



China's toxic informal e-waste recycling: local approaches to a global environmental problem



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ABSTRACT

Electronic waste or e-waste has been an increasingly severe problem over the last decade, and is the fastest growing waste stream in the world. China's inexpensive labour and manufacturing abilities have already made it “the world's factory” and for e-waste recycling it is no exception. Informal workers do the majority of e-waste collection and recycling in cities throughout China. E-waste recycling work provides livelihoods for migrant workers and the urban poor and has formed a well-established shadow economy. The improper dismantling and burning of e-waste for resource recovery exposes workers to toxins and heavy metals, and causes severe air, water, and soil contamination. The illegal global trade of e-waste makes it a transboundary environmental governance problem of local and global scales. This paper investigates informal workers' knowledge of the environmental impacts of e-waste, perceptions of their work and whether they would be receptive to government regulation of recycling work. It finds that informal recyclers interviewed lack environmental awareness of the dangers related to e-waste recycling and are unwilling to be regulated due to fear of losing jobs and profits through regulation. Weak e-waste legislation and social marginalization are also major barriers to protecting e-waste recyclers and the environment. Through a scalar analysis of environmental governance, this paper proposes strengthening the roles of small enterprises and inclusion of Non Governmental Organization (NGOs) and Government Organized NGOs (GONGOs) to work in the informal sector to find safer recycling solutions to fill the large gap between legislation and de facto practices.

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1. Introduction

As our world moves towards fast technological advances, the world's capacity to deal with the huge amounts of waste electrical and electronic equipment (WEEE), or e-waste,¹ declines. E-waste can be defined as, “end-of-life electronic products including computers, printers, photocopy machines, television sets, mobile phones, and toys, which are made of sophisticated blends of plastics, metals, among other materials” (Wong et al., 2007:133). The EU WEEE directive defines it as, “electrical or electronic equipment which is waste (...) including all components, sub-assemblies and consumables” (Directive, 2002/96/EC Article 3b), or any items which have a battery or a power cord (Perkins et al., 2014). In

developing countries, widespread improper informal e-waste recycling has led to severe water and air pollution, soil contamination, and health effects since products contain high amounts of hazardous materials, including heavy metals and Persistent Organic Pollutants (POPs). The global flow and trade of e-waste presents transboundary environmental governance problems on both international and local levels. The U.S., U.K., and the EU are the major exporters of e-waste to developing countries such as China, India, and Nigeria (Chi et al., 2011) benefiting from low-cost labour and “disposal.” Only 25% of all e-waste is accounted for and recycled safely by official means, the remaining 75% is lost in the illegal e-waste stream (Perkins et al., 2014).

Legislation such as the 1989 Basel Convention (ratified by 181 countries) has struggled to control illegal exportation of e-waste.

China is the largest producer, consumer and exporter of e-waste in the world (Chi et al., 2011). The global estimate of e-waste generation is 20–50 million tons annually (Ongondo et al., 2011:715), the UN predicts that by 2017, e-waste generation will increase to

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¹ In this paper the term “e-waste” is used as the same meaning as WEEE.

65.4 million tons per year (Perkins et al., 2014:287). Moreover, 70%–80% of all e-waste is exported to Asian countries and 90% of that is received by China (Ongondo et al., 2011:719). In China, individual collectors and dealers² (收电子废品人) of e-waste are the key intermediaries between first disposal and recycling or material recovery of an EoL (end of life) product. In 2004, informal workers made up more than 50% of the work force in China (Kumar and Li, 2007). Informal workers engage in recycling for income but are left vulnerable to the dangers of informal recycling of toxic materials. The informal sector's lack of awareness on e-waste's adverse environmental and health impacts highlights the fact that marginalised workers do not receive needed education, and their work mainly serves survival income purposes. These workers comprise a complex informal network that is also integrated with formal channels, forming a shadow economy that operates outside regulation, making legislation difficult to enforce.

1.1. Aims & objectives

The overarching aim of this research is to provide insight from within the e-waste recycling system in Beijing by conducting ethnographic interviews with informal e-waste collectors and recyclers to give them a voice. Other studies on e-waste workers have not included workers' opinions. If the e-waste sector is to change, solutions must come from within the system, requiring first-hand knowledge from workers that can only be obtained through direct exchanges. This work suggests policies that protect and support informal workers. It also illustrates that China's informal system of e-waste management occurs very locally but it is a phenomenon spurred on and affected by the global e-waste market. The arenas of e-waste management and recycling operate on multiple scales and across various actors, state and non-state, formal and informal. Given that e-waste is a non-linear environmental issue permeating all levels, a socio-economic scalar approach is taken to analysing the current e-waste recycling situation in China. This research suggests that NGOs can help informal workers and small enterprises work with government to protect the environment and health of individuals who practice e-waste recycling without sacrificing their livelihoods. This research hopes to open up the arena for more specific studies on the needs of the informal sector to develop safe and implementable e-waste recycling practices.

