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Extended Producer Responsibility in East Asia

Approaches and lessons learnt from the management of waste electrical and electronic equipment

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Environmental protection has become high in the policy agenda of East Asian countries by the end of the last century due to both internal and external stimuli. One of the main environmental issues is the management of solid waste. The concept of circular economy which encourages reduce, reuse, and recycling, i.e. 3Rs, together with the principle of Extended Producer Responsibility (EPR) has been promoted principally in the region by the Japanese government and the Organisation for Economic Co-operation and Development (OECD), respectively. This paper reviews approaches to pursue EPR and analyses factors behind policy development and environmental effectiveness of the respective programmes in China, Japan, South Korea, and Taiwan from the 1990s onward. The management of waste electrical and electronic equipment (WEEE, or e(lectronic)-waste) is selected as an object of the study. A two-step theory-based evaluation (TBE) is employed to evaluate the effectiveness of WEEE programmes. This paper concludes that internal factors such as limits in waste disposal capacity are more powerful in explaining the speed of policy development and the exact design of WEEE programmes though the role of epistemic communities helps in understanding the policy discourse. The adoption of the restriction of the use of hazardous substances (RoHS) in East Asia, on the other hand, was driven mainly by international trade harmonisation. TBE shows that the impacts of existing WEEE programmes on design improvements varied and the main explanation was the degree of producers' involvement in the end-of-life management, which was highest in Japan and lowest in Taiwan. It also shows that programmes in Japan, South Korea, and Taiwan, succeeded to an extent in promoting WEEE recycling although the actual achievements in the area of waste collection were not completely in line with the EPR intervention and implementation theories. In addition, this paper questions the role of exports of used products to less developed countries because this form of "reuse" can compromise environmental protection goals where the imported countries do not have a proper system to ensure environmentally sound management of WEEE when these products reach their ultimate end-of-life stage.

Keywords

Extended producer responsibility, waste electrical and electronic equipment, recycling, China, Japan, South Korea, Taiwan

Introduction

Decoupling is an often-discussed concept of sustainable development. It refers to the trends of decreasing negative environmental impacts while furthering economic prosperity. In resource management, this can even mean a double task – first, decoupling resource consumption from economic development and, then, decoupling negative environmental consequences from resource consumption. All these would require a shift from a one-way economy towards a circular one.

Circular economy has been popularised among policy makers in industrialised countries in the 1990s. Pioneers were the 1993 Swedish Ecocycle Bill, and the 1994 German Closed Substance Cycle and Waste Management Act. In Asia, Japan promulgated the Fundamental Law for Establishing a Sound Material-Cycle Society in 2000. Recently, China announced that it had been drafting its

Circular Economy Law (Sun 2007). Similarly, 3Rs has been promoted vigorously, especially by the Japanese government (see MOEJ 2008).

However, a mere concept of 3Rs does not prescribe any mechanisms to drive such a shift. In addition, in many cases the incentive structure of existing institutions is indifferent or even dampens 3Rs. For example, municipalities incur additional costs in implementing separate collection and recycling programmes while facing budgetary constraints; on the other hand, manufacturers of products which later become waste have a natural interest in increasing sales but not in the end-of-life management of their products. Against this backdrop emerged extended producer responsibility (EPR), formulated first as a policy strategy and later as a policy principle.

EPR comes with an ambition to drive a change in the products and the product systems by extending producers' responsibilities beyond conventionally defined, particularly to the end-of-life management. It was first put into practice in the German Packaging Ordinance in 1991. Since then it has underlined end-of-life legislation and programmes for the management of other product groups such as vehicles, electrical and electronic equipment (EEE), batteries, tyres, etc. in many jurisdictions.

Policy makers in East Asia have also found EPR attractive. The case in point is the management of waste electrical and electronic equipment (WEEE, also known as electronic waste or e-waste). The existing programmes in Japan, Taiwan, and South Korea are explicitly based on EPR¹ (see MOEJ 2003a; MOEK 2006a; Lu et al 2006). Though the programme has not been fully enacted yet, policy development in China is also claimed to follow the principle (e.g. He et al 2006; Tong et al 2004). However, it is less clear why these programmes in East Asia subscribe to the principle. The situation in the region differs from that in the European Union (EU) where producer responsibility is prescribed in the bloc's WEEE (2002/96/EC) and RoHS (2002/95/EC) Directives and member states are obliged to transpose them to national legislation. In other words, this is not a case of negotiated policy transfer (Evans 2004).

Theoretically, there can be various competing and complimentary explanations to this policy convergence. Literature is divided between internal determinants and policy diffusion/transfer models (Berry and Berry 2007). A good example of the former, which explain convergences with macro socio-economic factors and assumes a degree of automaticity, is the so-called environmental Kuznet's curve. On the other hand, proponents of policy transfer look more at the meso level into details of voluntary policy learning processes as a form of rational policy making. In the age of globalisation, the role of epistemic communities (Haas 1992) in the lesson drawing processes can be salient in the lesson drawing processes. Less inclined towards rationality are 'policy bandwagoning' (Ikenberry 1990) and 'isomorphism' (DiMaggio and Powell 1983) explanations.

