The flow of E-waste material in the Asian region and a reconsideration of international trade policies on E-waste

Takayoshi Shinkuma a,⁎, Nguyen Thi Minh Huong b

a Faculty of Economics, Kansai University, 3-3-35 Yamate-cho, Suita-shi, Osaka, 564-8680, Japan
b Department of Japanese, Hanoi University, Km 9 Nguyen Trai Thanh Xuan Ha Noi, Viet Nam

ABSTRACT

End-of-life home appliances discarded in Japan are reused in Southeast Asia; end-of-life computers are reused in China. E-waste scrap generated in Asia is recycled in China, especially in Guangdong Province. The informal sector in that province has been recycling E-waste scrap and its improper recycling methods have caused serious pollution. In response to this problem, there is wide support for a total ban on E-waste trade, including secondhand items and E-waste scrap. Alternatively, we recommend the establishment of an alternative proper recycling system in Asia that needs cooperation among all Asian countries. First, China is urged to promote proper domestic recycling activities by providing a subsidy for proper recycling. Second, Japan, as a main exporter of E-waste, should establish a traceability system that ensures E-waste scrap exported from Japan will be recycled at proper recycling facilities in China.

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1. Introduction

In the 1970s and 1980s hazardous waste exported from developed countries to developing countries caused serious environmental pollution. To solve the problem, the Basel Convention (the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal) was put into effect in 1992. After the Basel Convention came into force, the trade in waste has undergone enormous changes. As a result of the Convention, there has been a decrease in the export of waste for final disposal from developed to developing countries. There has been an increase, however, in the export of used products for reuse, as well as scrap for recycling.

Home appliances and computers used in Japan have to a large extent been exported into other Asian countries as secondhand products. E-waste scrap also has been exported for recycling to other parts of Asia, especially China, where E-waste scrap is defined as what is generated by dismantling electrical and electronic equipment and roughly sorting the parts according to the material they are made from.1

Circulation of resources (including the reuse and recycling of material) in the whole Asian region is essential in terms of effective utilization of resources. However, in China and other countries that import printed-circuit boards and other E-waste scrap, serious environmental pollution has been generated by improper recycling methods, according to a report published by Basel Action Network and Silicon Valley Toxics Coalition (2002). This report has revealed that not only final disposal but also the recycling of waste can cause environmental pollution.

As a solution to the problem, several countries have banned the import of secondhand items and E-waste scrap. There is also support for the idea that the Basel Convention should be amended so that all import of secondhand items and E-waste scrap. There is also support for the idea that the Basel Convention should be amended so that all export of scrap, including hazardous materials, from developed to developing countries — even for recycling — should be banned.

The first aim of this study is to convey an accurate picture of the material flow of secondhand items and E-waste scrap such as printed-circuit boards with emphasis on Japan, China, Vietnam, and Cambodia.2 The second aim is to examine the recent trend towards a ban on all waste trade.

The remainder of this article is organized as follows. In Section 2 we provide an overview of the Basel Convention and domestic laws in various Asian countries on the trading of E-waste scrap and secondhand

2 This study is based on six field studies. The first was carried out from 20 to 28 August 2005 (in Guiyu, Guangdong Province of China), the second from 15 to 25 December 2005 (in Shanghai, Ningbo, Taizhou, Hangzhou, and Beijing), the third from 20 to 27 August 2006 (in Hanoi, Haiphong, and Vinh in Vietnam), the fourth from 20 to 28 September 2006 (in Guangzhou, Qinyuan, and Dongxin in China and in Mong Cai in Vietnam), the fifth from 19 to 26 November 2006 (in Ho Chi Minh and around Chau Doc in Vietnam), the sixth from 15 to 22 February 2007 (in Phnom Penh, Sihanoukville, and Siem Reap in Cambodia).
electrical and electronic equipment. In Section 3 we describe the material flow of resources in the Asian region. In Section 4 we look at the environmental pollution caused by the recycling of printed-circuit boards in China and summarize the Chinese government’s policy in regard to the problem. In Section 5 we examine the recent trend toward banning the waste trade, and we propose an alternative policy. Section 6 presents our conclusions.