2. Discourses on informal e-waste recycling

2.1. Impacts of informal e-waste recycling

Informal e-waste collection, recycling, legislation, and its health impacts on informal workers have become an increasingly popular topic in the last ten years. There are a plethora of literature on e-waste toxins and their environmental and health effects, especially on informal workers in developing countries, who are easily exposed to toxins in dismantling and resource recovery. The production of electronics and recycling of e-waste has enormous impacts on the environment and accounts for a large amount of the world's hazardous pollution from the moment of obtaining raw resources to recycling the EoL product. Modern electronic appliances have a complex mix of materials and can contain up to 60 different elements, some of which are reusable, some hazardous and some both (StEP2009:6). This complex mix is especially found

within PCBs (Printed Circuit Boards), which are burned in the open air and mined for chips and precious metals. Informal workers do not utilize personal protective equipment due to either lack of education about the dangers of unsafe recycling practices or lack of access to equipment. Workers handle, disassemble, shred, burn, and smelter e-waste products to recover reusable materials within. The burning of e-waste is used to retrieve precious metals and raw material. Copper is stripped from wires in open-air acid baths, rotors are melted to extract aluminium and silver, and the majority of dismantling is done by hand (Yang et al., 2008). During dismantling, recyclers are exposed to dioxins, POPs (persistent organic pollutants), PAHs, PCBs, PHCs,³ hexavalent chromium, brominated flame retardants (Poly brominated diphenyl ethers PBDEs) and heavy metals, which persist in the environment for long periods of time. Emissions are exacerbated by crude recycling methods, and the combined burning of certain materials as shown in Table 1 creates harmful by-products. Many studies show workers are exposed to many toxins at e-waste sites, such as through contaminated dust inhalation and dietary exposure; severe soil contamination is also a problem (Tang et al., 2010; Fu et al., 2008; Luo et al., 2011; Labunska et al., 2014; Perkins et al., 2014). Song and Li (2014) give a review of these body burdens from e-waste exposure and (Zheng et al., 2008) show high levels of heavy metals in children exposed, as they are more susceptible. Xu et al. (2012) found that at the e-waste recycling town Guiyu, prenatal exposure to e-waste recycling had four times higher risk of stillbirth and resulted in high concentrates of cadmium, nickel, and lead in new-borns.

Many challenges and possible solutions to informal e-waste recycling have been discussed in current literature. Liu et al. (2006) believe that legislation should ban informal recycling techniques and large-scale formal recycling plants should be built, combined with a strengthening of EPR policies in the private sector. Wilson et al. (2009) discuss building recycling rates through the informal sector, as the informal system effectively reduces formal recycling costs. They also argue that informal labourers be organised into cooperatives to strengthen their bargaining power with the government. Kumar and Li (2007) address social protection for urban informal workers, and the question remains if it is possible to protect informal workers from unsafe recycling practices without a large percentage of workers losing their livelihoods. Rouse (2006) sees informal jobs as enabling the poor to improve their livelihoods. It is vital that the informal sector be seen not just as an objective whole, but as individuals that act as crucial links in a complex network. Tong et al. (2014) recognize the fragmented informal network in China and point out the shortcomings of formalizing the e-waste recycling system, including certified plants' lack of materials, its employment of family workshops and "certified salvagers" who work in conjunction with informal collectors. Gutberlet (2012) argues for cooperatives of informal recyclers (using Brazil as a case study) to help poverty reduction and to consider their work as an important aspect of realising development goals and promoting sustainable communities. The International Labour Organization also recently proposed cooperative models (Brazil, India, Serbia) to strengthen informal workers' rights and leverage their labour power (ILO, 2014).

There is much discussion on take-back mechanisms for e-waste and the principle of Extended Producer Responsibility (EPR) (Yu et al., 2010a, b, 2008; Zhang, 2011). EPR is also a main facet to most global WEEE legislation in the EU, U.K., U.S., Canada, Australia, and Japan. Connected to take-back effectiveness are studies on consumer behaviour and use of household electronics and their and

² The term "dealers" is used to refer to people who buy and sell e-waste products and components. They also may or may not be collectors and many times they are also dismantle e-waste products.

³ Polycyclic Aromatic Hydrocarbons, Polychlorinated biphenyls, Petroleum hydrocarbons.

Table 1

Primary, secondary, and tertiary emissions from various e-waste recycling processes.

	Primary emissions	Secondary emissions	Tertiary emissions
Origin	Hazardous substances that are contained in e-waste	Hazardous reaction products of e-waste substances	Hazardous substances or reagents that are used and released during recycling.
Causes	Unprovoked, contained in e-waste products	Improper treatment methods such as burning and smelting of certain parts which form new toxins	Inappropriate handling; such as disassembling products; inappropriate treatment.
Pollutants	Lead, mercury, arsenic, polychlorinated biphenyls (PCBs), fluorinated cooling fluids	Dioxins or furans (PCDD/F's) formed by incineration or inappropriate smelting of plastics with halogenated flame retardants	Cyanide or other leaching agents, mercury for gold amalgamation

^a polychlorobenzodioxins (PCDDs) and polychlorodibenzofurans (PCDFs).

Source: UNEP StEP "From Waste to Resources" Final Report 2009.

willingness to recycle (Wang et al., 2011a, b; Veenstra et al., 2010; Zhang et al., 2013). There are also some case studies that look at e-waste collection channels in Dalian (Qu et al., 2013) exploring a "green communities" model and in Taizhou (Chi et al., 2014) looking at household disposal strategies.

Consumers can now engage in e-waste recycling online. The Online to Offline (O2O) model is gaining popularity as people become more environmentally conscious. For example the website Aihuishou.com (love recycling) provides an online second-hand electronics market and offers competitive prices for old electronics as well as door-to-door pick-up. O2O helps locate resources for recycling and also provides a reliable collection method. However there are still questions of how and where components are recycled and the possibility of endangering informal workers' livelihoods. There is potential to optimize the e-waste recycling system by integrating the informal collection network, but this could only be successful if workers did not lose out on recycling profits (among other factors).

