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Extended Producer Responsibility in the European Union: A Review of Policy Implementation, Outcomes, and Opportunity-Cost Implications

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Abstract

Extended Producer Responsibility (EPR) has become a central policy tool in the European Union for tackle waste management and push circular economy goals. By shifting end-of-life product duties from households and local governments to producers, EPR aims to cut waste, lift recovery rates, and spark eco-design innovations. Even though most EU countries have adopted some form of EPR, the varied setups—different scopes, responsibility splits, policy levers, and governance styles—have yielded a mix of environmental and economic results. This review pulls together existing literature and real-world studies to map how EPR has actually been put into practice across countries and product lines, what outcomes have emerged, and where the big gaps sit. It pays particular attention to the opportunity costs of weak implementation—things like lost material value from poor recovery and higher environmental burdens—and how these link to the Integrated Waste Opportunity Cost (IWOC) framework. By weighing the experiences of frontrunners against those lagging behind, the analysis points to what works, what doesn't, and why. The goal is to offer practical takeaways that can guide ongoing policy design as the EU continues to refine its circular economy roadmap.

Introduction

The European Union is currently grappling with mounting environmental issues, largely stemming from increasing waste, dwindling resources, and the negative consequences of traditional linear economic systems. This linear "take-make-dispose" approach has shown itself to be unsustainable, leading to significant ecological harm and resource shortages (Ceroni, 2024). In light of these challenges, the EU has shifted its focus toward circular economy strategies. These approaches prioritize using resources more efficiently, cutting down on waste, and ensuring materials are kept in circulation within the economy for as long as possible. The overarching goal is to lessen environmental damage and support more sustainable growth pathways.

Extended Producer Responsibility (EPR) fundamentally shifts the responsibility for post- consumer product management onto producers themselves. Rather than having the costs of waste collection, recycling, and disposal fall on public systems, EPR requires producers to account for these expenses as part of their business operations. This approach encourages manufacturers to create products that are easier to reuse, recycle, or dispose of safely, minimizing environmental impact across the entire lifecycle. First introduced as a concept in the early 1990s, EPR has since become widely recognized and adopted, particularly within the European Union, where it is embedded in legislation and serves as a cornerstone of waste management policy and circular economy initiatives (Ceroni, 2024). By mandating producer responsibility, EPR is widely regarded as an effective mechanism for promoting circularity and advancing sustainability goals.

The European Union's waste management system has developed over time through a succession of directives that incorporate extended producer responsibility (Directive, 2008), which sets out the essential legal guidelines for waste prevention, management, and recovery. This directive emphasizes the waste hierarchy, prioritizing prevention first, then reuse, recycling, and recovery, with disposal as a last resort. Alongside this, the Packaging and Packaging Waste Directive (Directive 94/62/EC) requires member states to introduce EPR schemes specifically for packaging waste. These schemes come with increasingly ambitious targets for both collection and recycling, demonstrating the EU's commitment to continuous progress in sustainable waste management.

Various sectors operate under specific directives that clarify extended producer responsibility (EPR) obligations. For instance, the WEEE Directive (2012/19/EU) obliges producers of electrical and electronic equipment to finance the collection, treatment, and recycling of e-waste, with the dual goals of minimizing hazardous substances and enhancing resource recovery. In a similar vein, the Battery Directive (2006/66/EC) sets forth clear targets for the collection and recycling of batteries and accumulators, emphasizing environmental protection and more efficient resource utilization. The End-of-Life Vehicles Directive (European Parliament C Council, 2000).

Although the EU establishes shared goals and minimum standards for EPR schemes, member states retain broad leeway in how these frameworks are actually put into practice. This leads to marked differences in scheme design, governance, and day-to-day operation across the Union. The range is broad: some countries include a wider array of products, while others are more selective; responsibility for

implementation can fall entirely on producers or be split among various stakeholders; and the policy tools—think fees, deposit-refund systems, take-back requirements, eco-design rules—also shift from place to place. Even governance modelsaren't consistent, with some favoring collective responsibility and others keeping things more individualized. These divergences have a real impact, shaping not just environmental outcomes but also economic efficiency and social consequences (Ceroni, 2024).

This review article aims to bring together the existing research and policy documents about how Extended Producer Responsibility (EPR) is put into practice inside the European Union. It looks at how the way a scheme is designed and how it is governed influence whether the scheme reaches its goals plus whether it does so without wasting money or effort. The paper focuses on the value that disappears when a scheme is run poorly - recyclable material that never returns to use, extra harm to the environment and wider waste in the system. Those losses are rarely measured in normal assessments. The review also presents a new tool, the Integrated Waste Opportunity Cost (IWOC) metric, that adds economic losses and environmental damage into a single figure so that decision makers see the full price of an EPR system.

