Implementing Extended Producer Responsibility Legislation

A Multi-stakeholder Case Analysis

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Summary

The goal of this article is to contribute to the understanding of how the multiple, and sometimes conflicting, stakeholder perspectives and prevailing conditions (economic, geographic, etc.) in the implementation locality shape extended producer responsibility (EPR) "on the ground." We provide an in-depth examination of the implementation dimension of EPR in a specific case study by examining concrete activities at the operational front of the collection and recycling system, and probing the varying stakeholder preferences that have driven a specific system to its status quo. To this end, we conduct a detailed case study of the Washington State EPR implementation for electronic waste. We provide an overview of various stakeholder perspectives and their implications for the attainment of EPR policy objectives in practice. These findings shed light on the intrinsic complexity of EPR implementation. We conclude with recommendations on how to achieve effective and efficient EPR implementation, including improving design incentives, incorporating reuse and refurbishing, expanding product scope, managing downstream material flows, and promoting operational efficiency via fair cost allocation design.

Introduction

Extended producer responsibility (EPR) is a policy tool that holds producers responsible for the post-use collection, recycling, and disposal of their products (Lifset 1993). The basic concept is to promote environmental impact reduction at end of life by (1) making manufacturers internalize the end-of-life costs of their products so as to incentivize the design of products that are more recyclable and have lower toxicity,[1] and (2) to ensure there is sufficient and stable financing for running a collection and recycling system for post-use products (Mayers et al. 2012).

EPR initiatives have rapidly diffused throughout the United States in recent years. They target the waste streams of various products, including electronic waste (e-waste), mercury lights, carpets, packaging, paint, and pharmaceuticals (Nash and Bosso 2011). Among these, e-waste stands out: over the last decade, 25 states have passed e-waste bills, and legislation is pending in several other states; the vast majority of these e-waste bills are based on the EPR principle[2] (Electronics Take-Back Coalition 2011). The impetus is the potential impact of post-use electronics at home and abroad: consumer electronics contain toxic materials that are harmful to both the environment and human health if not managed properly. Nongovernmental organizations (NGOs) such as Californians Against Waste argue that in the United States, 70% of the toxic heavy metals found in landfills are estimated to come from e-waste (Californians Against Waste 2012). Documented e-waste exports to developing countries, where they are handled in a way that is particularly harmful, have attracted attention (Basel Action Network 2005). A well-functioning EPR implementation, in conjunction with adequate environmental regulation, can help alleviate these problems by ensuring the proper recycling of e-waste

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in the short term (via adequate financing) and reducing the environmental impact of e-waste in the long-term (via design incentives).

The process to implement the EPR concept typically involves the following three stages. First, an appropriate policy instrument that embodies the EPR principles is identified and a legislative framework is developed. Second, the legislation is translated into an EPR program. This involves designing a set of detailed operational rules (e.g., the specific mechanisms to finance the operations of the program and to monitor the legal compliance of each entity involved, within the parameters of the legislation). For example, many states in the United States have adopted a collective form of the EPR legislation (i.e., there exists a centrally operated network that handles a mixture of products from multiple manufacturers in an aggregate manner). Note that there is no definite boundary between these two stages: while some states adopt e-waste laws with high-level guidelines (e.g., South Carolina General Assembly 2010), there is also state legislation that already contains some operational details (e.g., Washington State Senate 2006). The final stage is the execution of the EPR program into a working system in practice. This stage is characterized by numerous interactions among multiple stakeholders whose own managerial and operational strategies are affected by the EPR legislation, and thus each of whom has its unique perspective toward the program. These interactions greatly contribute to the shaping of the actual practice of e-waste collection and recycling (see Atasu and Van Wassenhove [2012] for a detailed discussion).

A prominent phenomenon that arises during the above transitions is that the decision made in each stage is influenced by various factors other than environmental concerns. In particular, the proper handling of e-waste is typically a costly operation, and this economic burden is shifted from local governments to the electronics industry under EPR. In addition, EPR typically allows end users to return used electronics free of charge and requires advertising of take-back programs. This, in turn, typically increases the collection volume, implying that the economic burden can be higher under EPR than in its absence. A mandated EPR program can also give rise to economic opportunities for businesses involved in e-waste collection and recycling. In addition, political factors such as the lobbying influence of stakeholders may play a significant role. Another crucial element in EPR implementation is the challenge of executing legislative objectives using practical and efficient methods, especially considering the existing infrastructure related to collection and recycling operations in the area. For example, in Washington State, transportation efficiency depends on the geographic location of the route. The biggest differentiation occurs between the so-called west-of-the-mountains and east-of-the-mountains areas, as the former contains the Seattle–Vancouver corridor, where many trucking companies operate busy routes and thus can provide ample backhaul miles at cheap prices. This is an important factor when determining the location of collection and recycling facilities. Moreover, due to the multiagent nature of an EPR program, the efficiency of its implementation is also greatly influenced by the heterogeneity in the perspectives and individual incentives among the entities involved, even within a single stakeholder group. These challenges often result in a gap between the EPR system in practice and what is intended by the EPR principle and/or EPR legislation (Atasu and Van Wassenhove 2012).

The difficulty of achieving policy objectives in the EPR context has received some attention in the literature. For example, according to the environmental economics literature, mandated producer take-back policy may not be able to motivate manufacturers to adopt product designs that are more environmentally friendly (e.g., Walls 2006). Along similar lines, a number of papers (e.g., Calcott and Walls 2000; Fullerton and Wu 1998; Palmer and Walls 1997; Walls 2006) study policy instruments such as recycling subsidies, advance disposal fees, and command and control standards and point out the impact of certain externalities in determining the efficiency of these policy instruments. The environmental policy literature also recognizes the complexity in the implementation of policy tools. One seminal work is the study of public policy implementation by Pressman and Wildavsky (1973), which introduces a general framework to analyze factors in the implementation process that result in differences between the intended and the actual outcomes from the policies. This literature also highlights the additional complexity of the problem when environmental objectives are infused into the process (e.g., Nilsson et al. 2009).

The recent operations management literature also recognizes the challenges with implementing EPR, and investigates the translation of EPR principles into working systems from an operations perspective. For example, Atasu and Van Wassenhove (2012) provide a systematic overview of the operational issues in implementing e-waste take-back legislation. Another set of papers study specific outcomes of EPR implementation using analytical models. For example, Toyasaki and colleagues (2011) study the impact of recycling competition; Jacobs and Subramanian (2011) investigate supply chain configuration decisions under product take-back mandates; Krikke and colleagues (2003), Hammond and Beullens (2007), and Walther and Spengler (2005) study reverse logistics and network design; and Atasu and Subramanian (2012), Esenduran and Kemahlioglu-Ziya (2011), Plambeck and Wang (2009), and Zuidwijk and Krikke (2008) study product design implications of EPR. The industrial ecology literature has also provided evidence regarding the problem, pointing out the drawbacks and limitations of the current execution of EPR principles and suggesting conceptual solutions for improvement (e.g., Lifset and Lindhqvist 2008; Mayers et al. 2012; Tojo 2004; Van Rossem 2008).