Another important aspect is the different ways EPR have been (and will be) operationalised. It is not uncommon that an EPR programme will consist of a mix of policy instruments whose selection should be based on local contexts. In the area of WEEE management, the differences range from a product scope (whether a programme covers only few EE products or a few hundreds) to financial arrangements (pay-as-you-go (PAYG), financial guarantees, end-user-pays; market-share or return-share models; industry- versus government-managed funds) to target setting (no target, only collection or recycling targets, or both). Studies show that approaches in different jurisdictions in Europe and North America can vastly diverge and there is no exception in East Asia, as will be seen shortly. Intuitively, its design and configuration can have a major effect on the effectiveness of a programme. However, to my knowledge, there has not been a thorough investigation into these issues barring some pioneer work in (Murakami-Suzuki 2007; Murakami 2006).

This study aims to provide a systematic comparison of the WEEE management programmes in China, Japan, South Korea, and Taiwan. It is based on an extensive review of previous studies and

¹ In Taiwan, EPR can also refer to the term "Extensive Production Responsibility"; see <http://www.epa.gov.tw/en/artshow.aspx?art=2007121117321278&path=9061&list=115>

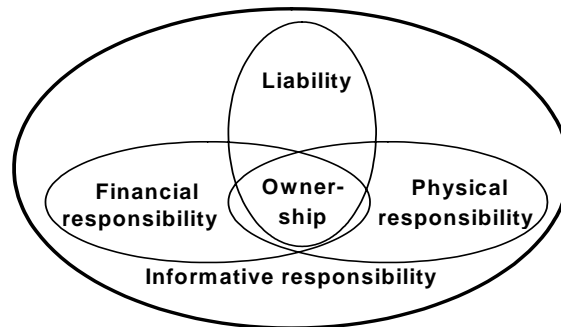
documentary research. It focuses on the drivers behind policy development in the four jurisdictions and the effectiveness of the programmes. The latter is based on qualitative theory-based evaluation (TBE). The rest of the paper is presented in the following way. The next section accounts for EPR and TBE in more details. Then, the programmes in the four jurisdictions are described followed with the analysis and discussion. The paper ends with conclusions and suggestions for future research.

EPR and its Evaluation

EPR is an environmental policy principle². It is a derivative of the polluter-pays principle, a pollution prevention approach, and life-cycle thinking. It redefines the end-of-life management of products as not a solid waste problem *per se* but that of product and product system design. Thus, its proponents argue that having producers who in general have the most influence over the design responsible for the end-of-life management “could provide ongoing incentives for the incorporation of environmental concerns into the design of products [and product systems]” (Lifset and Lindhqvist 2008).

An archetypal EPR model consists of four types of responsibilities: physical, financial/economic, informative responsibilities, and liability, as shown in Figure 1. As mentioned in my previous review of EPR literature (Manomaivibool et al. 2007), two important lessons from the previous implementation of EPR programmes are that (1) it is not necessary to rest all responsibilities on every end-of-life activities on (individual) producers but (2) the more individual producers assume physical and financial responsibilities, the more likely he/she will make design improvements *ceteris paribus*. An ultimate form is when a producer retains the ownership over the products and shifting from selling products to providing functions, i.e. the product-service system (PSS) business model.

Figure 1 Model of Extended producer responsibility (Lindhqvist 1992)



In practice, evaluating the effectiveness of EPR programmes is neither a trivial nor straightforward enterprise. The ultimate goal of EPR – “total life cycle environmental improvements of product systems” (Lindhqvist 2000) – is of a long-term nature and is very difficult, if not impossible, to measure with precision. I have argued elsewhere (Manomaivibool 2008) that this renders theory-based evaluation (TBE) preferable.

TBE circumvents this evaluation problem by employing a set of programme theories consisting of causal links between an intervention and its ultimate outcomes. It assumes that behind every intervention exist theories about how the intervention would bring about the desirable change and main tasks of an evaluator are to make explicit these theories and to use them as a standard of comparison. If an intervention follows closely the causal steps prescribed in its programme theories and intermediate outcomes are borne out well, then he/she can infer with a degree of confidence that the intervention is effective and likely to produce the desirable ultimate outcomes in a longer term. Thus, the strength of TBE is the attributability test, i.e. whether the change can be attributed to the intervention (Tojo 2004). In addition, it has been claimed that TBE is adept in detecting theory and implementation failures and hence bears practical value for programme design and implementation (Pawson 2002).

² Other terms that can be used to describe EPR are “strategy” (Lindhqvist 1992), “approach” (OECD 2001), and “policy paradigm” (Manomaivibool 2008) although each gives a special nuance to the definition.

The logics of TBE have been applied in previous evaluations of EPR programmes (see Manomaivibool, 2008; Gottberg et al 2006; Tojo 2004). However, often the two classes of programme theories, namely, intervention and implementation theories are not separated which, in turn, compromises the evaluation. An intervention theory is a set of propositions explaining mechanisms which an intervention releases to trigger anticipated outcomes. Theory failures mainly question the validity of intervention theories. An implementation theory is a set of propositions linking programme activities to anticipated outcomes. A mismatch between the intervention and implementation theories can result in implementation failures, providing the intervention theory is valid; otherwise we have a case of double theory failure (Chen 1990). Bamberg and Schimdt (1998) in their evaluation of transit policies provide a good example of TBE with a clear separate between the two classes of theories. Unfortunately, the discussion and evaluation of EPR in general and WEEE policies in particular has been mainly focused on the issues around the implementation aspect (e.g. Sanders et al 2007). Exceptions are (Herold 2007; Manomaivibool et al 2007) which try to test the boundary of EPR intervention theories for the EEE sector and the sector in one non-OECD context, respectively.