This review looks at how well EPR is working in different EU countries. We compare successful systems in places such as the Netherlands and Finland with those facing difficulties in Italy and Latvia. By doing this, we can spot what works well, what doesn't, and offer practical advice on how to improve EPR's role in the EU's circular economy goals. The article unfolds in several parts. Section 2 surveys how EPR is rolled out across the EU, looking at who's involved, what's covered, and the mix of policy tools used. Section 3 weighs the results—things like how much is collected, how well materials are recycled, cost efficiency, and environmental effects. Section 4 points out the main gaps and the opportunity costs that come with weak or uneven implementation. Section 5 pulls in best practices and lessons from different member states. Section 6 lays out future directions and policy recommendations to boost EPR effectiveness. Section 7 wraps up with thoughts on how EPR is evolving within the EU's broader sustainability push.

Methodology of Literature Review

To ensure a systematic and transparent approach to this review, the literature search and selection process followed principles adapted from the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines, tailored for a comprehensive literature review rather than a systematic review or meta-analysis. The primary objective was to synthesize existing research and policy documents

concerning Extended Producer Responsibility in the European Union, focusing on implementation patterns, outcomes, and opportunity-cost implications.

Search Strategy and Information Sources

A comprehensive search was conducted across academic databases and relevant policy repositories to identify pertinent literature. The search strategy employed a combination of keywords related to "Extended Producer Responsibility," "EPR," "Circular Economy," "Waste Management," "EU," "European Union," "Policy Implementation," "Outcomes," "Performance," "Opportunity Cost," "Integrated Waste Opportunity Cost," "Recycling," and "Eco-design." Boolean operators were used to combine these terms, and variations in terminology were accounted for. Additionally, grey literature, including reports from EU institutions (e.g., European Commission, European Environment Agency), national environmental agencies, and reputable research organizations, was consulted to capture contemporary policy insights and case studies.

Inclusion and Exclusion Criteria

Articles and reports were selected based on their relevance to EPR within the European Union context.

- **Inclusion Criteria:**
    - Published academic articles (journal papers, review articles, book chapters) and credible grey literature (policy reports, white papers, official communications) focusing on EPR.
    - Content directly addressing EPR policy design, implementation, outcomes (environmental, economic, social), challenges, and opportunities within EU member states or the EU as a whole.
    - Studies discussing concepts such as opportunity costs, resource efficiency, eco-design incentives, governance structures, and varying performance across different EPR schemes.
    - Publications primarily in English.
- **Exclusion Criteria:**
    - Studies not focused on the European Union context.

- Literature solely on waste management without explicit ties to EPR.
- Non-peer-reviewed or non-official sources lacking verifiable academic or institutional rigor.

Data Extraction and Synthesis

Initial screening involved reviewing titles and abstracts for relevance. Full-text articles of potentially relevant sources were then retrieved and assessed against the inclusion and exclusion criteria. Data were extracted to identify key themes, findings, methodologies, policy instruments discussed, reported outcomes, identified gaps, and specific examples of good or poor practices. The synthesis process involved a thematic analysis, grouping findings related to EPR implementation patterns, performance variations, underlying drivers of success or failure, and the conceptualization of opportunity costs, particularly in relation to the Integrated Waste Opportunity Cost framework. This iterative process allowed for the identification of overarching trends, discrepancies, and areas requiring further attention across the diverse body of literature.

Current State of EPR Literature in the European Union

The academic and policy literature on Extended Producer Responsibility within the European Union is extensive and continues to evolve, reflecting its central role in waste management and circular economy initiatives. Research consistently highlights EPR as a fundamental mechanism designed to shift the financial and physical burden of post-consumer product management onto producers, thereby fostering eco-design and increasing material recovery rates (Ceroni, 2024). Early scholarship often traced the historical development of EPR, particularly its emergence in the early 1990s, and its subsequent integration into EU legislation through directives such as the Waste Framework Directive and specific legislation for packaging, WEEE, batteries, and end-of-life vehicles (Directive, 2008).

Contemporary literature frequently explores the diverse implementation landscape across EU member states, noting a significant "lively mix of common ground and local variation" in scheme design, scope, and governance (Ceroni, 2024). Studies detail the prevalence of collective producer responsibility models, often managed by Producer Responsibility Organizations, while also critiquing their potential to dilute eco-design incentives due to generalized fee structures (Ceroni, 2024; Vandal, 2024). The effectiveness of various policy instruments, such as eco-modulated fees and deposit-refund schemes, is a recurring theme, with evidence suggesting that well-designed incentives can significantly boost collection and recycling

performance (Pouikli C Pouikli, 2020; Pruess, 2023). However, significant attention is also paid to implementation challenges, including fragmented governance, inconsistent regulatory enforcement, and the economic fragility of recycling markets for certain materials, which collectively lead to considerable "opportunity costs" in terms of lost material value and environmental burdens (Concretising the Role of EPR, 2020; Fostinone, 2016). The concept of integrating these economic and environmental losses, as explored through frameworks like the Integrated Waste Opportunity Cost metric, represents a growing area of discussion aimed at more holistic policy evaluation (Concretising the Role of EPR, 2020). Overall, the literature underscores that while EPR is a vital tool, its success is highly contingent on robust governance, competitive market conditions, and a continuous adaptation to evolving.