2.2. Problems in Chinese e-waste legislation and governance

2.2.1. China WEEE directive

The China WEEE directive, or the Regulations for the Administration of the Recovery and Disposal of Waste Electrical and Electronic Products, went into effect on January 1, 2011, introduces the principle of extended producer responsibility and covers the duties of manufacturers, importers, repairers and enterprises dealing with the disposal of e-waste. It contains a catalogue of WEEE products for disposal, but only mandates five disposed household electronics (DHA) for recycling, which are televisions, computers, washing machines, refrigerators and air conditioners (Zhang, 2011).

The Directive was drafted by multiple bodies that are responsible for different aspects of implementing and administering the directive, but does not provide details of supervision for any given department. Under the State Council, the Ministry of Environmental Protection (MEP) Ministry of Industry and Information Technology (MIIT) and the department of resource utilization are responsible for revision of the scope and technical specifications. The MEP and MIIT should be responsible for the supervision and administration of disposing and recycling WEEE in local regions, and should develop recycling programs to be submitted to the State Council (Zhang, 2011:24). The absence of one administrative governing body makes for weak enforcement and supervision, and globally, shows a lack of commitment to the problem.

Article 22 states that enterprises not qualified for disposal of WEEE shall be prohibited from disposing WEEE products. Qualification requirements include having proper facilities and professional technical personnel along with appropriate equipment for safety and environmental protection. Penalties will be given to companies found unqualified and the company may also be asked to halt operations (Article 28). Article 34 also calls for the use of centralised disposal areas, as to comply with the pollutant

discharge standards and with the environmental standards for pollution prevention and treatment caused by solid wastes. The WEEE does not consider the existing dispersed small shops that collect e-waste for disposal, many of which are not qualified.

Article 7 is one of the most important facets to the Directive, announcing a fund for the disposal of WEEE products to be established, thereby providing a funding mechanism for WEEE treatment. It states that enterprises producing EE products have an obligation to pay into the fund and it also provides subsidies to qualified disposal and recycling operations (Zhang, 2011). However, "Several critical matters concerning the fund also remain open for the MOF [Ministry of Finance] to determine (...) including what entities are required to contribute to the fund, and how contribution amounts will be determined" (Ji, 2011:368). This lack of detail on the provisioning of the fund leaves many questions about how licensed plants will be able to afford the treatment and processing costs, especially if they are faced with inadequate amounts of e-wastes. This also reflects the Directive's vagueness of producer responsibilities despite its focus on EPR.

Article 5 recognizes that the system should include the current multi-channel network of collectors, buyers and sellers of e-waste products but lacks coordination with these social realities. Informal collectors are hard to trace since they work on their own time and it is hard to determine the working relationships they have with which small enterprises or recycling plants. There is thus no way to monitor whether informal collectors deliver to certified enterprises as stipulated by the directive and qualifications of enterprises are not vigorously enforced (Chung and Zhang, 2011). Most buyers who engage in resource recovery are not certified, and so technically they engage in illegal work towards legal ends; legislation does not recognize the formal is still inseparable from the informal system (Tong et al., 2014:7). Furthermore, refurbished and resold second-hand products are not guaranteed to have met mandatory health and safety requirements as Article 12 requires, seeing as there is no authorized certification organization for second-hand products (Yang et al., 2008).

Lastly, the Directive excludes consumer responsibility in the collection process; instead, the Directive is focused on the safe recycling of e-waste after it has been collected. Studies have shown that the more environmental awareness and education a person has, the more likely they are to voluntarily recycle as long as it is not time-intensive (Wang et al., 2011a, b:980). The WEEE directive would greatly benefit from establishing efficient and convenient formal collection channels; however replacing the existing informal network may prove too difficult and expensive, suggesting why consumer responsibilities are ignored.

2.2.2. The China RoHS

The China RoHS or *The Administrative Measure on the Control of Pollution Caused by Electronic Information Products* was enforced in 2007 and aims to reduce or eliminate the pollution of toxins and harmful substances contained in EE products. The

RoHS limits six toxic substances, including lead, mercury, cadmium, hexavalent chromium, PBBs (polybrominated biphenyls), and PBDEs (polybrominated diphenyls ethers). Though it covers the same six substances as the EU RoHS, it does not prohibit the use of hazardous substances in production, but rather requires sufficient information labelling regarding them (Khan, 2009). Article 14 states that all products on the market need to be labelled with the names of all toxic and harmful substances contained in the product and their recyclability. Importers also must also mark all packaging that conveys the content and materials of the package, complying with industrial and national standards (Article 15).

Article 3 (5) introduces a safety period for electronic products, or an “environmental expiry date” EED, that is the time period before harmful substances may become unstable or harm the product’s user. The EED should be stated on products by the manufacturer to act as guidance to users (Article 11). However there are questions of how these environmental expiry dates are calculated and how accurate the information will be, since toxins are released during production (Chung and Zhang, 2011). Stating incorrect information could also cause consumers to dispose of EE products earlier, decreasing the product’s life span and stimulating a higher disposal rate (Chung and Zhang, 2011).

Article 23 of the RoHS states that manufacturers, designers, importers and sellers who do not comply with articles 11, 14 and 15 shall be penalised, but it does not state details regarding these penalties. Article 18 mandates that electronic products released from factories must have the appropriate certification and accreditation and this will be checked at each entry port. Also the number of companies with certification is unknown; in 2007 only five companies obtained this certification (Chung and Zhang, 2011). Another limitation with the RoHS is the directive does not apply to products made for export, meaning legislation applies mainly to e-waste produced for the Chinese market.

