EPA, 2007; Kuehr and Williams, 2003; Hickey and Fitzpatrick, 2008; Williams and Hatanaka, 2005). In the future, this storage effect could affect the opportunity to timely reuse a computer throughout Peru, where computer ownership is not as high outside the capital; in rural areas, ownership is less than 1 computer per 100 households (INEI, 2008a). For this reason appropriate systems and policies that incentivize the reuse of computers and reuse/recycling markets and that consider the cultural and social imperatives of the country should be put in practice. For example, the preference in the United States for free markets suggests that the proposed *e-Market for Returned Deposit* could be an attractive option in the U.S. context compared to command and control takeback/recycling systems (Kahhat et al., 2008). In Peru, the orientation is towards a free market economy; with an important particularity, the existence of a big informal economic sector (Loayza, 2007). In addition, the vast

majority of households believe that computers, monitors and electronics in general will negatively impact the environment if thrown in landfills, and this practice is currently the least common one. Still, computer and electronic ownership in Lima is still emerging and the future is uncertain. Studies are needed to understand and predict these trends and develop appropriate ways to manage this special waste stream in emerging countries.

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