In this paper, TBE is carried out in two steps. First, key aspects of programme configuration are linked with an evaluation scheme proposed by (van Rossem and Lindqvist 2005) in an *ex ante* qualitative fashion. This procedure captures implementation theories assessing how well the actual programme is in line with the EPR intervention theory. The second step tests the validity of the EPR intervention theory itself. It triangulates the results from this first step with the actual degree of upstream and downstream achievements. If the intervention theory is valid, the results of the two steps should be consistent, i.e. a programme bearing more causal EPR links should produce more desirable outcomes. It must be noted that evidences on the actual upstream improvements are scattered and, in some cases, commercially confidential; so, the results drawn from the second step in this area should be reckoned as indicative only.

Case Description

Japan

Traditionally, municipal solid waste management in Japan was completely under the remit of municipalities according to the Waste Management and Public Cleansing Law inaugurated in 1970. The law was amended in a major way in the early 1990s to address its inadequacies and *inter alia* to promote waste separation and recycling (Tanaka 1999). At about the same time, the Law for Promotion of Effective Utilization of Resources was enacted in 1991. Then, a few laws were developed and enacted in the second half of the 1990s and the beginning of the 2000s to regulate specific waste streams including the Specified Home Appliance Recycling Law (SHARL). Legislation was the product of the co-initiation between the then Ministry of International Trade and Industry (now the Ministry of Economy, Trade and Industry, METI), the then Environmental Agency (now the Ministry of the Environment, MOEJ), and the Ministry of Health, Labour and Welfare (MHLW) (Tojo 2000).

SHARL was the first piece of legislation in Japan that directly deals with WEEE. It was enacted in 1998 and came into force three years after. Tojo (2000) mentions “[s]carcity of the final disposal site, increase of EEE in the waste stream, and inadequacy of existing treatment plants under local governments to handle EEE” as main drivers for its enactment. SHARL is the second EPR legislation after the 1995 Law for the Promotion of Separate Collection and Recycling of Containers and Packaging (henceforth, Packaging Recycling Law). Its scope covers four home appliances that meet all four criteria³: refrigerators, washing machines, air conditioners (only unit-type), and television

³ The four selection criteria in Article 2.4 are: (1) a product that is difficult to be recycled under the existing facilities and technologies possessed by local governments; (2) a product that contains valuable resources that can be recycled and the cost for recycling is economically feasible; (3) a product whose design or selection of raw materials or components by the manufacturers exerts a great influence on the recyclability; and, (4) retailers deliver a substantial number of the products so that smooth take-back by retailers can be secured.

sets (only CRT-type). One of the issues under an ongoing review is to expand the scope to include clothes dryers and LCD-display and plasma-display TV sets in the future (van Rossem and Tojo forthcoming).

SHARL shifts legal responsibilities to manage these items from municipalities to businesses. Retailers are obliged to take back, i.e. collect, obsolete appliances from consumers and deliver them to regional aggregation facilities. Producers, i.e. manufacturers and importers, are then responsible for the environmentally sound management from the aggregation facilities onward including meeting the material recycling targets set between 50 and 60% by weight of products collected. The law allows retailers and producers to charge consumers for their extended “services”. In addition, the Association for Electric Home Appliances (AEHA) acts as an umbrella organisation and also a designated legal body handling orphan products. In practice, the fees charged by retailers vary considerably depending on the size of retailers and whether a new product is purchased, i.e. a take back on a 1:1 basis (van Rossem and Tojo forthcoming) while the charges for recycling were uniformly set by the government (DTI 2005). Consumers pay by buying a recycling ticket and the money is forwarded to producers by retailers or post offices. The five-copy recycling voucher also serves as a manifest, enabling consumers to track the movement of the products they handed in electronically via AEHA’s web page (MOEJ 2003b). Producers are divided into two groups, which DTI (2005) labels as Group A led by Matsushita and Toshiba and Group B led by Sony, Sharp, Sanyo, Hitachi, Mitsubishi and Fujitsu. DTI (2005) reports that each group controls some 190 take-back centres and there are 30 recycling plants used by Group A while producers in Group B have jointly invested in 16 plants.

Personal computers weighing more than 1 kg are under a separate scheme. The product is classified as a Specified Resources-Reconverted Product according to the Enforcement Order of the Law for Promotion of Effective Utilization of Resources. Manufacturers and importers who sell 10 000 or more personal computers are required to provide voluntary take-back services. In practice, the costs are internalised in the prices of new products (marketed after October 2003) which bear a sticker, which in turn, enabling consumers to dispose them free-of-charge (DTI 2005). The end-user-pays rule is still applicable for those without the sticker.

Producers in Japan also have prescribed physical and informative responsibilities regarding the use of hazardous substances in their products. Target substances are the six substances regulated under the EU’s RoHS Directive: lead, mercury, hexavalent chromium, cadmium, polybrominated biphenyl, and polibrominated diphenyl ether. According to Japanese Industrial Standard for Marking the presence of the Specific Chemical Substances for electrical and electronic equipment (JIS C 0950:2005 or "J-MOSS" Standard), standard value of these substances in seven products (4 HAs, PCs, cloth dryers, and microwave ovens) is set at 0.1 wt%, except cadmium which is 0.01 wt%. Products with any of the content rates exceeds the value can still be put on the market, on the contrary to the EU’s RoHS Directive, but must be marked with a designated symbol. An optional label, called green mark, can be put on products with content rates equal or under the standard value.