A revised RoHS was released to the public in draft form in 2010. Large differences include encouraging companies and government to buy China RoHS compliant products and include electrical appliances in addition to electronic information products. It also proposes violations to be reported, but there is no way to guarantee reporting and it may induce tension between companies in the same industry (Chung and Zhang, 2011). In terms of enforcement, the RoHS has multiple governing bodies including local governments; as with the WEEE, the supervision is left uncoordinated and responsibilities ambiguous. In addition to these regulatory barriers, Chinese consumers have little knowledge of RoHS compliant products, there is a lack of suppliers who screen for RoHS compliance, and there is a shortage of industry best practices in implementing RoHS, hindering industry from adopting China RoHS practices. There is also a lack of finances for RoHS training and problems with innovative technology. Dou and Sarkis (2013) found that major stakeholders in electronic manufacturing, industry, and corporate sector believed that the lack of government supportive economic policies was the strongest barrier to China RoHS implementation and that all three ranked lack of RoHS practices to be shared and studied was a significant barrier. This study sheds light on how RoHS can be better implemented in China and provides a

good example of a multi-stakeholder approach that could be used to inform e-waste policy.

3. Methodology

Research for this project was a combination of primary research and secondary research on current literature on e-waste flows and recycling in China and other developing countries. Secondary sources included academic, media, NGO reports, international e-waste legislation, and all relevant Chinese legislation. Understanding past and current legislation illuminated shortcomings of legislation especially to its lack of efficiency in addressing environmental and health problems with widespread informal recycling practices. Media reports (newspapers and programmes) and NGO reports helped to paint a picture of how the situation of e-waste is portrayed both to the Chinese and international public. These articles represented how multiple stakeholders might view the problem of e-waste.

Primary research consisted of fieldwork at waste recycling sites where 12 semi-structured interviews with 10 informal collectors and recyclers were conducted (two were follow-up interviews). Interviewees were individuals involved in electronic waste recycling across Beijing; some were collectors and dealers, and some were dissemblers, mostly from small family-run operations or individuals. E-waste dismantling methods and business transactions between collectors and dealers were observed during site visits. A student from the University of International Business and Economics was present at all interviews to assist with language barriers. It was important to have a native Chinese speaker to aid in approaching people so they did not feel uncomfortable. Having a native speaker also served to reduce inaccuracies in translation and meanings, though it must be noted that translating has inherent problems for ethnography in that it will always transform the meaning, maybe not in its function, but in its essence. It must be noted that 12 interviews is not a complete representation of the informal sector’s views, but larger trends such as lack of education and environmental impacts were palpable. Further research is needed to conduct comprehensive research of e-waste collectors based on social indicators.

Sites were chosen based upon prior research of where informal electronics disassembly might be taking place. The first site visited was the Zhongguancun (中关村) area of Beijing to explore the second-hand markets and electronics refurbishing, and where these parts came from. These retail areas allowed to gauge sellers’ knowledge of the origins of their products and also see which products were sold second-hand or refurbished, and if they were handled in an unsafe manner. Questions mostly concerned prices of products, where products came from, what they did with products once acquired and what happened to waste parts or EoL products. Conversations were mostly focused on prices of new and old products and parts than about recycling. Visits to this site painted a more complete picture of the market for old and new electronics in Beijing (Table 2).

Other sites visited were Houbajia (后八家) village and Dongxiaokou (东小口) village in Beijing. Houbajia was chosen as it has been well-covered in Western media by news agencies such as CBS

Table 2
Sites visited and interviews conducted.

Site	Site description	Interviews conducted
Zhongguancun	Second hand electronics markets	No full interviews, conversational
Houbajia	E-waste recycling village	1 interview
Dongxiaokou	Solid waste recycling site/village	7 interviews, 2 follow-up interviews
Weiyacun	E-waste recycling village	2 interviews

Table 3
Sample of types of questions asked in interviews.

Introduction questions	<ul style="list-style-type: none"> • Where are you from? (To ascertain if they are migrant workers) • Do you recycle old electronic products? • How long have you been engaging in this type of work?
Questions related to e-waste work and perception of work	<ul style="list-style-type: none"> • Do you collect, sort, disassemble, or treat this waste? (Or what do you do with e-waste) • Why do you do this work as opposed to another? • Do you see this work as important? As a service? • How do you organize sales/relationships with dealers • Where does this waste go after you sell it?
Questions related to environmental and health impacts	<ul style="list-style-type: none"> • Are you aware that electronic waste can be harmful? • What do you know of the environmental impacts of this type of waste? • Have you noticed any health problems since you have been doing this work? • Do you think e-waste can harm your health?
Questions related to regulation and policy	<ul style="list-style-type: none"> • Are you aware of the laws on e-waste recycling? • Have you ever formed a type of cooperative with others? • Would you be willing to work for the government, such as being organized, or selling to government plants? Why or why not?

and China Daily, as an area known for e-waste collecting and unsafe e-waste recycling practices. Dongxiaokou is a large waste recycling town that not only recycles e-waste but also cardboard/paper, plastics, and metals. Dongxiaokou was chosen as a site from information obtained from collectors in Houbajia. Upon arrival in Houbajia, it was discovered that people engaging in electronic waste recycling had been moved out of the area by the government, who cleared the area for new building developments. This could be part of an effort to reduce unsafe recycling practices; one woman who was weighing some cables said that the city police⁴ (城管) had been seizing some people's waste and forbidding the burning of polluting materials. Another man at a waste site nearby said that some collectors had moved to the Dongxiaokou area, but that it also would be shut down in the future. Dongxiaokou was chosen to visit based on this knowledge, since the recycling practices at Houbajia had mostly been stopped. The closing of these areas could be a sign that the government wishes to move these recycling and waste sites to the further edges of Beijing and use the land for more valuable real estate.