The goal of this article is to contribute to the understanding of how the multiple, and sometimes conflicting, stakeholder perspectives and prevailing conditions (economic, geographic, etc.) in the implementation locality shape EPR "on the ground." We aim to take a deep dive into the implementation dimension of EPR in a specific case study by examining concrete activities at the operational front of the collection and recycling system, and probing the underlying trade-offs that have driven a specific system to its status quo. To this end, we conduct a

detailed case study of the Washington State EPR implementation for e-waste, based on which we provide an overview of various stakeholder perspectives and their implications for the attainment of EPR policy objectives in practice. The Washington case is instructive because it shares some implementation features with other states, but also has some unique features that warrant discussion. Moreover, the scope, scale, and maturity of the Washington implementation for e-waste create a unique opportunity to do an in-depth analysis of certain regulatory design choices, and to generate insights not only for Washington, but for other states and even other waste streams as well. We then summarize the issues identified, discuss the challenges of better reflecting EPR goals into EPR legislation, and discuss the opportunities associated with translating EPR legislation into a comprehensive and efficient implementation.

Case Study: Extended Producer Responsibility in Washington State

The state of Washington, located in the northwest of the United States, was one of the first states to pass an e-waste bill (in 2006), to enact regulation (in 2007), and to start implementation (in 2009). In this section we briefly review the main elements of the Washington e-waste legislation, outline how it is implemented in practice, and discuss its implications for various stakeholders (regulators, city and local governments, manufacturers, collectors, processors, and consumers) that have shaped its translation and eventual impact.

Specifics of the Washington Extended Producer Responsibility Legislation and the "E-Cycle" Recycling Program

The main elements of the Washington e-waste legislation (Washington State Senate 2006) are the following:

- The law mandates free collection, transportation, and recycling services to be provided for covered entities (any household, charity, school district, small business, government in Washington State) for covered electronic products (CEPs) defined as televisions (TVs), monitors, and computers (excluding peripherals). The collection and recycling system is financed by manufacturers.[3]
- The Washington Materials Management and Financing Authority (WMMFA) was established to put in place and run a "default" collection, transportation, and recycling program (hereafter called the "standard plan"), and collect funds from the participating manufacturers to finance the operational and administrative expenses incurred. The authority is governed by a board of directors comprised of representatives from participating producers.
- All manufacturers must register with the Department of Ecology (hereafter referred to as "Ecology") and participate in either the standard plan or, alternatively, operate and finance their own "independent plan" if certain criteria are met (after approval of such plan by Ecology) in order to sell covered electronic products in the state.
- All collectors,[4] transporters,[5] and processors[6] participating in an approved plan must be registered annually by Ecology.
- Any plan (independent or standard) must provide collection service in every county, and every city of size greater than 10,000 (called "the convenience standard"), and implement and finance the sampling of brands processed in the plan for every program year. In addition, the standard plan is expected to try to come to a negotiated agreement with all collectors and processors that want to be in it. Each plan will be charged/paid for the deficit/surplus, if the e-waste processed by the plan within a program year, relative to the total weight processed by all plans, is below/above its return share, defined as the ratio of the participating producers' products returned to the total amount of electronic products returned by weight.[7]
- Ecology is responsible for the following tasks: (1) registration of manufacturers; (2) review and approval of independent plans; (3) setting the performance standards for collectors, transporters, and processors, and their registration and compliance auditing; (4) determining return shares[8] (and if needed, market shares[9]) of manufacturers; (5) monitoring the financial compliance of all existing plans; and (6) outreach and consumer education.

The electronic product recycling program[10] further defines detailed regulations with respect to the requirements for each entity involved in the system (see the section on *Stakeholder Roles and Perspectives* for details), as well as the specific procedures that Ecology will use to enforce these requirements and implement the legislation.

Implementation Overview

To date, only the standard plan operates in Washington (no independent plans have been approved by Ecology) and is thus responsible for handling all returned covered electronic products in the state. A description of the material and financial flows associated with the standard plan is provided in figure 1.

Product Flows

Consumers (including households and small businesses) bring post-use CEPs to collection points, and these CEPs are then transported to processors (potentially after being taken to consolidation points). Material flows are handled by transporters (represented by solid lines in figure 1). The Authority determines to which processor each lot from each collection point will be transported so as to minimize the total cost it is charged. Transport is either in the form of self-transport by collectors or takes place on transport capacity purchased by the Authority (typically in the form of backhaul miles[11]). At the processors, the CEPs are dismantled into parts and/or shredded and sorted into different materials. Processors incur the operational costs of dismantling and/or shredding materials. The

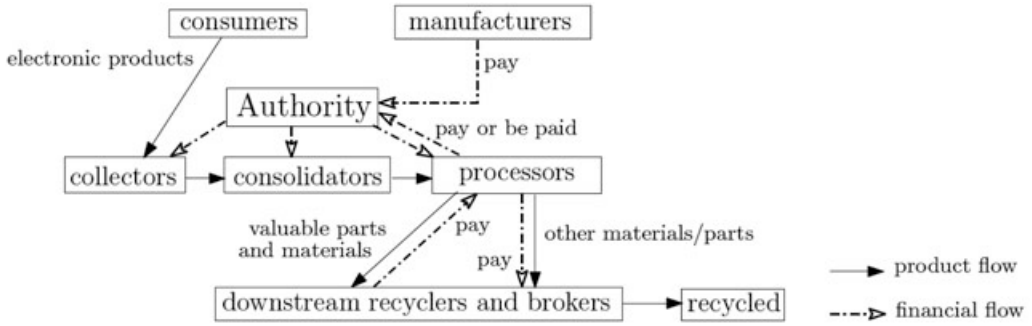

Figure 1 Product and financial flows of collective collection and recycling of electronics.

valuable parts and materials, such as computer processors and metals, are then sold to downstream parties (smelters, brokers, refurbishers, etc.) to be reused or further processed, which creates a net value. The rest of the parts and materials, such as leaded glass, can be delivered to downstream brokers or facilities for further recycling and/or landfilling, both of which lead to a net cost that the processor needs to pay. For example, in the Washington case, some processors send the leaded glass to a Mexican facility that processes and sells the glass for new cathode ray tube (CRT) TV production in India. Processors must follow environmental, health, and safety standards (including those for the downstream brokers they interact with) as outlined by Ecology.

The direct processor level is the "boundary" to which the oversight of Ecology and the financial responsibility of the Authority extend. The extent to which materials are recycled downstream does not need to be documented for plans that choose to adhere to the "minimum" performance standards. However, processors voluntarily adopting the "preferred" performance standards[12] must send materials and parts to downstream vendors that certify that they do not export the e-waste to developing countries that do not accept such waste.

Financial Flows

The authority pays each collector, consolidator, and transporter based on a unit rate per weight that they handle; the main cost of these entities is operational in nature. Processors incur operational costs to dismantle/shred products and separate materials, and may either incur a cost or make money on each material/part stream. Hence, in implementation, the Authority pays processors (by weight) for products that incur a net cost, but obtains a reduction on its invoices for products that generate a net value. The Authority's total operational and administrative cost then gets allocated to manufacturers whose products are sold in the state.