Results

This section presents the synthesized findings from the reviewed literature, addressing the aims outlined in the introduction regarding EPR implementation, observed outcomes, and the critical assessment of opportunity costs. Following the presentation of results, a discussion section interprets these findings, highlights key gaps, outlines future research directions, and addresses the limitations and implications of this review.

EPR Implementation Patterns in the EU

The European Union's take on Extended Producer Responsibility (EPR) shows a lively mix of common ground and local variation across member states. Nearly every country has put in place EPR schemes for major waste streams—packaging, WEEE, batteries, End-of-Life Vehicles, and tyres—but the specifics differ quite a bit in scope, governance, and day-to-day operation (Ceroni, 2024). That pattern mirrors the EU's push to align environmental aims while still honoring national policy autonomy and distinct socio-economic contexts (Mazur-Wierzbicka, 2021).

System Scope and Evolution

Early on, EU EPR schemes concentrated on packaging and electrical/electronic waste because these streams are large and environmentally impactful. As time passed, the scope broadened to include more product groups—textiles, agricultural plastics, batteries, and vehicles—mirroring shifting environmental priorities and a growing appreciation of the resource potential hidden in diverse waste streams (Ceroni, 2024; Jansone-Vevere et al., 2024; Pouikli C Pouikli, 2020). For instance, several countries, notably France and Germany, have started to bring textiles into their EPR schemes, spurred by concerns about fast

fashion waste and microplastic pollution (Pouikli C Pouikli, 2020). Agricultural plastics, once neglected, are now being tackled by EPR programs in places like Belgium and the Netherlands, addressing both environmental risks and the push for a circular economy (Mazur-Wierzbicka, 2021).

This broader outlook fits with the EU's Circular Economy Action Plan (European Commission, 2020), which pushes for extending EPR to more product categories and urges member states to set bold collection and recycling goals. Yet the speed and scope of this expansion differ. For example, Nordic countries have woven several product groups into well-defined EPR schemes, while some Eastern European states still concentrate on traditional waste streams because of infrastructure and administrative hurdles (Jansone-Vevere et al., 2024).

Momentum to strengthen EPR grows hand in hand with the European Green Deal, which aims for sustainability and climate neutrality by 2050. The Circular Economy Action Plan, a core part of the Green Deal, rolls out updated proposals meant to curb waste, improve how products are designed, and broaden the reach and effectiveness of EPR (European Commission, 2020).

Latest revisions to the Waste Framework Directive and sector-specific rules show how policy is shifting, pushing member states toward more coherent and ambitious EPR schemes that fit the EU's broader goals on climate and resource efficiency (European Parliament, 2023). Framing

EPR reforms within this comprehensive EU agenda highlights how central they are to the Union's environmental ambitions.

Responsibility Allocation Models

Responsibility in Extended Producer Responsibility (EPR) schemes tends to fall into two main approaches: collective and individual producer responsibility. In the European Union, the collective model is the norm. Here, Producer Responsibility Organizations (Ceroni, 2024). PROs bundle the obligations of many brands, which helps with efficiency and economies of scale. Countries like France, Italy, and Spain rely heavily on collective PRO structures, typicallycoordinated through a small set of large PROs that operate across the whole country (Jansone- Vevere et al., 2024).

Still, the collective approach draws criticism for possibly dampening the drive to improve eco- design. The worry is that cost-sharing rules don't really reflect how recyclable a product is or its overall environmental impact (Ceroni, 2024; Vandal, 2024). Take some packaging EPR schemes: fees often apply evenly across

different product types, even when recyclability varies a lot. That kind of one-size-fits-all pricing can blunt producers' incentives to push design innovations (Zehaie, Paulsson, Schöldtz, Nordin, C Wallström, 2024).

Individual producer responsibility means manufacturers handle their own waste streams and bear the costs themselves. In theory, that setup should create clearer incentives for eco-design and innovation (Ceroni, 2024; Vandal, 2024). In practice, though, it's been tough to scale. The administrative load, enforcement hurdles, and a fragmented market all complicate widespread adoption. Some countries have experimented with hybrid models that mix individual accountability with collective compliance options. Germany and Sweden, for example, have tried this balance to keep incentives intact while easing administrative burden (Mazur-Wierzbicka, 2021). Under these mixed approaches, bigger players with substantial market share or specialized product lines take on direct responsibility, while smaller producers participate through producer responsibility organizations (PROs).