Three visits to the Dongxiaokou area were made and one to Weiyaocun, a small e-waste recycling village north of Tiantong-beiyuan. People were approached based on signs outside their houses that said they receive e-waste, if e-waste products could be seen in their yard, or if they were actively disassembling e-wastes. The project was introduced and permission granted before proceeding with questions. It was easier to first approach asking about prices and business in order to introduce the research. The purpose of the third visit to Dongxiaokou was to conduct follow up interviews with people who were previously interviewed.

For interviews, a semi-structured open-ended method was used. Interviews started with basic questions to make participants feel more at ease and gain basic background information, such as what province they were from, age, and how long they had been doing recycling work. These questions were followed by more targeted socio-economic questions focused on finding out key research questions, including knowledge the informal sector has of the environmental impacts of e-waste recycling, knowledge of health risks of e-waste recycling, reasons for carrying out recycling work, how workers perceive themselves in society, how they are organized, and their willingness to be regulated. Table 3.

Interviews were then analysed to look for similarities and trends in their answers. These questions helped to reveal workers perceptions of e-waste as having significant value. These

questions were also designed to reveal how informal collectors and recyclers perceived their work in society, and if they would be receptive to government regulation or educational programs related to their work.

4. Findings: perspectives from informal e-waste workers in Beijing

The e-waste trade is its own informal shadow economy in urban areas made up of people and small enterprises that operate with little to no regulation. E-waste collectors go around the city on bikes and carts, collecting in residential areas, shops, and second-hand electronic markets. Collectors will weigh products such as cables and small electronics to determine price by weight. Price will also be determined by reuse value. After collected, the product is either refurbished to be sold for reuse, resold to a second hand market, or resold to individual dealers who may bring it to a plant for further recycling and extraction of materials. Buyers may also dismantle and sort components that will be sold to specialists (专业), who will further extract metals and raw materials by hand or mechanically. Many buyers are from Guangdong, Hebei, and Tianjin where larger sorting or recycling plants are located. Most people in Dongxiaokou first manually disassemble products and sell the reusable materials within, and they said the rest that is non-recyclable will go to a landfill with common solid waste. At different stage throughout this process, the informal and formal overlap and are highly dependent upon one another.

E-waste collectors have freedom to collect what they want, at locations they choose. They build business relationships with a large network of collectors, vendors, and small enterprises.

4.1. The flourishing informal system

This informal e-waste economy flourishes for a combination of socio-economic reasons, which make it difficult to regulate. Firstly, there is still a large disparity of income and livelihoods between rural and urban areas in China. This creates a flow of second-hand electronic and electrical products from urban to rural areas; Chinese recyclers also prioritize reuse over material recovery since functional value is higher (Chi et al., 2011:734). Secondly, there is a general unwillingness of consumers to return their WEEE to companies or licensed plants as the price consumers receive from formal or government facilities is significantly lower due to collection and treatment costs (Yu et al., 2010b). A pilot project in Suzhou could only offer 50 Yuan for an old computer, while informal collectors offered 150–200 Yuan, plus the convenience of door-to-door collection (Yu et al., 2010b:994). The “waste as value”

⁴ These are not police officers, rather they are officials who monitor areas for bad behavior but have no power to arrest anybody. They do however, report activities to the police. The literal translation for their position is “city manager”.

mentality in China also makes the informal system work “waste is in the first instance very valuable (... ; an) informal waste processing economy exists that aims to capture any value that is present in what people and companies throw away” (Veenstra et al., 2010:451).

All e-waste dealers (collectors and dismantlers) who were interviewed stated they engage in e-waste recycling because they have no or little education. However their work is not unskilled – the breaking down of components and selling requires a specific set of skills, which is vital to the informal economy’s success. A young man from Henan, who remains anonymous but will be called Zhang Jiaping, illustrated this point when he talked about his family business, “We are able to survive in this business because we have the experience and skill to tell which wastes are valuable.” For any given appliance or product, they know all the parts and raw materials that can be extracted and sold. Dealers know how to manually disassemble and sort components as well as what corresponding price they can expect for various pieces. In this pre-processing stage, manual dismantling is preferred over mechanical methods, and comparative studies of pre-processing have shown that more complete manual dismantling leads to better resource recovery (Schluep et al., 2013). This suggests that manual sorting practices can be further developed and improved (Chi et al., 2011:737), and that the informal sector is in need of equipment and technology that can recover resources more efficiently.

The informal system has an effective organized collection network that the formal system lacks. However part of the problem is that e-waste collection channels in formal and informal sectors are fundamentally tied together and operate with each other, not separate from each other. Many plants buy their materials from individual and family workshops, because they lack good collection methods. The added convenience and efficiency of informal peddlers to deliver e-waste from sellers to recycling and treatment sites (door-to-door) gives the informal sector a significant competitive advantage (Lu et al., 2015:9). Formal facilities’ absence of efficient collection networks results in a lack of material supply. This means there is also a shortage of funds and investments to finance improved recycling methods (Chi et al., 2011:733). Almost all of the formal, certified plants in Beijing eventually stopped operation since there were not enough products to recycle. The large demand from informal buyers and sellers absorbs most of the materials and products in the downstream, keeping the market strong. This second hand circular economy effectively reduces urban waste quantities and at the same time the shift to market-based materials that have been previously recycled has also increased the cost of state-funded waste management (Wilson et al., 2009). Many efforts to integrate sectors and divert e-waste to formal processing plants have failed due to lack of supply and the formal sector’s uncompetitive prices.