Implementation details in Washington

Here we provide some implementation details in the first year of the E-Cycle program in Washington (2009), mainly based on the annual report by Ecology.[13] In 2009, 38,509,563 pounds (lb) of CEPs were collected, of which TVs, monitors, and computers accounted for 58%, 32%, and 10%, respectively.[14] This corresponded to products from 137 different product brands from 87 producers with return shares varying from 0.0001% to 7.9%. The return rate among the counties ranged from 0.4 to 9.6 lb per capita, and King County alone, where Seattle is located, achieved a return volume of almost 15 million lb, or about 38.5% of the total volume.

There were 244 collection points registered with Ecology in 2009, whose concentration varied widely from county to county because the population densities of counties in Washington vary (figure 2a). Overall, the west-of-the-mountains area had a denser network of collection points compared to the east-of-the-mountains area. In particular, 15 counties, most of which are located in the east-of-the-mountains area, had only 1 collection point (which is mandated by the convenience standard), while King county (in the west-of-the-mountains area) had 58. The convenience standard assured that 38% of the 207 cities in Washington were covered and reached approximately 90% of the population (based on 2010 census data).

Eight processors were involved in the E-Cycle program in 2009, yet the majority of the total return volume (approximately 99%) was processed at the six in-state processors (see figure 2b for their locations). It can be observed that these processors are all located along the Seattle–Vancouver corridor with convenient and ample transportation capacity. Among these processors, there are large-volume high-tech processors that handled more than 60% of the total volume, and also small local businesses with mainly manual dismantling operations.

The average handling cost (including the cost of collection, transportation, processing, and administrative expenses) was 24 cents/lb[15] in 2009. The rates paid to collectors ranged widely, depending on the location of the collection point and its business scale. In particular, in counties with low population density, the collection points that were established largely due to the convenience standard mandated by the law and collected low volumes were typically compensated at a higher rate. The transportation rates depend on the location of the route: as described in the introduction, backhaul capacity can often be utilized very cheaply to serve the collection points in the Seattle–Vancouver corridor to the west of the mountains where the processors are also located, while a slightly higher price is paid to transport the return volume from east to west. The processing costs are largely influenced by the product characteristics, since products may require different recycling techniques and procedures, and/or generate parts and materials with different profitability levels.

Figure 2 Locations of (A) a representative sample of collection points (50 out of 244) and (B) all the in-state processors involved in the Washington E-Cycle program in 2009. Note that there are two processors near Seattle that are very close to each other and overlap in (b).

The biggest distinction exists between TVs/monitors and computers: TVs/monitors are expensive to recycle because of the hazardous materials contained in them, such as leaded glass, while computers often lead to a positive net recycling profit, as their components and materials have high reuse value. Hence the E-Cycle program pays processors for TVs/monitors and is effectively compensated by the processors for computers. The specific processing cost may also depend on the operational efficiency of the specific processors: processors with large-scale and automated operations incur lower processing costs. In addition, those that can perform advanced processing operations besides basic dismantling of products (e.g., shredding, material separation, and even computer refurbishing) are able to achieve better product recovery and greater recycling profits, which can be reflected in the processing rates they quote to the E-Cycle program. Similarly, processors that have in-house transport capacity can quote a combined and more advantageous rate to the Authority than those without such capacity.

Stakeholder Roles and Perspectives

As described in the previous section, the implementation of the Washington program is the result of the joint participation of various parties, including manufacturers, collectors, processors, and so forth. Therefore the perspectives of these stakeholders greatly influence and shape the current practice of the E-Cycle system. In the following discussion we aim to provide some insight concerning these perspectives.

System Management

There are mainly two agencies that participate in the management of the E-Cycle program: WMMFA and Ecology. Both of them play an essential role in coordinating the multiple dimensions of EPR implementation and the different perspectives of other stakeholders involved in the system, thus ensuring a balanced and efficient working system in compliance with the law. WMMFA is responsible for operating the "standard plan" in the E-Cycle program. Its mission consists of the following:

- Providing proper collection and recycling for end-of-life products in compliance with the state law and Ecology direction in the most cost-effective way. As stated on its website, "WMMFA is committed to being the lowest cost plan provided for mandated electronics recycling in Washington State" (WMMFA webpage[16]).
- Striving for fairness. This involves the following considerations: "to provide fair and equitable expenses allocation to our members," and "to treat all stakeholders and service providers fairly and reasonably" (WMMFA webpage).

Achieving these two objectives so as to satisfy all stakeholders is a complex and challenging task that can involve constant reassessment and rebalancing of different aspects of its operations. For example, the Washington e-waste bill was originally conceived as using cost allocation by return share among participating producers. To attain an equitable allocation, the WMMFA adopted a cost allocation based 50% on market share and 50% on return share; this weighting has further evolved since the inception of the program. Collectors operating in areas of high population density have a cost advantage relative to those operating in rural areas such that treating all collectors fairly may mean negotiating differing reimbursement rates for collection. WMMFA also needs to weigh whether to go beyond compliance; for example, whether to facilitate the inclusion of more collection points than the minimum required under the convenience standard, and whether to require the preferred or minimum performance standards defined by Ecology. Registered collection points have increased from 244 in 2009 to 291 in 2010 and 295 in 2011,[17] and all processors working with the WMMFA have adopted the preferred standards.

Ecology is a state government agency that "protects, preserves and enhances Washington's environment, and promotes the wise management of . . . air, land and water for the benefit of current and future generations."[18] It runs 10 major programs covering air quality, nuclear waste, water quality and resources, and so forth. E-Cycle is part of the "Waste 2 Resources" program. The main specific administrative and enforcement responsibilities of Ecology regarding E-Cycle are described in bullet six

of the section *Specifics of the Washington Extended Producer Responsibility Legislation and the 'E-Cycle' Recycling Program*, and include initial rule-making as well as ongoing compliance monitoring. In undertaking these responsibilities, the essential role of Ecology is to balance the environmental goals of EPR legislation with economic and social concerns. This, in particular, includes establishing rules that Ecology can enforce that are not in violation of interstate commerce laws and beyond Ecology's jurisdiction. A challenge is the number of differing stakeholders (producers, retailers, processors) that need to be brought into the system and followed for compliance in the face of finite resources. Overall, ensuring the existence and success of a working EPR system in an effective manner is the most important issue from the Ecology perspective.

City and Local Governments

There are three major roles that a local government plays in the EPR program in Washington. The first one is in promoting CEP recycling. Local governments are required by the law to educate their citizens about the recycling program. Local governments are also required to submit area satisfaction reports about the program implementation in their respective areas. Second, as a covered entity, local government agencies that meet certain conditions can dispose of their unwanted CEPs free of charge. In addition, local governments can, but are not required to, register with the program as a collector and receive compensation for their collection efforts.

The concerns of local governments revolve around how the E-Cycle program impacts the welfare of their respective areas, both environmentally and economically. Specifically, an immediate consequence is that the local governments are able to direct their constituents to the E-Cycle program instead of developing solutions to handle this waste stream themselves. At the same time, premium municipal services that charge a fee for service, such as curbside collection (which carries an extra charge for electronics), may see a drop in demand (although it is still appealing to a segment of the population that does not have the means to transport large equipment). Any collection facility operated by local governments that is not sufficiently competitive (in terms of the price quoted to WMMFA or service quality) relative to other collectors will find it challenging to participate in the standard plan. In Washington, around 17 local governments decided to become collectors, and others have chosen to leave the collection to the private sector.