2. The Basel Convention and relevant laws of other countries

2.1. The Basel Convention

In the 1970s and 1980s a number of developed countries exported hazardous wastes to developing countries for final disposal and their disposal caused serious environmental pollution. To remedy this problem, the Basel Convention came into effect in 1992. The trading of waste for final disposal has been replaced by the trading of waste for reuse and recycling. Recycling methods in developing countries, however, take little account of effects on the environment and have caused serious pollution. The recycling of E-waste, in particular printed-circuit boards, has caused serious environmental damage (Liu et al. 2006; Wong et al. 2007a; Wong et al. 2007b; Wong et al. 2007c).

The Basel Convention requires that prior notice of any proposed export of certain hazardous items be given to the government of an importing country and approved by it. But the Basel Convention does not regulate secondhand items and some E-waste scrap (including printed-circuit boards).3 The Basel Convention does not solve the new environmental problem caused by the recycling of E-waste.

To solve the new problem, it is argued that the Basel Convention should be amended in such a way that hazardous wastes must not be exported from developed countries to developing countries for any purpose (even for recycling). In 1995 the statement was presented as the Basel Total Ban, but it has yet to be agreed upon.

2.2. Domestic laws in Asian countries

Many Asian countries have built up their own legal frameworks to deal with the import of secondhand items and hazardous wastes. We shall summarize them briefly here, especially what relates to secondhand EEE (electrical and electronic equipment) and E-waste scrap such as printed-circuit boards. In addition, they are described with emphasis on China, Vietnam, and Cambodia.

2.2.1. China

To protect domestic production, China completely banned the importation of secondhand EEE from April 2000. The importation of printed-circuit boards is prohibited (Yoshida, 2006).

2.2.2. Vietnam

In 2001 the importation of secondhand EEE, including home appliances and computers, was banned. The importing of secondhand EEs, however, still took place in practice, owing to loose control and management on the part of the Vietnamese government. From May 2006 the enforcement of the ban on importing secondhand EEE has been tightened (with the promulgation of Governmental Decree No. 12/2006/NĐ-CP).

In October 2004 the importing of E-waste scrap (especially printed-circuit boards) for the purpose of re-export was banned (according to Decision No. 5678/VPCP made by the Minister for Trade). In July 2005 Vietnam intensified and tightened the ban on the importation of E-waste scrap for any purpose. Vietnam has also banned the dismantling of E-waste scrap.

2.2.3. Cambodia

Except for computers, secondhand EEE has not been regulated. Importing secondhand computers was banned in 1996 because of concern about the possibility of spreading a virus infection into domestic computer systems. E-waste scrap is not subject to any legal regulations.

2.3. The recent argument for amendment of the Home Appliance Recycling Law in Japan

The Home Appliance Recycling Law of Japan (applicable from 2001) stipulates that producers have an obligation of “resource recovery” in regard to four types of end-of-life home appliances: televisions, refrigerators, washing machines, and air conditioners. The costs of transportation and “resource recovery” are to be paid by consumers when they dispose of these end-of-life home appliances (Kawakami, 2001).

It is worth noticing that “resource recovery” is defined as the “conversion of the discarded products into a state suitable for sale in value” rather than as the obligation to recycle (domestically). In other words, it is allowed to export “recovered resources” overseas as scrap to be recycled. And in fact a large proportion of end-of-life home appliances in Japan is exported to China as “mixed metal,” where it is shredded and sorted into different materials by machine.

Another point to note is that only 10,760,000 out of 22,870,000 end-of-life home appliances discarded in 2005 came into the possession of home appliance recycling factories (Japanese Ministry of Environment, Japanese Ministry of Economy, Trade and Industry, 2006). This means that over half of such home appliances are discarded in ways that get around the Home Appliance Recycling Law, and this portion is referred to as “unregulated flow.” The greater part of “unregulated flow” is made up of home appliances exported as secondhand home appliances (the total number in 2005 is estimated to have been 7,350,000)4. The number of end-of-life home appliances illegally disposed of is estimated to be low (140,000 in 2005)5.