Taiwan

Taiwan underwent a major environmental reform in the second half of the 1980s. The Taiwanese government developed some 70 pieces of environmental legislation by the end of the decade (Feeley 1990). One of the legislative efforts was the amendment of the Waste Disposal Act in 1987. The amended Act stressed the importance of recycling and its Article 10.1 obliged the producers, i.e. manufacturers, importers, and retailers, of products with certain characteristics to be responsible for their end-of-life management. At first, nine product groups were under the provision but not any EEE. In practice, producers fulfilled their responsibilities by forming sector-specific management organisations (Lee et al 1998). Producers paid fees to these collective bodies that, in turn, managed the contracts with existing waste management companies to ensure that the prescribed recycling targets were met. However, this industry-led regime run into several problems including transparency of self-reporting procedure, the management of collected fees, improper targets, unfair competition and lack of coordination (Lee et al 1998) and was discontinued with the amendment of the Article 10.1 in 1997.

The 1997 amendment consolidated the management of recycling systems under the control of the Taiwan Environmental Protection Administration (TEPA) (Fan et al 2005). TEPA established and managed the Resource Recycling Management Fund (RRMF). Existing 13 management organisations ceased their operation and transferred their remaining funds to RRMF (Lee et al 1998). A new product scope was set in the Official Announcement of the Responsibility of Manufacturers and Importers with Regards to the Recycling, Clearance, and Disposal of Articles and Containers, and the Scope of Responsibility of Enterprises with Regards to Recycling, Clearance, and Disposal. Four electric and electronic appliances, similar to that of SHARL, were included in the list of the regulated recyclable waste in July 1997 and later came IT products: personal computers, notebook computers, monitors, printers, and computer components and subassemblies. Under the new system, also known as the 4-in-1 Recycling Program, fees from producers are the main source of RRMF's revenues (Fan et al 2005). Producers are obliged to pay recycling fees to RRMF. Funds raised are used to subsidise downstream activities, collection, storage, transportation, recycling, and treatment and disposal. Consumers also get compensated for items they deliver to the system. The finances are arranged in a PAYG fashion. The Resource Recycling Fee Rate Review Committee sets the fee, buy-back, and subsidy rates.

The third-party auditing system has been developed extensively in Taiwan. This is understandable considering the salience of the transparency issue in the 1997 amendment. Recycling and waste disposal related businesses are not eligible to get subsidies from RRMF unless third-party auditors certify their work in accordance with the procedures and provisions in the Regulated Recyclable Waste Auditing and Certification Regulations. RRMF finances the auditing system.

Taiwan has not yet promulgated any product standards restricting the use of certain chemical substances in EEE. However, the Bureau of Standards, Metrology and Inspection (BSMI), Ministry of Economic Affairs (MOEA), issued regulations forcing its exporters of EE products to the EU to conduct compliance tests with designated Taiwanese laboratories (Design News 2006).

South Korea

The first break away from the management of mixed municipal solid waste in South Korea was the introduction of a “deposit-refund system” (DRS) in 1992 (MOEK 2006b). DRS initially targeted packaging and containers before expanded its scope to cover CRT TV sets and washing machines, then, refrigerators, and, lastly, unit-type air conditioners in 1992, 1993 and 1997, respectively. In the system, deposits were levied on the products and packaging at a constant rate and refunds were paid back when they were recycled. Recycling was further strengthened in the 2nd Comprehensive National Waste Management Plan (2002-2011) promulgated in March 2002 with a goal to establish sustainable and resource circulating socio-economic foundation (MOEK 2006b).

The EPR system replaced DRS in 2003 after the amendments of the Waste Management Act and the introduction of the Act on the Promotion of Saving and Recycling of Resources a year earlier (MOEK 2006a). A few more EE items were included in the scope of the new system with the addition of personal computers in 2003, audio equipment and mobile phones in 2005, and printers, copiers and facsimiles in 2006 (Park 2007). Producer responsibility in South Korea was arranged in a way that each producer⁴ had a quota of WEEE he/she had to collect and recycle in a year. The assigned quota, called mandatory recycling rates, was calculated based on his/her sales in the previous year. If the targeted volume could not be met, the producer had to pay a recycling fee with a penalty of up to 30% of the fee to the government. In practice, most producers formed resource recycling associations to comply with the requirements. Regulated WEEE were collected through three main channels: municipalities (consumers must buy a sticker), retailers (for free on a 1:1 basis), and private collectors/recyclers who normally paid consumers for relatively new obsolete products (Yoon and Jang 2006). Unlike municipalities and retailers, private collectors/recyclers were not obliged by laws to deliver collected items to producers' storage centres though they still had to comply with legal recycling procedures, methods and standards, at least in principle.

⁴ Producers are defined as domestic manufacturers with a yearly output of 1 billion won or more, and importers with yearly imports of 300 million won or more.

South Korea has built up its capacity to collect and recycle regulated WEEE under its EPR programme. Park (2007) reports that 98 companies operate more than 3 200 take back points in addition to 234 municipal drop-off centres. Manufacturers have also erected five automated recycling centres: Sudokwon Center (253,000 kg/day), Mid-area Center (267,000 kg/day), South-area Center (250,000 kg/day), Honam-area Center (150,000 kg/day), and Jeju-area Center (60,000 kg/day), on the top of the other 38 independent plants with a combined capacity of 140 000 tonnes per year (Park 2007).