Another factor that determines E-Cycle's impact is how well the program serves the area; a convenience standard of the kind used in Washington ensures the establishment of many collection points and provides substantial coverage of free collection service, reaching 90% of the population according to census data (based on 2010 census data). Moreover, since it is not efficient for local governments to create unique programs for their jurisdictions, E-Cycle Washington provides economies of scale for the state.

From a long-term point of view, the E-Cycle program has the capacity to boost local economic development, particularly by stimulating local collection and recycling businesses. Indeed, one of the criteria used by Ecology for evaluating a plan is whether the plan uses sufficient local resources. At the same time, when this means routing waste to smaller, less technology-focused processors rather than national state-of-the-art recycling facilities, it can create a conflict between the cost efficiency of the program and promoting the local economy. The capacity of the recycling program to attract state-of-the-art facilities to the state is limited because of the size of the state population and because of the noncontractual nature of the arrangement between the Authority and any processor; please see the *Processors* section below for more details.

Manufacturers

Manufacturers are the main stakeholders that the EPR legislation targets, and are responsible for financing the implementation of the program. The legislation requires every manufacturer to register with Ecology and participate in the standard plan or an approved independent plan. A given plan's total share in the state is calculated according to the return share of the manufacturers making up that plan, but within a plan, manufacturers are free to use any cost allocation method they choose as long as they cover the total operational and administrative costs of running the plan. Manufacturers are also required to promote CEP recycling and collaborate in educational campaigns. Manufacturers participating in the standard plan oversee its operations as well. For example, some manufacturers are represented in the board of directors of the WMMFA.

Under EPR, end-of-life costs are internalized into manufacturers' bottom line and are a significant consideration (Mayers et al. 2012). Hence one important concern of manufacturers is the determination of their share of the recycling program's total cost. As mentioned earlier, monitors and TVs impose a cost, while computers generate revenues at the processing stage. Moreover, TVs make up a larger share of the return stream by weight for three reasons: they have been accumulating in households for a longer time than computers, they are on average heavier (especially the older console CRT TVs[19]), and the E-Cycle program is the primary outlet for consumers, as most TVs have no residual market value (e.g., no eBay resale opportunities). Consequently, in 2010, 63.3% of the collected e-waste by weight was attributable to TVs.[20] At the same time, some TV manufacturers have seen their market shares erode over time. Thus it is not surprising that cost allocation based on market share would be preferred by most TV manufacturers (who have higher return shares relative to their market shares) and that cost allocation based on return share would be preferred by most computer manufacturers (who have higher market share relative to their return shares). Although the Authority's board is making an effort to arrive at an equitable allocation scheme by using a combination of return share and market share, the intrinsic fairness issue these simple heuristics create is expected to persist due to the complexity of the system. Even within a sector, manufacturers may have different perspectives, depending on their historical versus current sales rates.

Because of these issues, it can be expected that some manufacturers (either individually or jointly) would like to break

away from the standard plan to operate their independent plans, especially when they have access to cheaper/higher value-added out-of-state recycling capacity/technology. A typical example is those manufacturers who are already engaged in the end-of-life management of their products at a regional or national level. According to Ecology, two independent plans were indeed submitted to Ecology, but were not approved, primarily on the grounds that they did not meet the required convenience standard. However, in the future, it is possible that multiple plans will be operational in Washington. This creates many issues, and we mention three prominent ones:

- To meet the convenience standards, a plausible approach for independent plans is to share collection points with the standard plan (as is the case in the state of Oregon). This, however, calls for better separation and sampling techniques along with well-defined protocols for allocating recovered CEPs and the associated costs in order to monitor the compliance of multiple plans. However, whether sharing these collection points would be desirable from the standard plan's perspective is a challenging question to be addressed.
- Another issue is whether the collectors would be willing to participate in multiple plans and incur the risks of having no single entity assured to take all that is collected and of dealing with the added administration and paperwork (multiple contracts, additional billing, etc.).
- Manufacturers who envision operating independent plans will either have access to lower cost or higher value-added processing capacity (some of which may be out of state), or different collection and transportation capacity options that can provide cost savings (e.g., a retail partnership for collection or backhaul miles on its own distribution network). For example, the Electronic Manufacturers Recycling Management Company (MRM), sponsored by six TV manufacturers, has contracted with Universal Recycling Technologies (URT), a recently established Oregon-based processor that has advanced TV/monitor recycling technology (especially in glass recycling). An interesting question in this regard is whether the Authority could "compensate" these manufacturers for bringing in these capacities into the standard plan in lieu of breaking away to form an independent plan. If so, and as long as these capacities meet the performance standards of the state plan, all parties could continue to benefit from economies of scale and a more extensive and flexible collection and recycling network (Gui et al. 2012).

Another economic concern of manufacturers is that state-by-state e-waste compliance and fragmented operations can increase their compliance costs and operational costs (due to the loss of economies of scale). Thus some manufacturers are expected to prefer regional or national collection and recycling networks that operate under a unified legislative framework. One reason for the presence of independent plan provisions in the Washington bill appears to be some manufacturers' preferences for independent plans. In actuality, as noted above, no independent plans have been approved to date.

Besides cost, another issue that directly affects manufacturers' perspectives of the recycling program is the design incentives provided by the program. The long-term goal of an EPR program is to incentivize better product design. There is some evidence that manufacturers are paying attention to end-of-life processing costs (see, e.g., Srivastava [2008] for results of a survey conducted by Dell to determine which design improvements would facilitate recycling the most). Another example is that under return share-based cost allocations, manufacturers' costs are largely determined by the weight of their products returned. Hence manufacturers can be motivated to make lighter products that last longer, which effectively reduces the weight of those manufacturers' products in the waste stream, and in turn their return shares.

However, some problems regarding design incentives still exist. For example, it is not clear how one can prevent free riding[21] on others' design efforts under a collective system, especially under simple return/market share-based rules that do not consider potential recycling cost/value differentials between products. Moreover, two key points in improving product design are reducing toxicity and enhancing reuse/refurbishing possibilities. However, the current framework not only limits direct incentives for reuse and refurbishing, but also underincentivizes the design of less toxic and more recyclable products. The reasons are the lack of product or recycling fee differentiation with respect to product toxicity,[22] the emphasis on recycling as the main form of recovery, and manufacturers paying an average price for all products and thus the reuse or recycling value of different product types not being well reflected in cost allocations.[23]

Collectors

Collectors play an important role in the E-Cycle program, in that meeting (and exceeding) the convenience standard is the tool to achieve a large collection volume. Ecology requires that any business that collects CEPs register with the department as a collector and comply with certain performance standards, such as collecting any CEPs for free for any covered entity, except certain circumstances such as premium/curbside services and for large quantities from small businesses; operating regular hours and staffing the collection point during these hours; having enclosed storage space; and not processing (dismantling) any CEP for the purpose of recycling unless the collector is also registered as a processor. (The criteria for processors are stringent, and hence few collectors do this. For example, some former refurbishing businesses that used to do partial recycling or refurbishing have registered with E-Cycle only as collectors and limit their recycling/refurbishing activity to e-waste obtained outside the program. See the *Refurbishers* section below for details.)