One of the reasons that about half of the end-of-life home appliances are exported as secondhand items is that consumers have been obliged to pay the transportation and recycling costs when they dispose of them. Consumers can evade paying the transportation and recycling costs if they sell end-of-life home appliances to the exporters. Therefore, the number of items in “unregulated flow” would be reduced, if consumers were to pay those costs in advance, at the time they buy new home appliances. This proposition can be easily shown in a simple theoretical economic model (see Shinkuma (2007a,b)). Currently there is widespread support for the idea of changing the timing of the payment for recycling costs.

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3. Printed-circuit boards have been listed among unregulated items (Annex IX List B of the Basel Convention). Now, printed-circuit boards usually contain lead, which is regulated by the Basel Convention (in Annex I); at the same time, lead is also listed in Annex III (a table of harmful properties). Given this inconsistency, it is difficult to determine whether printed-circuit boards are regulated or not. Hence, the regulation of trade in printed-circuit boards differs among Asian countries. According to the domestic policy of Japan, E-waste scrap with over 0.1% lead content shall be regulated. In China the import of E-waste scrap mixed with a single printed-circuit board is prohibited in principle, but the Chinese government approves it in practice if the content of printed-circuit boards does not exceed 3% of the E-waste scrap. Therefore, it is possible to export printed-circuit boards along with other scrap (as “mixed metal”) from Japan to China.


5. See the same reference listed in footnote 4.
3. Material flow of secondhand EEE and E-waste scrap in Asia

3.1. Material flow of secondhand EEE in Asia

What happens to the secondhand EEE and E-waste scrap such as printed-circuit boards after they are exported from Japan? In this section we investigate the material flow of such goods, with emphasis on China, Vietnam, and Cambodia. Recall that in the previous section we indicated that China and Vietnam have banned the import of secondhand EEE and printed-circuit boards. Yet in both countries a considerable amount of secondhand EEEs and printed-circuit boards is traded. The reason is that there is a large gap between the policies in principle and the implementation in practice.

Firstly, let us look at the trade of secondhand EEEs between China and northern Vietnam. In principle, China enforces an absolute ban on the import of secondhand EEE. However, in reality large amounts of secondhand EEEs are imported into China. This contradiction is attributed to the fact that the government of China allows secondhand EEEs to be imported as long as they are rebuilt and then re-exported. Indeed, the government of China encourages the export of secondhand products by reducing the value-added tax (VAT) on secondhand products to 4%. Although the import of secondhand EEEs for the purpose of re-export was banned after 2002, in actuality this type of import is still unofficially allowed to go on (Yoshida, 2006).

The domestic demand in China for secondhand home appliances, especially TV sets, is decreasing because such items have to compete in price with new domestically made products, whereas the demand for secondhand home appliances in other developing countries is still very high. For that reason, China has imported secondhand home appliances (especially secondhand CRT television sets) from Japan and the United States, rebuilt or renewed them mainly in Guangzhou, and then re-exported them to other countries including Vietnam. There are two import routes for this. In the first one, secondhand EEEs are imported via Hong Kong from Japan and the United States and then brought into Guangzhou for renewal. The rebuilt secondhand EEEs are eventually smuggled to Vietnam at the Dongxin border area.

The second route is roundabout. First of all, all the CRT television sets are imported at Haiphong international port (in northern Vietnam) from Japan and the United States, from which they are exported (from Vietnam) through the Mong Cai border gate to Dongxin in China. They are then taken to Guangzhou by truck, rebuilt in Guangzhou, and finally exported illegally back to Vietnam. Note that Vietnam also bans the import of secondhand EEEs in principle. However, the Vietnamese government also applies the same exemption to the import of secondhand EEEs that China does; that is, it allows the importation of secondhand EEEs for the purpose of re-export. This makes it possible for China to import secondhand EEEs from Vietnam by this route.