The EPR system for EEE (and vehicles, as it matters) underwent a significant change when the Act for Resource Recycling of Electrical and Electronic Equipment and Vehicles went into effect in January 2008. Park (2007) explains that the promulgation reflects a need for a system that is profoundly different from that designed for packaging waste. In the beginning, the product scope would be the same as that of the prior system (though LCD and Plasma TV sets were now included) but in a long run there is a plan to include all EEE in a similar manner as the EU's WEEE Directive (MOEK 2006a). Main additionalities of the new law lay in its upstream measures such as the restrictions and the assessment of the use of hazardous substances, and ecodesign provisions. There are plans to establish an Eco-Assurance Review Committee and an Operation Management Information System to review the measures and to oversee enforcement and reporting, respectively (Park 2007). A manifest system will also be put in place to strengthening system monitoring.

China

Environmental activism turned the WEEE issue into a policy agenda in China in the early 2000s. The infamous report of the Basel Action Network (BAN) and Silicon Valley Toxics Coalitions (SVTC), *Exporting Harm* (February 2002), introduced the world to health and environmental hazards of the so-called backyard recycling took place in Guiyu town, Guangdong Province⁵. As an immediate reaction to the scandal, the Chinese government issued a blanket ban on any imports of used EEE, even for reuse as second-hand products, to the mainland China in August 2002 though this prohibition did not apply to Hong Kong. It is worth noticing that the imports of certain WEEE for recycling were already prohibited under a Notice on the Import of Wastes of the Seventh Category under the Interim Provision on Wastes Import and Environmental Protection issued by the State Environmental Protection Administration (SEPA) in 2000. Besides the import ban, a longer-term approach to set up a WEEE management system was also initiated.

The approach comprised of two main components: the development of legal frameworks and physical infrastructures. For the former, three legal documents were promulgated. The first was an Ordinance on the Management of Waste Household Electrical and Electronic Products Recycling and Disposal (China WEEE) drafted by the National Development and Reform Commission (NDRC). This ordinance would lay a foundation for the management of, at first, five products: TV sets, refrigerators, washing machines, air conditioners, and personal computers. It would be based on the EPR principle with some modifications to the Chinese contexts (He et al 2006). The draft Ordinance proposed to establish a special fund and producers were expected to pay contributions and comply with ecodesign provisions while municipalities were responsible for collection and treatment. The draft came into the public in 2004 but since then had yet been finalised. The second was the Measures for Administration of the Pollution Control of Electronic Information Products (China RoHS) prepared by the Ministry of Information and Industry (MOII). It was enacted in 2006 and became effective in March 2007. China RoHS requires all electronic information products manufactured and imported to be tested in Chinese certified laboratories and labelled if the content of the six hazardous substances exceeds the standard value. Lastly, SEPA developed a Technical Policy for the Prevention of Pollution from Waste Electrical and Electronic Products.

To build physical infrastructure, WEEE management projects have been piloted in a few locations. In 2003, NDRC selected Zhejiang Province, and Qingdao City to experiment two models of WEEE management, an independent recycling plant model and an EE manufacturer-led model,

⁵ Recently, a number of scientific studies have confirmed grave health and environmental impacts from the uncontrolled recycling of WEEE; see a review in (Wong et al 2007).

respectively (Tong et al 2004). He et al (2006) report other trails in Beijing City and Tianjin City. So far, the results of these projects were less than satisfactory with collection turned out to be a major bottleneck to sustain formal systems (Streicher-Porte and Yang 2007). Besides the pilot projects, material recycling in general and recycling of specific electronic parts in particular attracted private investments. New plants and facilities were set up along the east coast of China (Liu et al 2006). However, most for-profit plants focused more on imported pre-processed recyclables or domestic industrial wastes than post-consumer WEEE (Yang et al. 2007).

Analysis & Discussion

Is there a case of policy convergence?

There seems to be a convergence in a policy discourse. All four jurisdictions claimed EPR was an underline principle of their existing and future WEEE management programmes. In Japan and Taiwan, EPR was credited for the achievements in waste minimisation (e.g. Yamaguchi 2002; Lu et al 2006). The Korean approach has become more “EPR” and more comprehensive with time and the Ministry of Environment Republic of Korea (MOEK) has been speaking out about it. A similar but slower trend can be noticed in Chinese policies.

This might be due to the influence of epistemic communities. In 1994, the Organisation for Economic Co-operation and Development (OECD) initiated projects on EPR which later it championed as an approach to operationalise the polluter-pays principle. It even published a guidance manual for governments “to provide information to national governments that may wish to establish EPR policies and programmes” (OECD 2001). Japan and South Korea have already been members of OECD while China is one of possible candidates for membership. The Government of Japan in particular was instrumental as it funded (part of) the OECD EPR Programme, especially the 1999 workshop in Paris. Besides intergovernmental bodies, transnational movements including BAN and SVTC also promoted EPR to advance their cause, environmental justice (Pellow 2007). This was particularly relevant for China one of the main campaign targets.

On the other hand, the speed and system design were determined largely by internal factors. Setting up a WEEE recycling system is no trivial matter and local conditions must be taken into account. Two parameters, the stock of EEE and the capacity of conventional waste management infrastructures, can constitute necessities for such a system. First, the magnitude of potential WEEE is a necessary condition for the establishment of a national WEEE system. The majority of households in Japan, Taiwan, and South Korea enjoyed the use of major home appliances well before the 1990s; and, by the end of the decade almost all households owned the major four appliances, i.e. the markets were saturated. During the first half of the 2000s, the share of households with a personal computer(s) jumped from below 40% to almost 70% in these jurisdictions. China started with much lower rates in the 1990s but caught up rather quickly in the 2000s. Table 1 compares the ownership of selected items per 1 000 households in China and Japan.