The current set of collection sites registered with Ecology[24] mainly consists of four categories:

- Charities and churches, such as Goodwill (the largest collector in the standard plan, having 88 collection points in 2009, around 36% of the total collection points), Salvation Army, and St. Vincent de Paul. Their advantages include a large and established network that covers the entire state, ample storage space that is capable of handling large quantities, and logistics assets and expertise.
- Retail stores, such as Video Only. They have chain stores that also cover multiple locations in the state. On-site collection at retail locations provides an opportunity to educate the public about the recycling program, as required by Ecology.
- Processors and refurbishers, such as PC Recycle, RE-PC, InterConnection, and Total Reclaim.
- Local government-managed sites (e.g., waste transfer stations).

The establishment of the E-Cycle program affects each collector type differently. For charities that used to receive post-use electronics and had to handle them at a net cost, the E-Cycle program represents not only the ability to avoid these costs, but also an opportunity to obtain a stable revenue stream (from a much larger e-waste return volume). Any instability in future revenues (e.g., as a consequence of the establishment of independent plans) is undesirable from the perspective of nonprofits, who value stability in revenue rather than a larger revenue potential because of their nonprofit status and their reliance on (often fluctuating) donation volumes and after-market sales revenues. For retailers, refurbishers, and local governments, please refer to the specific sections discussing their perspectives. However, all collector types would more than welcome the expansion of the E-Cycle program to include peripherals, as consumers often bring these in with the CEPs and they represent a net cost to the collectors that they are not reimbursed for.

Collectors may face challenges if multiple plans are operational in the state: the standard plan and potential independent plans would compete and/or share collection capacity under the convenience standard mandated by the Washington legislation. However, there is no clear rule about monitoring the sharing of collection capacities among multiple plans (Sepanski et al. 2010). This can cause confusion for collectors in terms of separating and routing different product streams to different plans. Moreover, in this case, collectors may be concerned about the uncertainty and fluctuation in funding received from the independent plans, as well as a potential decrease in payment from the heretofore stable standard plan (e.g., as a result of a loss of economies of scale).

Processors

Processors must register with Ecology and meet the minimum standard or the (voluntary) preferred standard. The minimum standard has requirements including legal, record-keeping, transport, facility access, materials of concern, recycling, reuse and disposal, and so forth. Processors are required to have an environmental management system in place such as ISO 14000 (ISO 2012). The primary additional requirements in the preferred standard relate to the selection and monitoring of downstream vendors (including export issues) and environmental, health, and safety requirements. All registered processors in Washington satisfy the preferred standard.

The direct processors in Washington are mainly engaged in the manual dismantling and sorting of materials, with some of the larger processors using shredding for further material separation/value recovery. Some of the larger processors also engage in computer refurbishing and provide transportation capacity to the program. The cost to process TVs/monitors comes mainly from the leaded glass contained in CRTs. Thus the cost efficiency of processors for this e-waste stream largely depends on the type of CRT glass processing technology they can access.[25] The Authority pays the processors for TVs/monitors and typically obtains a reduction on its invoices for computers.

The significant volume of e-waste collected in the state via E-Cycle means more business for processors. At the same time, where they could charge to accept electronics before E-Cycle, processors can no longer do so for electronics coming from covered entities. Processors face two main interrelated issues. One is competing for volume from the standard plan, and the other is investing in/finding better in-house and downstream processing technology. Specifically, while the standard plan is expected to include all processors registered in the state, there is no minimum amount any processor must receive. Processors quote prices[26] to the Authority, who decides, on a continuing basis, to which processor to route the collected e-waste so as to minimize the Authority's cost, subject to capacity constraints at the processors. With six processors operating in the state, some smaller and some larger, there is overcapacity in the system. Thus no processor is guaranteed a given volume over an extended period of time. In practice, the larger, established, more diversified processors obtain the bulk of the volume from the standard plan, presumably because they are able to offer lower prices. Despite the stipulations in the program concerning the use of local resources, it appears inevitable that national recyclers may come to the state at some point if the collection volume becomes large enough. For processors large and small, the lack of certainty in volume can be a short- and long-term barrier to investing in better recycling technology or to going beyond the minimum environmental performance required to be in compliance with the standard plan requirements in order to operate in Washington. Thus, in the short run, the manufacturers in the standard plan can benefit from the type of competition the current business model engenders, but may lose out in the long run from cost reduction opportunities that require a significant initial investment.

Refurbishers

Electronics (typically computers) refurbishing refers to repairing, cleaning, and restoring a product to its original condition. Due to the rapid technological obsolescence of certain electronics (e.g., laptops, cell phones), many products that consumers replace are in working condition or can easily be refurbished. Thus refurbishing can be an important part of the end-of-life management of such products. Reuse and

refurbishing do not belong to the standard operations defined in Washington; these options are identified as "collection," "transportation," and "recycling." The program does not specify a reuse and refurbish category and an associated standard (i.e., businesses cannot be certified as refurbishers under the plan). At the same time, the program indirectly takes into account the reuse value of CEPs by rewarding plans that use the services of nonprofit charitable organizations that mainly engage in reuse.

The introduction of the E-Cycle program impacts refurbishers in a number of ways. First, the ease of entry into the collection business together with the convenience standard that establishes a large number of collectors[27] means that the volume they directly obtain from consumers decreases. Moreover, they are not allowed to process (dismantle for component sales or recycling) consumer returns unless they register as a processor with the program, which may fall outside their expertise (which is the case with a number of refurbishers). In response to refurbishers' concerns, E-Cycle now allows them to glean fully functional CEPs and components for reuse, which allows them to carry out (limited) refurbishing. Finally, where they might have been previously charging consumers to take used electronics, refurbishers now have to take them for free, which represents a loss in revenue. Consequently, refurbishers may need to reorient their business toward e-waste streams that fall outside the E-Cycle program to maintain their profitability.

Retailers

The program requires all retailers to only sell electronic products from registered manufacturers and to provide information about the E-Cycle program at the point of sale (a crucial part in public outreach). Some retailers are classified as brand owners, and thus are considered to be manufacturers for purposes of reimbursing the Authority for the expenses deriving from their store brands (e.g., Wal-Mart). Retailers can register as collectors, which may create the opportunity to increase store traffic. However, particularly in more expensive retail locations, the space needed to handle e-waste may render the location uncompetitive relative to other collectors.

Consumers

Consumers are responsible for returning their post-use CEPs to the collection points on a voluntary basis. To motivate consumer participation, the program provides convenient collection services at no cost and educates the public (the goal is to achieve a good recognition of the program in 5 years). Consumer education is required to be done at points of sale, and through a collaboration of local governments, collectors, processors, and manufacturers. The program achieved an initial collection rate of approximately 6 lb per capita in 2009 and 2010.