The smuggling between Dongxin and Mong Cai is quite simple. Secondhand EEEs are carried over the river in small boats, covered only with blue canvas. Secondhand home appliances smuggled from Dongxin into Mong Cai have been put up for sale in secondhand markets in northern Vietnam, including in Hanoi and Haiphong.

Not all the secondhand EEEs imported into China, however, are eventually exported to other countries. In China there is still a large demand for secondhand computers, even though the demand for home appliances has been decreasing. Chinese business firms in particular need a great deal of secondhand computers. The secondhand computers imported from Vietnam ("for the purpose of re-export") remain in China and are sold in the secondhand markets. Customs officials in Dongxin tacitly permit the importation of secondhand computers even though they know that the goods will remain in China.

Vietnam also allows secondhand EEEs to be imported for the purpose of re-export, despite the fact that not all of them are re-exported. Some of them (especially secondhand home appliances) remain in the country and are sold in the domestic markets. It seems difficult for both governments to check that all the secondhand EEEs imported for re-export are really exported.

Judging from what we observed, we are inclined to conclude that the trade of secondhand EEEs between China and Vietnam is being carried out with at least partial consent by the two governments.

The smuggling of secondhand EEE in the south of Vietnam is a little bit different from that in the north. In the south, a number of secondhand EEEs have been illicitly imported, mainly from Japan and the United States. Since May 2006, however, the ban on importing such items has been tightened, and almost all the secondhand EEEs sold in the south now are smuggled in from Cambodia, where control over such items is much laxer.

Cambodia imports secondhand EEE through Sihanoukville international port, then transports it to Phnom Penh by truck. Containers of imported secondhand EEEs are put up for auction every weekend. A number of Vietnamese dealers also participate in these auction sales. Some of these secondhand EEEs are smuggled into Vietnam through the border areas in the south between Vietnam and Cambodia. There are up to seven hot-spot smuggling places; huge amounts of secondhand EEEs are smuggled especially between Go Tamau (Cambodia) and Chau Doc (Vietnam), and between Babet (Cambodia) and Moc Bai (Vietnam). A portion of the smuggled EEEs is consumed in the Mekong River delta in southern Vietnam, while the remainder is transported to Ho Chi Minh City for sale. The Nhat Tao market in Ho Chi Minh is a central market for secondhand EEE. In Ho Chi Minh one rarely sees the original imported television sets for sale. In most cases, the glass of the CRTs is polished and the original covers and printed-circuit boards are replaced by new ones.

Not all the secondhand EEEs imported into Cambodia are smuggled into Vietnam. On Kampuchea Krom Street in Phnom Penh there are about 150 shops selling secondhand EEE. The country also has a large-scale secondhand market. As stated earlier, Cambodia allows the import of any secondhand EEEs except secondhand computers, and yet there are still nearly 20 shops selling secondhand computers on Kampuchea Krom Street in the capital. Most of the time these secondhand computers are concealed at the bottom of the containers being smuggled into Cambodia. Customs officials in Sihanoukville are aware of the methods used in illicit operations, but they still stop short of strict regulation.

The prices of secondhand television sets and computers in Cambodia, Vietnam, and China are shown in Table 1. We can see that the price of a secondhand TV set is much higher in Vietnam than in Cambodia and China, which explains why secondhand EEEs like TV sets have been flowing from Cambodia and China to Vietnam. On the other hand, the price of a secondhand computer is highest in China, followed by Vietnam, so this explains why secondhand computers are exported to China from Vietnam and from Cambodia to Vietnam.

<table>
<thead>
<tr>
<th>Selling price of a secondhand television and a computer set</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>A secondhand personal computer set (including a monitor)</td>
</tr>
<tr>
<td>Secondhand television (21 in.)</td>
</tr>
</tbody>
</table>

Sources: Practical survey.

6 The material flow and price of secondhand EEE is obtained in our field research (see footnote 2). The price of secondhand EEE is found by hearing in secondhand markets. The material flow is also found by hearing from traders of secondhand EEE. We also confirmed it by visiting the trade spots and taking photos if possible.