4.2. E-waste collectors as a social category

E-waste recycling in China is an inherently socio-economically bound activity. The informal workers who engage in collecting, selling, and recycling e-waste occupy a special niche in society that both determines and is driven by their social status. The concept of the informal sector originates from “third world” studies (Chi et al., 2011). The informal sector is often seen as operating in a type of self-governance as well as being beyond the reach of official governance, lacking in regulation or structure (Guha-Khasnobis et al., 2006).

E-waste collectors are comprised of two main social groups – migrant workers and the urban poor both which are highly marginalised in society and do this work because they have no other options. Part of this marginalization is due to their lack of *hukou* (户

口), or household registration, which gives individuals state benefits and rights as a Chinese citizen. Individuals and families that were spoken to all identify themselves as “people who take back waste” (收电子废品 or 收废品人). Individuals or groups who are “marginalised” can be identified as those who are involuntarily excluded from certain realms of society, which includes public participation (Wong et al., 2007). Informal workers are often seen as “dirty” and unsafe by formal waste collection channels and this view surely reflects on their image of their own social status, creating challenges for cooperation. Zhang Jiaping said, “This work may be important, but I do not see it in that way, it is just to make a living. I am not proud of what I do, I cannot be proud of this kind of work.” This social perception creates a barrier to government recognising that workers are vital members of society whose work provides livelihoods and a valuable community service.

4.3. Lack of awareness of the risks of informal recycling

The lack of education about the environmental and health hazards of e-waste proved a significant barrier in speaking with individuals about the topic and is a barrier to developing effective e-waste legislation. Many workers did not comment on legislation or the legality of their work. One young man who dismantled refrigerators said his work did not seem harmful, even though dismantling refrigerators can leak mercury, oil, and other substances and emits CFC emissions. He said he knew computers could give off harmful radiation. A woman whose lawn was covered with old batteries and electrical appliances, said that she believed there was no health threat: “When they are collected I wash them, as long as they are clean (干净), they should not be harmful to our health.” When lead in batteries was mentioned, she responded with the same reasoning. When asked about burning appliances for material recovery she replied, “Oh we are not allowed to burn things anymore, also our neighbours do not like the smell.” She did not know about the legislation on e-waste, but she did have knowledge about the “Old for New” policy.⁵ Zhang Jiaping’s father knew a little about the dangers of recycling; “If we were to break down copper, and inhaled the copper dust (铜末子), then I think it would cause some health problems, but the way we deal with it, it should not, since we handle it in large pieces.” However not one of the interviewees admitted to any health problems. Even one man who had been an e-waste dealer and dismantler for over 20 years said “I am pretty sure I have no health problems from this work, but I know these things can cause pollution if you burn them.” Most dealers had knowledge that burning is bad, but are in general unaware of environmental impacts of specific or hazardous parts in appliances. Health questions were a sensitive issue and most workers were not willing to answer or said they do not know if health problems were related to their work.

4.4. Unwillingness to be regulated

The informal sector’s unwillingness to be regulated is perhaps the largest barrier to ensuring safe practices in e-waste recycling work. As seen from previous sections, the extent to which collectors and dealers are free to buy and sell to who they choose is a marker of the informal economy’s independence and also speaks to its activity as a shadow economy. They do not want to lose money with mandated pricing or lose their jobs to mechanical processing.

⁵ “Household Electrical Appliance Program” enacted from 2009 to 2011 where the government provided subsidies to consumers for returning their old household appliances to be formally recycled when buying new appliances, implemented in cities such as Beijing, Tianjin, and Shanghai.

Workers also have freedom in terms of organising their own time and space that is related to their collection and this allocation of time and space is also a skill (Li, 2002). These are central reasons (very much “free market rational”) why most dealers do not want to be regulated and prefer informal self-organisation. When Zhang Jiaping was asked about forming cooperatives or having the government organize and regulate them, he responded,

“The system should stay as it is. The government should not interfere with what we have. This type of work provides many jobs for people. If the government organised us in some way, a lot of people may lose their jobs. I think we already help the government a lot, they do not need to regulate or organise us. Also there may be some people who steal appliances or parts to sell, and if the police or government found out about that it could threaten our jobs even if we do not know about it. It is best for them to stay out of it.”

This cooperative model has proven useful with informal workers in places like Brazil and India (ILO, 2014) providing a greater chance for collective bargaining to gain recognition and labour rights. In China types of public organization are seen as threats to the government's authority, making labour unions virtually non-existent. Worker's lack of *hukou* also makes forming informal cooperatives very difficult, since their social rights are already limited. The biggest hurdle is the government's lack of direct recognition and reluctance to address poor working conditions, health, and environmental risks in the informal sector.

Unfortunately, profit – and not health – is their primary concern for “survival.” When asked about the dangers of handling and recycling these materials, Zhang Jiaping shared a story of a few men in Hebei who were injured while they were melting down aluminium, one was killed and two were hospitalised. Despite accidents such as this one, he said, “we can protect ourselves, we learn from experience and we know how to protect ourselves, the government doesn't need to.” Through interviews it was obvious that workers have a strong preference for self-regulation, especially since they have little to no power to express their needs in wider society.