Table 1 Ownership of selected items in Japan and China (units per 1 000 households)

	RF	WM	AC	CTV	PC	Mobile
Japan'94^a	1249	1110	1665	2214	190	n.a.
Japan'99^a	1281	1098	2056	2318	485	1061
Japan'04^a	1274	1086	2347	2140	999	1823
China'95^b	662	890	81	898	n.a.	n.a.
China'00^b	801	905	308	1166	97	195
China'05^b	907	955	807	1348	415	1370

Source: a Statistics Bureau, Government of Japan; b National Bureau of Statistics of China

Second, limited waste disposal capacity might be a more crucial factor of the promotion of recycling in general and WEEE recycling in particular. In this respect, the island jurisdictions face a

greater challenge. In 1999, it was estimated that the remaining capacity of landfill sites in Japan would last for only another 12.3 years (MOEJ 2000). Similarly, Chen et al (2005) report that if all waste in Taiwan was landfilled, the capacity would last for only 8 years. This might explain why the two were frontrunners in implementing EPR programmes. In the beginning, their EPR programmes targeted packaging waste which account for a lion share of municipal solid waste by volume. Then, certain WEEE, namely large household appliances and television, came into the picture as their exhausted the capacity of municipalities. We can also see a similar trend in South Korea where these items were added to a recycling system initially designed for packaging waste. China differed from the rest with its vast land areas. In addition, like other non-OECD countries, private/informal recycling businesses were prolific there. These actors by diverting waste from final disposal reduce pressures on the underdeveloped MSW infrastructures.

These differences reflect well in the focus and a cautious approach in policy development in China. There, waste computer was at the centre of policy discussion, thanks to a few precious metals and a range of hazardous substances present in it. The former made it attractive to recyclers, formal and informal alike, to engage in the recycling of WEEE. The latter, however, implies grave health and environmental risks when uncontrolled and rudimentary methods in the informal sector are applied to this hi-tech waste. Not only does this put human health and the environment at risks, but it can also harm the viability of the formal businesses. Savings on safety and environmental protection give the informal actors an unfair financial advantage over their counterparts in a regulated sector (Manomaivibool et al 2007). On the other hand, any harsh measures on this shadowy sector could adversely affect socially disadvantaged groups employed there (not to mention that the enforcement would be prohibitive) and might not be popular particularly to local authorities (Lin et al 2002). Although many reached a conclusion that the informal sector was better be integrated into a future recycling system (e.g. Streicher-Porte and Yang 2007; Manomaivibool et al 2007), such integration had proved to be a challenging task. However, owing to less stress in terms of disposal capacity, the government could afford to take a trial-and-error approach on a pilot scale.

Areas where external drivers can be salient are those relating to international trade. The restriction of the use of hazardous substances (RoHS) is a good example. To harmonise (or, as some commentators argue, retaliate) with the EU's RoHS Directive, similar standards were quickly adopted in most jurisdictions in this study after the EU standards became effective in July 2006. Regardless of local conditions, the list of six regulated substances and threshold values in East Asian standards were identical to those of the EU's RoHS Directive.

What are the effects of different programme design?

This section evaluates the effects of different programme design of the existing WEEE programmes in Japan, Taiwan, and South Korea. China is not included here because it is too early to perform the evaluation at this stage of policy development. The Japanese system, on the other hand, is split into two mainly because the mechanisms behind the PC programme are qualitatively different from those of SHARL. Table 2 summarises the programmes in nine key areas.

Table 3 presents summative results of the first step of TBE. Space does not allow a full presentation of a complete linking of programme configuration and *ex ante* scorecards which involves a matrix of 6x9 for every single programme. The evaluation shows that the Japanese programme for personal computers contains a strongest set of incentives for upstream improvements thanks mainly to its new/historical split which makes possible the financial guarantee model for all new products. This interpretation applies only to new complete computers from identifiable producers, but not historical or new computers from small assembling shops, a consequence of the programme's narrow scope. Incentives in other programmes based on present costs are discounted due to relatively long life spans of EE products. In addition, the market-share allocation dilutes incentives for product and individual system improvements even further. The Taiwanese programme is particular weak in this respect. Besides the financial models (aspects 3-5), its organisational arrangements (aspects 8-9) requires the least involvement of producers which can, in turn, mean minimal informative feedbacks to and learning in the design phase.

Table 2 Key aspects of WEEE programmes in Japan, Taiwan, and South Korea

	(1) Scope	(2) New/historical split	(3) Financial mechanism	(4) Fee characteristics	(5) Financial consequences at disposal	(6) Collection target	(7) Recycling target	(8) Responsibility organisation	(9) Ownership of facilities
Japan – SHARL	Selective (4+1)	No	Present costs, return share	Visible, no brand differentiation	End users pay	No	Yes, sectoral, material-based	Two consortia, competitive	Group A: Some Group B: Yes
Japan – PC		Yes	Historical: Present costs, return share New: Future costs, all items	Historical: Visible, no brand differentiation New: Internalisation	Historical: End users pay New: Free	No	Yes, sectoral, material-based	Individual	Some
Taiwan	Selective (7+)	No	Present costs, market share	Visible, no brand differentiation	“Refunds” to end users	No	No	Governmental fund	No
South Korea	Selective (10)	No	Present costs, market share	Invisible, no brand differentiation	End users pay (municipality) Free (retailers)	Yes, individual, volume-based	Yes	Multiple (dominated by few major actors)	Yes, for major players