7 The material flow on the whole of Asia is roughly sketched in Widner et al. (2005).

8 Mong Cai (Vietnam) is located on the border between China and Vietnam. Part of the borderline is a river, and Dongxin (China) is located just across that river.
With all the data taken into account, the flow of secondhand EEEs can be described as shown in Fig. 1.

Let us refer at this point to the number of secondhand CRTs and computer monitors exported from Japan to overseas countries in 2005 (see Tables 2 and 3). Both these secondhand EEEs have mainly been exported to Hong Kong. Note that Hong Kong is just a transition point in the trade and the secondhand EEEs imported there will be re-exported from there to other countries. According to the figures shown in Table 2, the number of CRTs exported to Vietnam is relatively small. On the other hand, the numbers exported to China and Cambodia are relatively large. These statistical data do not contradict the material flow described earlier in this section, since secondhand TV sets are re-exported (or smuggled) into Vietnam from China and Cambodia. The statistical data shown in Table 3 indicate that the number of computer monitors imported into Vietnam is larger than the number imported into China, while the demand for secondhand computers is relatively lower in Vietnam than it is in China. These statistics also do not contradict our observations, since secondhand computers and monitors get re-exported from Vietnam into China.
It is quite difficult to grasp the actual flow of secondhand EEEs by reviewing the trade statistics only. Smuggling generates large gaps between statistical data and facts.

3.2. Material flow of E-waste scrap such as printed-circuit boards in Asia

In those countries that import secondhand EEEs, there can be found many repair and maintenance shops in the secondhand markets. Workers in such repair shops look for components that are damaged or worn out and replace them with new components made in China. Those components that are seriously damaged and incapable of being reused, however, still have a positive sales value because they can be recycled. A printed-circuit board in particular is most valuable. Those printed-circuit boards in Cambodia that are damaged beyond reuse are exported illicitly to Vietnam. Of these, only a small portion is recycled in Ho Chi Minh; the major are transported to northern Vietnam and then illicitly exported to China via Mong Cai.

Guangdong Province in China is the largest recycling center of printed-circuit boards in the world; the area around Guiyu town in the same province is most famous. But because the Chinese government has strengthened controls over the importing of printed-circuit boards, recently several Chinese firms have begun to recycle printed-circuit boards in Mong Cai in Vietnam.

National policies also have strong effects on the flow of printed-circuit boards. In principle, China bans the import of printed-circuit boards, especially from developed countries, and yet unofficially it has allowed the import of printed-circuit boards from Vietnam. Taking advantage of this loophole, some dealers have imported E-waste scrap, including printed-circuit boards, from Japan and the United States into Haiphong and then dismantled the items in areas surrounding Haiphong before exporting the scrap to China through Mong Cai. To remedy the situation, the government of Vietnam has since October 2004 banned the import of E-waste scrap for the purpose of re-export, although it is not clear whether or not any requests were made in this regard by the government of China. Additionally, in Vietnam today both the importing and dismantling of E-waste scrap are strictly prohibited. As a result of this policy, the amount of imported E-waste scrap, including printed-circuit boards, has been decreasing drastically. It is assumed, therefore, that the printed-circuit boards exported from Vietnam to China have their origin in Cambodia and Vietnam.

Although China bans the import of printed-circuit boards from Japan in principle, a great deal of printed-circuit boards generated in home-appliance recycling factories in Japan have been imported into China along with other metal scrap (as a form of mixed metal). In practice, if the amount of printed-circuit boards in a consignment of mixed metal scrap does not exceed 3% of the total amount, the entire consignment can be allowed into China.

Table 4 shows the buying prices of printed-circuit boards in southern Vietnam, northern Vietnam, and Guangdong Province in China. The price is lowest in the south of Vietnam, higher in the north, and highest in Guangdong Province. These figures support our observations regarding the flow of printed-circuit boards. Table 4 also indicates the buying price offered by a firm in Hangzhou, China, that does proper recycling of printed-circuit boards. The price is quite low, which indicates that it is costly to minimize the adverse environmental effects. Because of the low price, this recycling firm authorized by the Chinese government cannot collect enough printed-circuit boards to make profits. The recycling method adopted in Guangdong Province (the representative improper recycling center of printed-circuit boards) does not take into account the adverse environmental effects and then they can buy printed-circuit boards at a higher price.