Although EPR internalizes end-of-life costs into manufacturers' bottom lines, depending on the competition level in each sector, different levels of cost pass-through to consumers can be expected (see Atasu et al. [2009, 2012] for a detailed discussion), although this has not been observed in a recent study on TVs and personal computers (Seattle Times Editorial Board 2011). While this motivates reduced consumption of electronic products, it can still serve the purposes of EPR legislation, but at somewhat reduced direct consumer welfare (excluding indirect benefits from environmental impact reduction).

Summary of Stakeholder Impact on Extended Producer Responsibility Implementation

The discussion above provides an analysis of different stakeholder perspectives regarding different EPR policy implementation options and highlights the misalignment of preferences among the stakeholders in Washington State. The authorities' attempt to balance these varying perspectives influences the final implementation structure. In this section we illustrate this by providing examples of how such perspectives have been reflected in the Washington State implementation.

As described above, the product recovery process directly monitored by the E-Cycle program in Washington consists of four stages: collection, consolidation, transportation, and processing. In the collection stage, the Washington legislation departs from other states in adopting the convenience standard to ensure comprehensive coverage, reaching 90% of the population. This approach gives strong consideration to the consumers who highly value the convenience of the service, and also local governments who are concerned about the equity of the program across the state as well as the economic and environmental benefits in their areas. While manufacturers may be concerned about the cost of extensive coverage, and indeed small collectors are paid a higher collection rate, as discussed earlier, the volume collected at these locations is rather limited as well, so that the additional cost impact of the convenience standard does not appear to be onerous in this state.

The economic concerns of local governments are also reflected in the stipulation that the Authority give preference to processors operating in the state, creating an opportunity for small-scale processors to be involved in the program. This can help bolster the local economy by providing new employment opportunities. At the same time, focusing on local e-waste operations, especially in processing, may forego the economies of scale advantage obtained by using only large processors and the use of state-of-the-art recycling technologies that exist outside the state. The consequence of balancing local economic development and cost-efficiency concerns in Washington State is the presence of a mixture of high-volume, established facilities with partially automated equipment that are assigned a large percentage of the total return volume, and a set of facilities (some new) that are characterized by low volumes and manual operations.

The current scope of EPR legislation does not include peripherals (e.g., keyboards and mice), and yet a steady stream of peripherals (typically associated with computers) is brought to collection sites by consumers. These returns are either not accepted, or are accepted but are handled outside the E-Cycle program, with landfilling being the primary outlet. A recently proposed bill amendment would add some peripherals to the

electronic products covered. Clearly, expanding the scope to include peripherals would be convenient for consumers and beneficial for collectors (and the environment), but primarily represents a cost burden for the program.

One prominent feature of e-waste recovery is that it is a multistage process where different recovery methods, such as parts reuse and product refurbishing, can be used according to the product condition. The current Washington system, like many others, focuses primarily on recycling. The main concern from the perspective of the standard plan is that it would be much more complicated to manage and coordinate different recovery operations, especially considering the fact that different cost/revenue structures are observed for reuse and refurbishing compared to recycling. From a manufacturer's perspective, reuse and refurbishing can indeed be a desirable option. This, however, is the case only if each individual manufacturer refurbished its own products and the market valuation of reused and refurbished products resulted in positive margins for the manufacturers. If third parties (i.e., processors registered in the state) were to reuse or refurbish, this would effectively imply the creation of a strong secondary market that would cannibalize manufacturers' new product sales. Moreover, reuse and refurbishing require a different skill set and expertise than new product manufacturing. Manufacturers who do not possess this capability are likely to prefer shredding, as it is cheap and keeps cannibalization at bay. Inclusion of reuse and refurbishing in the e-waste program appears to benefit consumers and third-party remanufacturers the most. In particular, low-cost refurbished products can attract low-budget consumers to purchase products (albeit used) that they could not otherwise. For third parties possessing the skill to refurbish, an inclusion of reuse/refurbishing targets, similar to those that are considered for the recent revision of the European Waste Electrical and Electronic Equipment (WEEE) Directive (EU 2012), would imply a bigger revenue stream (i.e., refurbishing on behalf of manufacturers who do not possess the skill) as well. The Washington State implementation appears to be maintaining its emphasis on recycling, although some refurbishing is already taking place.

The EPR legislation in Washington allows manufacturers to set up and operate their own independent plans, considering the perspectives of some manufacturers who have established their own collection network and recycling facilities, and the economic advantage of using available resources. However, no independent plans have been approved in Washington to date, the main reason being the challenge of developing independent collection networks that meet the convenience standard. This is partially due to large-scale collectors' concerns related to the operational difficulty and the revenue uncertainty inherent in managing capacity-sharing among different plans, especially when no clear rules have been established regarding this issue. From the standard plan's perspective, the existence of independent plans may also imply an efficiency or bargaining power loss as well. Hence the status quo with an efficient standard plan benefits both the Authority (and by extension, the manufacturers) and the large-scale collectors in the state.

A central implementation design issue for a working collective EPR program (such as the standard plan in Washington State) is to provide stable financing such that the program continues to run efficiently and benefits all stakeholders. Currently this appears to be one of the major issues for manufacturers associated with the program. Indeed, as described above, the discussions between TV and computer manufacturers have led to the use of dynamically evolving combinations of return share and market share to determine each manufacturer's cost allocation. These changes have not allayed fairness concerns, however, as some manufacturers continue to benefit from a market share-based cost allocation, while others prefer a return share-based cost allocation, and others prefer to build individual systems. The fact that the current cost allocation model in Washington (within the standard plan) uses a dynamically changing combination of return share and market share is an outcome of the need to balance these perspectives.

Looking Forward: Challenges and Opportunities

The Washington EPR program is one of the most comprehensive working EPR implementations in the United States, having initially enlisted more than 240 collection points (this number has risen to close to 300) and several recyclers (including some new entrants), and collected approximately 6 lb per capita in 2009 and 2010. This volume may grow, especially if the scope of the covered electronics is expanded (considering its European counterpart that reached 17.6 lb per capita [Eurostat 2009] over 11 product categories). Some of the future challenges and opportunities are discussed below.

Better Reflecting Extended Producer Responsibility Goals into Electronic Waste Legislation and Implementation

Design Incentives

Since the introduction of the EPR concept, it has been argued that it is not simply about diverting waste away from landfills, but more about providing incentives to manufacturers to design more environmentally friendly products (Atasu and Van Wassenhove 2012; Lifset and Lindhqvist 2008; Mayers et al. 2012). Thus an essential element to be considered in designing e-waste regulation is the type of design incentives that it provides to manufacturers. Under this issue, problems to be addressed include free-rider prevention, reuse/refurbish incentives, and toxicity reduction. It is clear that simple volume-based cost allocations (such as return or market share heuristics) that are essentially targeted at managing the allocation in an effortless manner are not going to provide these incentives (see Gui et al. [2012] for an illustration of this problem using Washington data). At best, they can result in reduced consumption (through increased prices to cover end-of-life expenses), reduced weight, or reduced product size (called miniaturization in practice) in order to reduce end-of-life costs. If

the real goal of e-waste regulation is to achieve design incentives, there is the opportunity to tailor the implementation to exploit design improvements (e.g., by source separation and routing of e-waste to the appropriate processors) and to reflect their actual cost to each manufacturer (e.g., product or recycling fee differentiation with respect to product toxicity).