5. Discussion

Intuitively clear throughout this paper is that e-waste is both a local and global problem, with e-waste flows transcending territories of space and place (Renckens, 2007). The scales of e-waste need to be disaggregated in order to effectively manage the problem. At first the production and breaking down of e-waste seems

tied to geographical spaces; in China the localization of commodity chains reflect the spatial division of labour (Tong et al., 2014). Today e-waste transcends borders; technological advances and global software become “new sources of enormous e-waste creation” (Renckens, 2007:13), and the recycling of e-waste cannot be separated from the production and consumption system from local to global scales (Lyons et al., 2009). The subsequent disassembling of e-waste in geographically different places (refer to Fig. 1) and based on international “trade logic” has resulted in social inequalities and shifts of power. The globalisation of e-waste has created new forms of authority, located in the global economy “with private actors emerging as new sovereigns” (Falkner, 2003:74). The concept of environmental problems taking place in the “global arena” disembodies “the causes and consequences of such problems (...) from practices and politics taking place at a multitude of sites and scales of governance” (Bulkeley, 2005:10). In the upstream, regional legislation such as the RoHS and the Directive indirectly affects multinational companies (such as Dell, HP, Lenovo) and their manufacturers since they limit the amount of hazardous materials in EE products and promote more sustainable product design and take back (EPR). This trickling down of supranational authority creates linking vertical chains – supply chains and authority chains, as well as horizontal chains that link across multiple actors of governance (Tengku-Hamzah and Adeline, 2011).

In the downstream, informal workers deliver materials back into the market through recycling processes, thereby contributing back into the formal economy. The informal recycling system works mostly outside of regulation until end-processing stages for raw material extraction or a new product is made from recycled materials. Informal intermediary dealers link companies, consumers, and themselves as key actors in different spaces. Fig. 2 below shows the hierarchal but intersecting scales of e-waste management and regulation. NGOs and civil society (consumers) interact and supply the informal sector and dictate industry trends. State actors pass legislation and form partnerships with industry and some influence NGOs at differing levels. Transnational networks of industry experts and global civil society also must be taken account of and should be imagined as external and influencing these spheres across horizontal planes (Bulkeley, 2005).

5.1. Recommendations

Legislation has mostly focused on producers in the upstream and official recycling processes in the downstream. However, the large gap between legislation and actual practices remains. Regulations drafted specifically for informal e-waste recycling is needed. Looking at the different scales and fragmented nature of e-waste

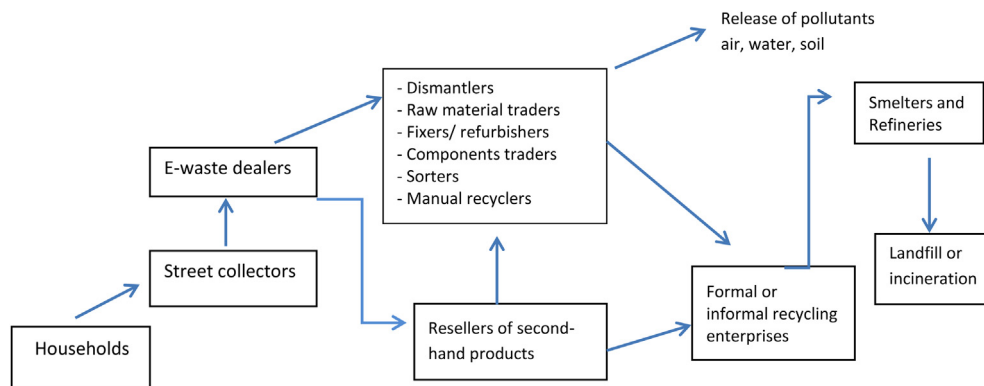


Fig. 1. Simplified flow chart of informal waste process in Beijing.
Source: Chi et al., 2011.

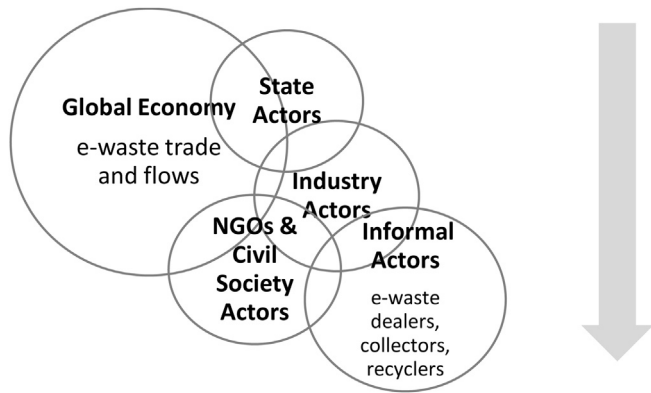


Fig. 2. Intersecting hierarchal scales of e-waste management.

management, the e-waste problem in China requires a paradigm shift in thinking. The current informal e-waste system needs to be recognised. After recognition it should be strengthened through practical improvements. This requires action from all sectors in four areas:

- 1) Government → National and regional legislation
- 2) Industry → Private environmental governance and EPR
- 3) NGOs and GONGOs → Research, education, monitoring of small enterprises
- 4) Informal E-waste dealers → Community collaboration, knowledge sharing

On national and regional levels, a governing body devoted to urban e-waste recycling should be created to streamline and strengthen supervision. By doing this, China would show international leadership in addressing the problem, demonstrating it is ready to meet international standards and not just national ones. Specific regulations need to address the health and environmental risks faced by the informal sector to improve livelihood conditions. Regional governance required by the WEEE directive and RoHS should not only regulate transboundary e-waste movements but can improve sustainable development of EE by fostering innovation in technologies as well as knowledge exchange and education (Ji, 2011:269). Regulation should include creating partnerships with Southeast Asian countries to increase monitoring at ports of entry and customs where the illegal e-waste trade is active.

