Journal of Environmental Management 124 (2013) 8–16

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Management

journal homepage: www.elsevier.com/locate/jenvman

E-waste bans and U.S. households' preferences for disposing of their e-waste

Natalia Milovantseva [a,1], Jean-Daniel Saphores [b,c,d,*]

[a] Department of Electronic & Computer Engineering, University of Limerick, Limerick, Ireland
[b] Department of Civil and Environmental Engineering, University of California, Irvine, CA 92697, USA
[c] Department of Economics, University of California, Irvine, CA 92697, USA
[d] Department of Planning, Policy, & Design, University of California, Irvine, CA 92697, USA

ARTICLE INFO

Article history:
Received 10 December 2012
Received in revised form
8 March 2013
Accepted 11 March 2013
Available online 18 April 2013

Keywords:
E-waste
Disposal bans
Multinomial logit
Public policy

ABSTRACT

To deal with the inadequate disposal of e-waste, many states have instituted bans on its disposal in municipal landfills. However, the effectiveness of e-waste bans does not seem to have been analyzed yet. This paper starts addressing this gap. Using data from a survey of U.S. households, we estimate multivariate logit models to explain past disposal behavior by households of broken/obsolete ("junk") cell phones and disposal intentions for "junk" TVs. Our explanatory variables include factors summarizing general awareness of environmental issues, pro-environmental behavior in the past year, attitudes toward recycling small electronics (for the cell phones model only), socio-economic and demographic characteristics, and the presence of state e-waste bans. We find that California's Cell Phone Recycling Act had a significant and positive impact on the recycling of junk cell phones; however, state disposal bans for junk TVs seem to have been mostly ineffective, probably because they were poorly publicized and enforced. Their effectiveness could be enhanced by providing more information about e-waste recycling to women, and more generally to adults under 60. Given the disappointing performance of policies implemented to-date to enhance the collection of e-waste, it may be time to explore economic instruments such as deposit-refund systems.

1. Introduction

Driven by innovation, fads, and the universal success of consumer electronics, the global volume of e-waste (defined herein as any unwanted product with one or more circuit boards; see Widmer et al., 2005, for other definitions) has been increasing by approximately 4 percent per year (UNEP, 2009). In the United States, for example, e-waste is now the fastest growing fraction of municipal waste (USEPA, 2011). However, e-waste is more problematic than ordinary municipal waste because it contains potentially toxic materials such as heavy metals and flame retardants, which threaten environmental quality and public health if they are not handled properly. An unknown volume of e-waste (up to 80 percent of total annual generation by some estimates; see Basel Convention, 2011, or Robinson, 2009) is shipped to developing countries, where inadequate handling can have devastating ecological and human health consequences (Sepúlveda et al., 2010; Leung et al., 2008). Moreover, leaving e-waste unprocessed represents a lost economic opportunity since many e-waste items contain valuable materials in concentrations higher than raw ore (Betts, 2010; Hagelüken and Corti, 2010).

Two types of measures could be adopted to address the public health and environmental challenges created by e-waste: recycling could be drastically enhanced, or producers could strive to "green" electronics by avoiding potentially toxic materials. Unfortunately, neither is a panacea. Efforts by regulators (in Europe, California, and China, for example) and consumer advocates have led to the adoption of regulations banning some toxic materials (such as lead) from electrical and electronic products (China RoHS Solutions, 2012; CDTSC, 2006; EU, 2003) but electronics still contain many potentially dangerous materials. Stepping up recycling efforts has also proven problematic. In addition to creating an adequate recycling infrastructure, it can be implemented in a variety of complementary ways, which include (1) educating consumers about the dangers of dumping e-waste and the social benefits of recycling it properly; (2) making producers responsible for the end-of-life of their products; (3) creating economic incentives to foster recycling; and (4) passing regulations to ban the improper disposal of e-waste.

* Corresponding author. Department of Civil and Environmental Engineering, University of California, Irvine, CA 92697, USA. Tel.: +1 949 824 7334; fax: +1 949 824 8566.
E-mail addresses: Natalia.Milovantseva@ul.ie (N. Milovantseva), saphores@uci.edu (J.-D. Saphores).
[1] Tel.: +353 085 140 6877.

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http://dx.doi.org/10.1016/j.jenvman.2013.03.019

Even though research indicates that pro-environmental attitudes are good predictors of increased e-waste recycling (Saphores et al., 2012), educating people to change their attitudes and foster e-waste recycling has proven to be difficult (Petty and Briñol, 2008). The second alternative (making producers responsible for the end-of-life of their products) has been popular in some parts of the world (Schnoor, 2012; Zoeteman et al., 2010; Khetriwal et al., 2009) but its implementation is still limited and some producers are pushing back citing the lack of incentives for collective responsibility (i.e. extended beyond their own brand) (Van Rossem et al., 2006). Unlike the third alternative (creating economic incentives to foster e-waste recycling), which has not been seriously considered yet, bans prohibiting the improper disposal of e-waste have been implemented in a number of U.S. states (see Table 1). However, we could not find any published paper that explores empirically the impact of bans on the disposal of e-waste by households. The purpose of our study is to start addressing this gap.

Using discrete choice models applied to data from a national survey of U.S. households, we analyze the impact of e-waste disposal bans on households' past recycling of broken or obsolete ("junk") cell phones and on their intentions to recycle junk televisions (TVs). To tease out the effects of e-waste bans, our models include factors that summarize general environmental beliefs, self-reported past pro-environmental behavior, and attitudes toward recycling small household electronics (for cell phones), as well as socio-economic and demographic variables.