Reuse and Refurbishing

Reuse and refurbishing are clearly essential components of EPR. They extend the product life cycle, reduce the amount of waste generated, reduce the amount of virgin materials and energy usage (see Williams et al. [2002] regarding this issue in the context of chip production), and most importantly, they are likely to achieve waste diversion at a net profit. Hence it is surprising that most e-waste laws continue to focus on recycling as their ultimate goal. The downsides of incorporating reuse and refurbishing goals appear to be the question of whether a newer device will have sufficiently improved environmental performance that it outweighs the benefits of waste diversion (see Gutowski et al. 2011), and the complications that can arise in managing and accounting for the contributions of reuse and refurbishing operations in a traditional take-back setting. Also from a social perspective, incorporating reuse and refurbishing is a complicated issue: mass exporting of e-waste becomes possible (and is indeed observed in practice) under the guise of reuse (Basel Action Network 2005; Templeton 2012). Moreover, mandating reuse may violate the interstate commerce clause. Hence, before attempting to incorporate reuse and refurbishing targets into EPR laws, such factors need to be considered carefully. Nevertheless, there is an important opportunity to observe the implications of such requirements, as the recent revision of the European WEEE Directive (EU 2012) considers the inclusion of reuse and refurbishing operations in the scope of the directive. The European experience could provide valuable policy input as to the impact and feasibility of such targets: if the experience is successful, it should be equally feasible to explicitly incorporate mechanisms to reuse/refurbish items into e-waste regulations and program implementation in the United States.

Building a More Comprehensive Electronic Waste Recycling Program

Product Scope

A bill amendment to add peripherals to the electronic products covered under the Washington program was proposed in 2011. The expansion of covered products indicates a level of maturity and acceptance of the program, and provides the opportunity of proof of concept for a multi-category implementation of EPR in the United States.[28] However, expanding product scope also brings operational challenges and has the potential to exacerbate complications in achieving a fair cost allocation and strong design incentives in a collective implementation, as different products have different characteristics. In particular, it can be expected that cost allocations that are only based on product weight (e.g., those determined by a combination of return share and market share) will not be able to capture the full complexity of a multi-category system and reconcile the different perspectives of many more manufacturers involved.

Independent Plans

In the long term, the program should be able to handle the coexistence of independent plans along with the currently operational standard plan. Achieving this requires an unambiguous definition of program rules regarding the individual responsibility of each plan, especially when multiple plans share collection, transportation, and processing capacities. When independent plans become operational, they may bring in additional capacities that are located out-of-state and may be more efficient. This raises the question of how to control, harmonize, and utilize these capacities to achieve a higher operational efficiency of the entire system, while still promoting local economic development. We also note that such an integration and harmonization issue has long been a major concern in the European Union (EU) because of the need to coordinate the legislation in different countries.[29] A similar problem has already emerged in the United States at the state level and can be expected to become a significant challenge to effective EPR implementation that calls for a national solution (Nash and Bosso 2011).

Downstream Material Flows

One of the implicit objectives of e-waste legislation is to avoid e-waste exports to undesirable parties. However, products are not fully recycled at the processors and there are many more steps in the entire product recovery process beyond the current scope of such programs. In particular, most parts and materials obtained at processors are sent to downstream brokers, vendors, or recyclers for further processing. The Washington program specifies "preferred standards" under which direct processors are expected to do some due diligence regarding the downstream vendors they ship to. However, tracing all e-waste to its ultimate destination would be onerous if not impossible at a processor or even an Ecology level. The piecemeal nature of e-waste laws in the United States makes this even more difficult. Hence it is impossible to know the ultimate destination and usage of the e-waste, which is a serious problem, as it can defeat the environmental goal of an EPR program. In particular, at present, toxic trade into developing countries is still a prominent issue in the downstream recycling business, despite various influential anti-toxic-trade campaigns worldwide.[30] At the state level, it is not clear that much more can be done than Washington's preferred standards, except to reinforce the processor certification requirement and establish even stronger reporting and audit systems. Clearly, federal e-waste legislation can help close within-country loopholes. Absent this, building a national clearing house for data on material exports by the largest recyclers can be an effective information-based tool. In addition, specifying the level of post-disassembly material separation and processing can be effective because some of the greatest abuses occur when nonworking whole units are exported.

Towards Effective and Efficient Extended Producer Responsibility Implementation

Fair Cost Allocation and Collective Efficiency

It is crucial to find a way to settle potential fairness concerns among manufacturers regarding their fair cost shares within the standard plan or any independent plan, otherwise the long-term viability of any plan will be at risk. The current weighting method between return share and market share does not seem to be effective and may not necessarily reflect the fair cost shares of individual manufacturers. Hence finding new approaches for fair cost sharing remains one of the most (if not the most) critical challenges of collective e-waste systems. One possible approach is by Gui and colleagues (2012), who study this issue and propose adjustments to the return share method by compensating manufacturers for bringing in additional capacities based on rates that reflect the operational efficiency of these capacities, adjusting the return share of manufacturers to reflect the use of critical resources to process their products, and using a cost-weighted return share to reward manufacturers for having products with low processing costs and/or high recycling revenues. The authors provide theoretical and empirical analysis that indicates that these adjustments can be effective in better reflecting the differentials in cost burden among manufacturers in the standard plan and thus improve the fairness of the allocation. Another approach is by Mayers and colleagues (2012), which proposes a novel cost allocation mechanism considering the requirements of the WEEE directive regarding future and historical waste electrical and electronic equipment. It should be noted, however, that the feasibility of these approaches would significantly depend on the support of producers in the state, who may have varying preferences.

Local Economic Development

Maintaining the balance between program efficiency and local resource utilization has been a consideration from the earliest stages of the EPR debate in Washington. Local governments and businesses regard e-waste programs as an opportunity to bolster the local economy by creating jobs. Yet focusing on local processing may forego the use of state-of-the-art recycling technologies and the economies-of-scale advantage of large-scale processing systems. The embedded trade-offs between local economic development and cost efficiency remains an open question to be investigated for a well-balanced choice.

Education and Outreach

Washington drives collection by consumer education, relying on manufacturers, retailers, and local governments to expend effort to do so. Hence it is crucial for the viability of the program to design and implement efficient consumer education campaigns to achieve extensive diffusion of the EPR concepts. It should also be noted that having independent plans in parallel with the standard plan may raise the question of how to coordinate education and advertising efforts among different plans to achieve optimal results.

Volume Uncertainty

There was (and still is) a lot of uncertainty about how much e-waste would be collected under the program. Given the amount of unused electronics that are expected to have accumulated in households (if not small businesses), and the diffusion dynamics of information about the program, it can be expected that collection will initially mostly consist of old electronics, will peak as information diffuses throughout the state population, and will settle to a steady-state tracking the disposal of recently purchased electronics. It is necessary to understand the implication of such a trend for the operations in the existing collection and recycling system and to design implementation strategies accordingly. Meanwhile, it is also important to develop forecast mechanisms for the specific changes in the demand volume and distribution over the region.