4. Environmental pollution in China

4.1. Environmental pollution caused by improper recycling methods

Given the background reviewed in the previous sections, it is clear that in Asia a major portion of E-waste scrap such as printed-circuit boards has been, and is being, recycled in China. The concern is that the recycling of E-waste scrap may pollute the soil, the air, and the water. Water resources can be seriously polluted through the improper disposal of wastewater, and the recycling of printed-circuit boards in particular generates the most serious pollution. Guiyu in Guangdong Province is widely known as a center of improper recycling of printed-circuit boards. Besides Guiyu, there are several lesser printed-circuit board recycling areas in Guangdong Province, such as in Guangzhou, Dongguan, Foshan, Shunde, Zhongshan, and Shenzhen. There are several reasons for this concentration. Firstly, the province is adjacent to Hong Kong; secondly, it has several big cities like Guangzhou and Shenzhen, where huge amounts of end-of-life home appliances are generated; thirdly, it is located near Southeast Asia.

Let us move on to review how printed-circuit boards are recycled in Guangdong Province (see for example Liu et al. (2006)). A printed-circuit board has many IC chips attached to it. To remove the IC chips, workers first have to heat the printed-circuit board over charcoal briquettes, then detach the IC chips from the melted lead. During the process, lead is released into the surrounding area, affecting human health. The IC chips are utilized as components in other products (in toys, for example, in Guangzhou). After the IC chips have been removed, printed-circuit boards still contain precious metals like copper and gold. Workers try to recover the copper mainly by using a strong acid liquid. This process releases very toxic wastewater. If the wastewater runs off directly into a river or the soil, serious damage is done to the environment. Wong et al. (2007a) and Wong et al. (2007b) found that water in Guiyu is heavily contaminated by heavy metals accrued from E-waste recycling.

Recycling of E-waste scrap is polluting not only the water but also the soil and the air. According to a recent study (Wong et al. (2007c)), concentrations of POPs (PCDD/Fs, PBDEs, PAHs, and PCBs) and heavy metals are detected in the Guiyu air and they are due to incomplete combustion of e-wastes. In addition, this leads to the severe pollution of soils by POPs and heavy metals.

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*9 The material flow and buying price of printed-circuit boards is found by our field research (see footnote 2). We contacted many traders or recycling companies of printed-circuit boards and obtained the information on the material flow and buying prices. The median of buying prices are listed in Table 4.

10 Guiyu is situated in Chaozhou region of Guangdong Province, South China at 23.3 N and 116.3 E.

11 Researchers from the Department of Medicine in the University of Shantou studied the health of 165 Guiyu children in 2003 and 2004; 135 children were found to be afflicted by lead poisoning (Huo et al., 2007).
4.2. Policies and their effects

At first the Chinese government had a policy of removing recycling facilities when improper recycling activities were detected. In practice, however, it was hard to control and enforce the ban because a recycling facility is usually managed by a household or a small firm, and so it can easily move to other areas. Mandatory removal resulted in spreading improper recycling activities to other places. So the Chinese government has changed its policy to one of building up a proper recycling section (a recycling industrial park), attracting to it selected firms, and encouraging proper recycling.

Recycling industrial parks have been established in Tianjin, Taicang, Ningbo, Taizhou, and Zhangzhou, with a major aim of properly recycling imported metal scrap. These recycling industrial parks are capable of treating approximately one million tons of metal scrap each year. In each recycling park several large-sized companies have put into operation simple equipment such as copper core retrieving machines, but most of the work is still done by manual dismantling. The wastewater and solid waste that is generated by the recycling can be centrally treated inside each recycling park.