Table 3 Summative qualitative results from the first evaluation step

SCORECARDS		Japan – SHARL	Japan – PC	Taiwan	South Korea
Upstream improvements	Product	Limited, discounted and externalised incentive; recyclability as a design parameter; more likely in Group B	Clear incentive; recyclability as a design parameter	No incentive; no end-of-life design parameter	No clear incentive; but more likely among major players; recyclability as a design parameter
	Individual system	Limited, discounted and externalised incentive	Can be incentive (providing no underestimation of future cost)	Discouraged	Some weak incentive (depending on the level of collection target)
	Collective system	Clear but somewhat weakened incentive; more likely in Group B	Unclear incentive	Very weak incentive (if at all)	Some limited incentive (depending on the level of fees and penalties)
Downstream improvements	Collection	Problem of illegal disposal; but good cost recovery for collected items	Limited problem of illegal disposal; potential underestimation of future cost; but good cost recovery for collected and new items	Collection potential (depending on the level of “refunds”); good cost recovery for collected items	Collection potential and can be improved (depending on the level of collection target and fees); good cost recovery up to the overall target
	Treatment	Ensure sound treatment with self- (Group B) or contract-monitoring (Group A)	Potential underestimation of future cost; but ensure sound treatment with self- or contract monitoring	Improved quality with the auditing system	Ensure sound treatment with self- or contract monitoring
	Reuse & Recycling	Promote material recovery; good cost recovery for collected items; can be better in Group B	Promote material recovery; potential underestimation of future cost	Only baseline recovery; but good cost recovery for collected items	Only baseline recovery; but good cost recovery and supply certainty up to the overall target

Looking at downstream improvements, scope, financial consequences to end users at the point of disposal, collection and recycling targets, and organisational control are the key design aspects. The Japanese programmes are the least favourite in terms of collection due to its limited product scope, lack of collection target, and an end-user-pays method, in the case of SHARL. But, once WEEE is collected into the system, the recycling potential of the two programmes are higher thanks to the existence of recycling targets. On the other hand, the strength of the Taiwanese and the Korean lies in their collection potential. The former employs monetary incentives to encourage end users' cooperation while the latter approaches the issue from the other end by setting collection targets on producers with financial sanctions. Volume-based collection targets in South Korea also improve predictability of supplies crucial for investments in recycling infrastructures. Last but not least, quality treatment can be secured in all programmes albeit through different means. In Japan and South Korea, this comes from a close tie between downstream facilities with major producers or groups of producers, i.e. the system ownership. In Taiwan, independent downstream actors undergo intensive audit to ensure the quality of their work in exchange with government subsidies.

The second step reviews actual upstream and downstream achievements of the programmes and triangulates them with the results from the first step. Overall, downstream improvements are more visible and measurable in the three programmes than the upstream improvements. Infrastructures such as collection points and recycling facilities mushroomed, as described above, and the amounts of WEEE collected and valorised increased continuously in all the three cases. However, there are limitations and external factors influenced the success in these areas. Particularly, the actual collection rates seem to deviate from the prediction of the first step. The evidences of design improvements, on the other hand, are in tandem with the prediction. The rest of this section presents details of the findings.

Most studies have reported a collection rate of around 50% or (much) below of estimated WEEE arising (see, for example, Oguchi et al 2008; Lee et al 2007). The explanation behind this considerable hidden flow, i.e. the amount of obsolete products not accounted for in any WEEE formal management systems, is mainly economic. A fraction of used products considered "obsolete" with some kinds of average lifetime methods are still functional and commands high market value. It is unlikely that the existing WEEE programmes designed to collect WEEE for recycling would be able to compete with the second-hand market. This explains why the hidden flow of products such as notebook computers and mobile phones are particularly large. For example, in Taiwan only 9 233 units of notebook computers were collected and verified in 2006, equal to 2.7% of the estimated obsolescence of 342 977 (comparing to 49.3% in the case of desktop computers in the same year); Lu et al (2006) report that the average price offered for reusable notebook computers in Taiwan was higher than the refund by the factor of 44. When the international trade of used EEE is taken into account, the picture becomes even more drastic. There, the demand from the less developed countries does not only limit to reusable products, but also for valuable materials from the recycling of WEEE. With cheaper labour cost, Kondo et al (2007) demonstrates that similar recycling processes could be more profitable in China than in Japan. Streicher-Porte and Yang (2007) and Manomaivibool et al (2007) even go further to argue that the processes were not the same and savings from the lax enforcement of environmental regulations and standards in less developed countries would only make the economics of the informal sector all the more attractive, financially speaking. However, because the exports/imports of WEEE for recycling have been restricted, the trade are done in secretive manners and, hence, its flow hidden in the official trade statistics (Terazono 2007).