We focus on cell phones and TVs for several reasons. First, cell phones contain materials analogous to those found in "generic" e-waste, including arsenic, beryllium, cadmium, lead, polyvinylchloride and brominated flame retardants (Wäger et al., 2011; Barba-Gutierrez et al., 2009). Second, the useful life of cell phones (~18 months in the U.S.) is the shortest among current consumer electronic products (Entner, 2011). Third, since the number of cell phone subscribers skyrocketed from 16 percent of the U.S. population in 1996 to almost 88 percent in 2011, cell phones are emblematic of the success of electronic products but also of the challenges of e-waste because their estimated 2009 recycling rate was only 8 percent (USEPA, 2011).

In addition, we analyze intentions to recycle junk TVs because improperly discarded TVs are a major source of lead (from cathode-ray tube (CRT) glass) and mercury (from flat panel and rear projection screens) with potentially detrimental ecological impacts (King County Solid Waste Division, 2007; Socolof et al., 2005; Matsuto et al., 2004). Moreover, because of their number, junk TVs contain substantial amounts of rare, strategic, and precious metals (Milovantseva and Saphores, 2013). Finally, fast-changing new technologies are creating new challenges for recycling TVs (Lim and Schoenung, 2010).

This paper is organized as follows. First, we briefly review relevant papers from the recycling literature to justify our modeling choices. After providing an overview of our dataset, we summarize our modeling methodology. We then discuss our results before concluding.

Table 1
State bans on e-waste landfilling in effect before 2010.

State	Products covered
Arkansas	TVs, computer equipment
California	TVs, cell phones, computers, peripherals, printers, fax machines, DVD/VCR players, tablets, e-readers
Connecticut	Computer monitors
Illinois	TVs, computers and computer monitors, printers
Maine	CRT TVs, computer monitors
Maryland	All devises with display greater than 4 inches diagonally
Massachusetts	CRT TVs, computer monitors
Minnesota	CRT TVs, computer monitors
New Hampshire	TVs, computers, computer monitors
New Jersey	TVs, computers, computer monitors
North Carolina	TVs, computers, computer monitors
Oregon	TVs, computers, computer monitors
Rhode Island	TVs, computers, computer monitors

Sources:
1. Arkansas: http://www.arkleg.state.ar.us/assembly/2007/R/Acts/Act512.pdf.
2. California: http://www.leginfo.ca.gov/pub/03-04/bill/sen/sb_0001-0050/sb_20_bill_20021202_introduced.pdf; http://www.leginfo.ca.gov/pub/03-04/bill/asm/ab_2901-2950/ab_2901_bill_20040929_chaptered.html.
3. Connecticut: http://www.cga.ct.gov/2007/ACT/PA/2007PA-00189-R00HB-07249-PA.htm.
4. Illinois: http://www.ilga.gov/legislation/95/SB/PDF/09500SB2313lv.pdf.
5. Maine: http://www/mainelegislature.org/legis/statutes/38/title38sec1306.html.
6. Maryland: http://www.mde.state.md.us/assets/document/HB488_Third_Reader.pdf.
7. Massachusetts: http://www.mass.gov/dep/service/regulations/310cmr16.pdf.
8. Minnesota: https://www.revisor.mn.gov/statutes/?id=115A.9565.
9. New Hampshire: http://www.gencourt.state.nh.us/legislation/2006/HB1455.html.
10. New Jersey: http://www.njleg.state.nj.us/2008/Bills/PL08/130_.HTM.
11. North Carolina: http://www.ncleg.net/Sessions/2009/Bills/Senate/PDF/S887v6.pdf.
12. Oregon: http://www.leg.state.or.us/07reg/measures/hb2600.dir/hb2626.en.html.
13. Rhode Island: http://webserver.rilin.state.ri.us/Statutes/TITLE23/23-24.10/23-24.10-5.HTM.
14. The state of New York enacted a law ordering retailers to take back old cell phones, however they were only required to comply by 2011.

2. Literature review

Although this paper contributes to the household recycling literature, we do not attempt to summarize this literature because it is extensive and facets relevant to our work were reviewed in Halvorsen (2012), Ramayah et al. (2012), or Saphores et al. (2012), for example. Excellent reviews of older papers can be found in Hornik et al. (1995) or Schultz et al. (1995). In the following, we review some recent papers to identify determinants of e-waste recycling and to justify our modeling choices. We begin with studies dealing with e-waste recycling for cell phones and TVs, before considering studies that examine the impacts of beliefs, attitudes, behavior, and socio-demographics on household recycling.

2.1. Recycling of junk cell phones

A number of recent studies have focused on cell phones recycling. However, we found no published study on cell phone recycling behavior by U.S. households.

Using data from 115 survey respondents, Nnorom et al. (2009) reported that almost two thirds of their respondents were willing to bring obsolete devices to a nearby drop-off recycling facility; moreover, half of their respondents agreed hypothetically to pay a 20 percent premium for "greener" cell phones. Jang and Kim (2010) analyzed cell phones reuse and recycling in Korea based on a survey of 1090 consumers, visits to e-waste recycling facilities, and interviews with service providers and environmental regulators; their investigations suggest that from 2000 to 2007 only one third of the 14.5 million cell phones retired annually were collected. Ongondo and Williams (2011) examined students' cell phone disposal preferences at 5 U.K. universities. Half of their 2287 respondents stockpiled unwanted phones, one third was unaware of recycling programs, and only 27 percent of the rest actually used them. Their findings suggest that incentives are necessary to spur cell phone recycling. Geyer and Blass (2010) investigated the economics of cell phone recycling based on reverse logistics data from the U.K. and the U.S. They concluded that cell phone reuse drives recyclers' cell phones collection efforts. In their summary of cell phone recycling schemes in the U.S., Silveira and Chang (2010)