China has thus changed its policy on recycling from banning improper recycling to encouraging proper recycling. In 2004 the Chinese government made plans to build a recycling industrial park in Guiyu (China Economy, 2004), but as of the present date (2007) construction has yet to get under way.

5. Policy recommendations — examination of resources circulation in Asian region

We have provided an overview of the circulation of secondhand EEEs and E-waste scrap in the Asian region with emphasis on Japan, China, Vietnam, and Cambodia. Our overview of E-waste scrap was mainly focused on printed-circuit boards, because their recycling can cause serious pollution. We mentioned how secondhand EEEs have been exported from Japan to China and Southeast Asia. These items can be used for ten years if they are repaired repeatedly. Broken parts, especially printed-circuit boards, are sold to dealers and eventually end up in Guangdong Province in China, where improper recycling has caused serious environmental pollution.

So the question here is whether the best policy is to prevent completely the circulation of secondhand EEEs and E-waste scrap for the sake of the environment, or not. Streicher-Porte et al. (2005) reveals that reuse and refurbishment of EEE creates monetary flows which are much greater than recycling and that it slows down the flow rate of the whole system. Therefore, the complete ban of secondhand EEE generates loss of reuse values and increases the flow of resource inputs on the whole of Asia.

In view of the material flow of resources described in earlier sections above, only in Guangdong Province is serious environmental pollution generated by improper recycling; in other areas no serious pollution has occurred. Therefore, it seems more effective to construct a legal and/or economic system to promote proper recycling in China rather than to try to prevent the trade.

An effective method for ensuring the proper recycling of printed-circuit boards in China is to build a recycling industrial park as planned (in 2004) in Guangdong Province. However, as shown in Table 4, the buying prices for printed-circuit boards offered by improper recyclers are higher than those offered by the authorized recycling firms. Therefore, it is not enough just to construct a recycling industrial park; other assistance is also needed. We highly recommend the adoption of additional policies, such as preferential tax treatment or an economic subsidy, to ensure that recycling firms in the recycling industrial park can afford to offer prices equal to or higher than those offered by improper recyclers. The subsidy to proper recycling firms may be financed by a tax on imported E-waste scrap. If the trade of E-waste scrap were banned, it would become difficult to finance the proper recycling of imported E-waste scrap, because it might be smuggled.

A policy like that recommended in the last paragraph is also under consideration in the domestic E-waste management system. Due to the overwhelming economic growth that China has experienced, a huge amount of E-waste has been generated. Several national-level regulations regarding domestically generated E-waste have been drafted in China and the most important one is the draft ordinance on the management of waste household electrical and electronic products recycling and disposal. The National Development and Reform Commission began preparation of this law in 2001, but as yet (October 2007) this law has not been enacted. The draft of the law obliges producers to cover the costs of collection, recycling, and disposal. In practice, consumers pay a fee for proper recycling of E-waste in advance when they purchase new items. The collected fee is used as a subsidy to proper recycling companies to recycle E-waste properly (see Hicks et al., 2005) for more information on recent domestic policies in China).

On the other hand, policies in exporting countries may also be effective. In order to ensure that E-waste scrap is not recycled improperly, it is necessary to set up a traceability system to make it possible to follow the flow of E-waste after shipment from Japan. In fact, a traceability system has been tested by using GPS equipment, digital cameras, IC tags, and bar codes (Re-Tem Co. Ltd., et al., 2006). Alternatively, eco-friendly product designs can also reduce the environmental pollution caused by recycling E-waste scrap. At present, DfE (Design for Environment) is attracting much attention in the world as a new method to solve environmental pollution. There are four types of DfE: 1) Design for easy disassembly to encourage recycling of home appliances; 2) Design for recycling by using recyclable materials; 3) Design for energy saving; and 4) Design for reducing hazardous material such as lead, mercury, cadmium, and hexavalent chromium. Research into, and the development of, technologies for eliminating the use of such elements are being promoted. As the last type of DfE in particular becomes more widespread, we can expect significant mitigation of environmental damage caused by recycling E-waste scrap.