Despite the existence of large hidden flows and its economic drivers, collection of regulated WEEE into the programmes was continuously improved in the three jurisdictions. Table 4 reports a calculated collected units of four major home appliances per 1 000 persons. Here, only items directly under the remit of the programmes, i.e. those handled by producers in Japan and South Korea, and those verified by third-party auditors in Taiwan, are included

into the calculation. It was estimated that this fraction accounted for around 60% and 70% of the unhidden flow in Japan in 2006 and in South Korea in 2004, respectively (van Rossem and Tojo forthcoming; Yoon and Jang 2006); it is not possible to estimate collected items not verified in Taiwan. This might seem as if the results contradict the evaluation in the first step with Japan tops the table. However, one possible explanation is the target setting and the level of refunds in South Korea and Taiwan, respectively. Although the figures of South Korea in Table 4 were the lowest, they exceeded the mandatory recycling rates by large margins of over 50% (Lee et al 2007). A continuous increase can also be interpreted as a result of an incremental but frequent adjustment of the collection targets. Thus, the outcomes might reflect rather low levels of its parameter than the inherent potential of the policy instruments. In Taiwan, the performance leapfrogged in 1999 after the introduction of refunds. The trend afterward fluctuated within a narrow range (apart from the outlier in 2001), which might reflect the full potential of the levels of existing refunds and the fact that the levels were not frequently reviewed in practice.

Table 4 Collection rates of four home appliances per 1000 populations

Year	Japan ^a	Taiwan ^b	South Korea ^c
1998		18	
1999		50	
2000		43	13
2001	83	80	14
2002	96	57	17
2003	98	56	21
2004	104	56	33
2005	107	64	
2006	107	64	

Source: a AEHA, pop ~ 127 millions; b TEPA, pop ~ 23 millions; c AEE, pop ~ 49 millions

Actual recycling rates in Japan exceeded the targets from the first year and continuously increased. In 2005, the actual rates in the programme were 84%, 77%, 66%, and 75% for air conditioners, televisions, refrigerators, and washing machines comparing to the targets of 60%, 55%, 50% and 50%, respectively (Ogushi and Kandlikar 2007). The recycling targets in South Korea were also met and the targets were increased in 2006, e.g., from 55 to 65% for televisions and computers, from 60 to 70% for mobile phones, audio, refrigerators, and from 70 to 80% for washing machines and air conditioners (Lee et al 2007).

The patterns of upstream improvements conform well to the *ex ante* evaluation. The improvements can be categorised into product design (e.g. design for disassembly, design for recycling, design out toxics, etc.), downstream technological innovation (e.g. disassembly methods, separation techniques, reapplication of recovered materials, etc.), and changes in product systems (e.g. PSS). Evidences of innovation by individual producers in terms of product design and technological innovation in Japan after the programmes are well documented in (Ogushi and Kandlikar 2007; DTI 2005; Tojo 2004). Downstream technologies and innovation in South Korea are presented in (Lee et al 2007) and Park (2007) provides some evidences of product design but in a more general way. To my knowledge, there has been no evidence in upstream improvements in Taiwan that was attributable to the implementation of the WEEE programme, except one Taiwan-based electronic multinational corporation whose designer teams paid visit to recycling plants.

Comparing to the WEEE programmes in Europe, the scope of East Asian programmes is much less comprehensive. Only a few major products are regulated. This is understandable if landfill diversion is a prime driver of the policy development. For example, Oguchi et al (2008) find that the regulated items in Japan accounted for almost 70% by weight of the total

94 EE products. However, the merit of a selective scope can be questioned from a different perspective. It can be argued that in certain areas such as RoHS in new products a more comprehensive scope could provide stronger drivers for technological changes and innovations. Smaller and less valuable items are also less likely to be collected and recycled and consumers are often discarded them mixing with other waste (Darby and Obara 2005). Therefore, in a not-so-far future, waste from these products could be a source of lost resources and contamination at the disposal sites, unless they were gradually incorporated into the system.

Conclusions

The management of post-consumer waste has seen a shift in policy paradigms in the last two decades. Government embraced the EPR principle as a way to create circular economy and promote 3Rs. In this respect, WEEE was singled out as a priority waste stream as it contained both valuable materials that should be recovered and hazardous substances that should be reduced and handled properly. Japan, Taiwan, and South Korea have WEEE programmes up and running for some years while China is in the process of erecting its national programme. In this study, I argue that, although the proliferation of EPR in the policy discourse owed much to the work of epistemic communities, whether and how (and how fast) it would be translated into action depends largely on local conditions. The so-called bandwagoning effect was evident only in the case of product standard (i.e. RoHS). Looking at the impacts, in general, it is found that the existing programmes succeeded in building up and improving downstream capacity though the problem of hidden flows was still prominent. There are also evidences of design improvements such as design for disassembly, design for recycling, and design out toxics, and technological innovations, especially in the programmes where producers are not only financially responsible but also involve in physical management of WEEE both collectively and individually. TBE shows that the EPR intervention theory can explain the behaviours of economic actors such as producers, collectors and recyclers rather well, providing that the implementation theory is first evaluated. It also highlights the importance of the fine-tuning of policy instruments such as targets and fees. However, alone it cannot explain consumers' replacement and disposal decisions in their entirety.

Based on this study, there are many issues worth further investigation. First, the EPR intervention theory should be developed and specified based on new findings on the effects of policy instruments and the role of contextual conditions. Of particularly interest is the incorporation of knowledge about consumers' behaviours. This can enhance the explanatory power of the theory. Second, policy effectiveness is the only evaluation criterion concerned in this study. Future research should pay more attention to other criteria such as relevancy, economic efficiency, cost-effectiveness, distributional effects, social acceptability, and political feasibility. This can provide a more comprehensive and critical understanding, for example, to target setting. Last but not least, policy processes should be studied in more details. With more information and experiences from existing programmes become available and more and more jurisdictions are in the process of policy development, the process of voluntary policy transfer is particularly interesting. Hopefully such an understanding can strengthen a link between science and policy.

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