Long-Term Contracts

A barrier to recycling technology investment by processors is the noncontractual nature of the relationship between the Authority and recyclers. To overcome this, a first step would be to evaluate what type of long-term contract (if any) would be most effective at both maintaining a competitive environment and incentivizing investment under collection volume and mix uncertainty.

Conclusion

From its few-sentence principles to a statewide program consisting of thousands of entities and influencing millions, EPR implementation is a complex process. During this process, multiple dimensions of environment, economics, politics, and operations come into play, and the differences among them create challenges in achieving an efficient balancing of environmental and economic trade-offs. Moreover, the exponential growth of the number of stakeholders involved poses additional challenges to coordinate and reconcile different individual agendas. In this article we provide a comprehensive and in-depth discussion of these issues. Using a case study of the E-Cycle program in Washington, we analyze the stakeholder roles in EPR implementation, highlight some of the differences among stakeholder perspectives and policy objectives, and explain how balancing these trade-offs shapes current collection and recycling practices. These findings shed light on the intrinsic complexity of effective EPR implementation, and point to directions and/or possible solutions to them, as summarized in the section *Looking Forward: Challenges and Opportunities*.

Our analysis uncovers a strong relationship between some of the issues identified and the characteristics of the electronics industry. In fact, we find that the electronics industry combines some features that complicate the development of a comprehensive and efficient EPR system. We summarize these features as follows. First, due to the rapid technological obsolescence of electronics, many products are still in working condition when they are replaced. This creates a need for multiple forms of product recovery to extract the most value out of post-use products,

including reuse, refurbishing, and different levels of recycling. This not only complicates the operations of an EPR system, but also leads to more stakeholders with different perspectives being involved. Second, the potential residual value, combined with the toxicity of the product, creates export concerns that are difficult to manage within the scope of EPR legislation. Third, there is high product heterogeneity even within a small range of electronics. For example, TVs and computers are very different in terms of weight, recovery cost/revenue, market share evolution, and so forth. Hence weight-based cost allocation purely based on market or return share may not be sufficient to reflect the true cost burden of each producer, and designing fair cost allocation mechanisms becomes a challenge. Fourth, different manufacturers have made different levels of progress with respect to engaging in product recovery. Some had years of experience before the E-Cycle program was launched and had established mature infrastructures of their own, while some were new to the EPR concept. This contributes to different attitudes toward the state legislation, and brings about the provision that allows the establishment of independent plans. Some of these features are specific to electronics and will not carry over to other product categories. For example, few of the products for which EPR legislation is diffusing in the United States (mercury lights, carpets, packaging, paint, and pharmaceuticals) lend themselves to reuse or refurbishing. At the same time, the heterogeneity in manufacturer perspectives as well as some of the other fundamental tensions discussed herein are expected to persist.

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Notes

1. Conceptually, EPR assigns end-of-life costs to producers, so if toxicity is regulated and affects end-of-life management, then EPR incentivizes toxicity reduction.
2. The exceptions are California (CA) and Utah (UT). California collects an advance recycling fee from consumers at the time of purchase, which is then used to finance a state-run collection and recycling program. For some, this is not considered to be an EPR model, as it is implemented by the state government rather than a stewardship organization. The Utah bill only mandates education on recycling by manufacturers (Electronics Take-Back Coalition 2011).
3. "Any person in business who, irrespective of the selling technique used, including by means of distance or remote sale: (a) manufactures a covered electronic product under a brand it owns or is licensed to use for sale in or into the state; (b) assembles a covered electronic product that uses parts manufactured by others for sale in or into the state under the assembler's brand names; (c) resells under a brand it owns or is licensed to use a covered electronic product produced by other suppliers, including retail establishments that sell covered electronic products under brands they own or are licensed to use; (d) manufactures a co-branded product for sale in or into the state that carries the name of both the manufacturer and a retailer; (e) imports a covered electronic product into the United States that is sold in the state; and (f) sells at retail a covered electronic product acquired from an importer that is the manufacturer as described in (e), and elects to register in lieu of the importer as the manufacturer for those products" (Washington State Senate 2006, pp. 3–4).
4. "Entities licensed to do business in the state that gathers unwanted covered electronic products from households, small businesses, school districts, small governments, and charities for the purpose of recycling and meets minimum standards that may be developed by the department" (Washington State Senate 2006, p. 2).
5. "Entities that transport covered electronic products from collection sites or services to processors or other locations for the purpose of recycling" (Washington State Senate 2006, p. 6).
6. "Entities that disassemble, dismantle, or shred electronic products to recover materials contained in the electronic products and preparing those materials for reclaiming or reuse in new products" (Washington State Senate 2006, p. 5).
7. www.ecy.wa.gov/programs/swfa/eproductrecycle/returnShare.html.
8. "Return share is the proportion of a manufacturer's share (by weight) of the total e-waste volume returned" (www.ecy.wa.gov/programs/swfa/eproductrecycle/manufacturer.html).
9. Market share is the proportion of a manufacturer's sales volume of the total CEP sales within a time period.
10. www.ecy.wa.gov/biblio/0707042.html
11. Transportation using empty trucking capacity, typically on the return leg associated with a shipment by a transporter.
12. In practical terms, the minimum standard is what the state originally believed it could legally enforce. The preferred standard, however, was developed to go further, and is a voluntary choice of the plans, which has been adopted by WMMFA.
13. www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/2009AnnualReportfromWMMFA.pdf.
14. One pound (lb) ≈ 0.4536 kilograms (kg, SI).
15. www.productstewardship.net/PDFs/productsElectronicsEcycleWAORReport.pdf.
16. www.wmmfa.net/.
17. www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/2011AnnualReportfromWMMFA.pdf.
18. www.ecy.wa.gov/about.html.
19. The authors witnessed a 187 lb TV being weighed during a return share sampling event in May 2011.
20. www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/2010TotalCEPPoundsWA.pdf. The percentage has increased to 68.8% in 2011 through October (www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/Collections.pdf).
21. See work by Atasu and Subramanian (2012) and Gui and colleagues (2012) for detailed discussions on the free-riding issue.
22. See the governor's message at the end of the Washington legislation urging the evaluation of the use of product toxicity in determining equitable cost shares.

23. With the exception that reused products are not counted in calculating producers' return share, implying a lower share of the total cost to manufacturers.
24. www.ecy.wa.gov/programs/swfa/eproductrecycle/.
25. CRT glass recycling capacity is globally limited and processors have no guarantee that CRT glass recycling capacity will be sufficient to cover the near-future demand. One of the better options appears to be a recycling facility in Mexico that sells leaded glass to India, the only country where CRTs are still being produced. URT has an in-house high-tech glass recycling capability, but is not currently part of the standard plan in Washington.
26. A variety of prices can be quoted to the Authority, including those for only processing, for transport and processing, or for collection, transport, and processing, depending on whether the processor is also registered as a collector and/or a transporter as well.
27. A total of 291 collection sites were registered in Washington in 2010 (www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/2010AnnualReportfromWMMFA.pdf) and 295 were registered in 2011 (www.ecy.wa.gov/programs/swfa/eproductrecycle/docs/2011AnnualReportfromWMMFA.pdf).
28. The WEEE implementation in the EU includes many other categories of electronics.
29. See www.insead.edu/weee.
30. See www.ban.org.

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