### Table 3

<table>
<thead>
<tr>
<th>Country</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong</td>
<td>1354963</td>
</tr>
<tr>
<td>Vietnam</td>
<td>197815</td>
</tr>
<tr>
<td>Thailand</td>
<td>65323</td>
</tr>
<tr>
<td>Arabian</td>
<td>27264</td>
</tr>
<tr>
<td>Malaysia</td>
<td>14440</td>
</tr>
<tr>
<td>China</td>
<td>13011</td>
</tr>
<tr>
<td>Cambodia</td>
<td>8598</td>
</tr>
<tr>
<td>Indonesia</td>
<td>6643</td>
</tr>
<tr>
<td>Others</td>
<td>18015</td>
</tr>
</tbody>
</table>

Sources: Japan Environmental Sanitation Center et al. (2007).

### Table 4

<table>
<thead>
<tr>
<th>Location</th>
<th>Price per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chau Doc (South of Vietnam)</td>
<td>$475</td>
</tr>
<tr>
<td>Trang Minh village (North of Vietnam)</td>
<td>$600</td>
</tr>
<tr>
<td>Guiyu town (Guangdong Province in China)</td>
<td>$420–$1900</td>
</tr>
<tr>
<td>An authorized recycling firm (Hangzhou in China)</td>
<td>$250</td>
</tr>
</tbody>
</table>

Sources: Practical survey.
6. Conclusion

It is possible to obtain a rough idea of the flow of secondhand EEEs and E-waste scrap in Asia, although the material flow of E-waste cannot be accurately estimated on the basis of statistical data because of the smuggling that takes place. End-of-life home appliances discarded in Japan are reused in Southeast Asia; end-of-life computers are reused in China. E-waste scrap generated in Asia is recycled in China, especially in Guangdong Province. Such recycling of E-waste scrap has caused serious pollution in that province. In response to this problem, there is wide support for a total ban on E-waste trade, including secondhand EEEs and E-waste scrap.

If, however, E-waste trade were completely banned, improper treatment and disposal of E-waste might spread to other parts of the Asian region. First of all, it can be predicted that the recycling cost of end-of-life home appliances in Japan will increase sharply due to higher labor cost in Japan if end-of-life home appliances have to be recycled domestically. Consumers there are required to pay recycling costs at the time they discard the EEEs. If recycling fees increase, illicit disposal dumping will increase. Consumers can evade the payment of the high recycling cost by illegal disposal.

Secondly, if the export of printed-circuit boards to China were banned, improper recycling would spread to other places in the Asian region. If Chinese government completely banned the importation of printed-circuit boards, printed-circuit boards generated in Vietnam should be recycled domestically. Indeed, several Chinese-funded firms have begun to recycle printed-circuit boards in Haiphong, Mong Cai, and Ho Chi Minh in reaction to the strict regulation of the trade in printed-circuit boards. The environmental pollution accrued from the recycling of printed-circuit boards has been observed in some areas in Vietnam. If E-waste scrap were generated in other areas that lack recycling technologies (for example Cambodia), much of the scrap, and materials needed to recycle it, would be discarded into the environment.

By way of concluding this study, we recommend the establishment of an alternative proper recycling system in Asia that needs cooperation among all Asian countries. First, China is urged to promote proper domestic recycling activities by providing a subsidy for proper recycling. Second, Japan, as a main exporter of E-waste, should establish a traceability system that ensures E-waste scrap exported from Japan will be recycled at proper recycling facilities in China.

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References


Takayoshi Shinkuma received a Ph.D. in Human and Environmental studies from Kyoto University. His major is environmental economics and the present theme is the WEEE recycling systems from both micro economic theory and field research. He is a professor at Kansai University. His works on waste disposal and recycling systems are published on Environmental and Resource Economics (vol.24 (2003) 77-95) and Journal of Environmental Economics and Management (vol. 53 (2007) 110-121).

Nguyen Thi Minh Huong received Master’s Degree in International Corporation from Tokyo University of Foreign Studies. Her theme is also WEEE recycling systems especially from international trade aspects. She is a professor at Hanoi University.