In China's private sector, it is abundantly clear that company take-back programmes can only be successful if they can provide collection channels as convenient and efficient as those of the informal system. Companies should launch more localized efforts that aim at educating consumer about e-waste recycling and disposal. Tong et al. (2014) highlight the need to create new linkages between consumers, producers, and recyclers in both the informal and formal sectors. Solutions trying to divert more e-waste to formal channels have failed. One project, the "Green Communities" programme by the Dalian municipal government in 2008, which encouraged people to sell to community e-waste collection stations and bypass informal channels, found that the uncompetitive price for formal collection and insufficient infrastructure, such as collection centres, posed large challenges; and even public institutions preferred to sell to informal collectors since the formal plant could not afford the prices for e-waste (Qu et al., 2013).

The "Best-of-2-Worlds" solution aims to employ informal workers in the pre-processing stages of dismantling and then use formal state-of-the art raw resource recovery in end-processing in countries such as Europe (Wang et al., 2012). This would be

successful in reducing crude recycling methods while preserving informal jobs and would aid in efficient resource recovery. However, a pilot program carried out in China showed it faced the same problem of insufficient materials for facilities and inability to collect waste at reasonable prices – coupled with the internalization of environmentally safe treatment it could not be competitive with informal counterparts. They also faced a myriad of issues with customs regulations, lack of transparency, and communication problems showing shipping e-waste back to Europe is not the answer to solving local problems (Wang et al., 2012).

5.1.1. Special roles for NGOs and GONGOs

So far the public sector has been slow to be integrated into e-waste control efforts and lack of public participation in policy making remains a challenge in China (Lu et al., 2015). NGOs should help fill the "governance" gap in informal e-waste recycling. Already well-known NGOs like Greenpeace and the Basel Action Network and many others have illuminated the enormous health risks faced by informal plastics and e-waste recyclers, but few have yet to take action on the ground to address the problems. In China, NGOs have now become important non-state actors in the political arena (Mol and Carter, 2006). Lu et al. (2015) and Qu et al. (2013) also propose more public participation and grassroots efforts to help government deliver education on policies related to e-waste management. NGOs and GONGOs in China are good resources to help the government implement on-the-ground work at the intersection of e-waste policies, government, and real life recycling practices.

NGOs need to conduct more local research, including interviews and surveys that take a social perspective to understand the complexities of the e-waste sector, and understand how e-waste dealers work every day, what challenges they face, and what methods would be most beneficial in enabling their safe work. GONGOs and local government can deliver education on the health hazards of e-waste (putting up informative posters, having volunteers speak with e-waste recyclers) in a way that fosters community knowledge exchange and cooperation. NGOs have been working with government on informal e-waste recycling in countries such as India, but NGO work is still limited in this area in China, even though there has been advocacy work (such as Greenpeace).

Both NGOs and GONGOs can also help build monitoring capacity of small enterprises so that practices meet occupational health and safety standards, even if they are not licensed. Strengthening small recycling enterprises that conduct business with informal collectors and dealers will ensure that small enterprises will have a steady supply of e-waste to recycle. Through on the ground research, NGOs and GONGOs can develop safer manual dismantling practices with workers so that they reduce dangers of contamination. Education should include how to properly handle certain EE items such as batteries, rotors, and PCBs along with proper dismantling of appliances such as refrigerators and air conditioners. Methods should not be replaced but rather improved with effective changes that can be monitored and evaluated by NGOs or research institutions. This way the local flows of e-waste can be managed on local levels with regulation that takes into account social realities.

Currently, it is unrealistic to expect to formalise or organise the informal sector due to the well-established informal economy that has proved to be efficient over formal models. Supporting the informal sector requires the government to officially recognise the service and employment that informal e-waste collection and recycling provides (it is already recognised by scholars) on social and political levels. There is no doubt that this empowerment of the informal sector will require a restructuring of agency between private companies, local governments, and national policy.

6. Conclusion

China is faced with an environmental problem of complex spatiality, created by social and political processes and shaped by transnational networks (Bulkeley, 2005). The informal economy of e-waste recycling is firmly established and cannot be phased out, especially with the rapid growth of the global e-waste stream. Legislation needs to recognise the efficiency of the informal recycling market to strengthen safer modes of recycling. This means realising the potential of the informal work force and legitimising their work and place in society by creating legislation that integrates the existing system by improving existing methods and not necessarily replacing them. NGO and GONGOs can help fill the governance gap by talking with informal workers about methods they use and finding realistic, employable solutions. In the upstream, companies need to move away from end-of-pipe technologies and move towards Design for Environment (DfE) and clean production processes so that EE products will be safer to handle and recycle. Local EPBs should partner with NGOs and the public sector on e-waste recycling education and later can build capacities through best practice cases studies.

Future research is needed to provide more first-hand perspectives from e-waste collectors to evaluate their roles in society and willingness to work with NGOs and small enterprises. This paper hopes to provide a starting point from which to conduct deeper ethnographic research that can inform policies that support informal workers' social needs. China needs innovative and situation-specific solutions so that e-waste recycling becomes safer without losing the economic benefits of the informal system.

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