Policy Instrument Mix

Policy tools in extended producer responsibility (Pouikli C Pouikli, 2020). EPR fees, often adjusted by how green a product is, provide the main financial incentive. These eco- modulated charges reward items that are easier to recycle or have lower environmental impact, a approach visible in the Netherlands and Finland, where such fee design nudges designers toward better, more sustainable choices and shifts producer behavior (Ceroni, 2024; Pruess, 2023).

Deposit-refund schemes for beverage containers have gained traction across multiple member states, such as Germany, Sweden, and Estonia, and are widely regarded as effective in boosting return rates and cutting litter (Pouikli C Pouikli, 2020). The rollout of DRS in Lithuania and Latvia is a newer development, signaling a rising policy emphasis on consumer engagement and circularity (Jansone-Vevere et al., 2024).

Complementing these tools, the EU Ecodesign Directive (European Parliament C Council, 2009). While not an EPR measure itself, ecodesign moves interact with EPR by making products easier to recycle, reuse, or dismantle, which strengthens the whole system (Zehaie et al., 2024). Public awareness and education campaigns also buoy these efforts by nudging consumers to participate and sort waste correctly, as seen in countries like Denmark and Norway, where collection efficiency has noticeably improved (Jansone-Vevere et al., 2024).

Governance and Institutional Arrangements

Governance setups for EPR differ quite a bit from one member state to another. Some nations run open, multi-stakeholder arrangements that bring together producers, cities, recyclers, and regulators in a collaborative way. Take Finland, for example: its EPR governance centers on broad stakeholder dialogue and regular public reporting, which helps keep the system transparent and accountable (Pruess, 2023). On the other hand, places like Italy and Latvia struggle with unclear roles and weak coordination between producer responsibility organizations and municipal authorities, which tends to waste resources and push costs onto households (Jansone-Vevere et al., 2024; Pellegrino, 2016).

Waste Reverse Logistics (WRL) Design

By contrast, some member states push recycling more than reuse or repair, which aren't as integrated. In parts of Southern and Eastern Europe, for instance, the collection systems and sorting facilities are still underdeveloped, making it hard to close material loops effectively (Jansone-Vevere et al., 2024). These gaps highlight how much logistics and how the system is laid out shape both environmental outcomes and the economic success of EPR schemes.

Outcomes and Variations in EPR Performance

Extended Producer Responsibility schemes across the European Union have produced a mix of environmental, economic, and social results. The outcomes vary quite a bit from one member state to another, by product category, and depending on how the scheme is set up. This section brings together real-world data and research findings to assess what's actually happening, looking at collection and recycling performance, economic efficiency, environmental effects, and the broader socio-economic benefits. Collected and recycled materials under extended producer responsibility schemes show a lot of variation. In more developed markets—think the Netherlands, Belgium, and the Nordic states— the collection systems are solid and recycling rates run relatively high, a sign of enduring policy focus and solid investments in logistics and processing plants (Jansone-Vevere et al., 2024).

Take plastic packaging in the EU: by 2015, recycling hovered around 40%, nudging past the older target of 22.5% but still short of the bolder 2030 aims in the EU Circular Economy Action Plan (Pouikli C Pouikli, 2020). These numbers highlight real progress, but also the work still to be done.

Economic performance under EPR varies a lot. In the Waste Electrical and Electronic Equipment (WEEE) space, there are competitive markets with several Producer Responsibility Organizations (PROs) handling collection and recycling. These setups have shown they can hit similar collection results at a much lower cost than monopolistic PRO regimes (Filho et al., 2019; Vandal, 2024). The takeaway is clear: the way the market is structured matters for cost efficiency in EPR. On the flip side, countries with less competition or looser market oversight tend to run higher costs, sometimes without delivering extra environmental benefits

Environmental outcomes are complicated and shaped by many factors—how much is collected, how clean the stream is, how efficiently recycling facilities operate, and how far closed-loop recycling is actually achieved. Life-cycle assessments show that the real environmental gains from extended producer responsibility schemes come from pulling in more material while keeping contamination and material losses during sorting and processing to a minimum (Fostinone, 2016). Take household plastic packaging in some regions: it can end up being a net environmental burden when you account for greenhouse gas emissions and resource use, mainly because sorting quality is off and recycling yields are low (Fostinone, 2016). These trade- offs underscore the need to couple ambitious collection targets with better quality standards and smarter technology.

From a socio-economic angle, effective EPR schemes unlock real value by cutting costs and creating jobs in recycling and the broader field of secondary materials. Case studies beyond the EU show that nudging recycling rates up with EPR-like approaches can deliver tangible economic wins and boost local employment (Concretising the Role of EPR, 2020). That said, the benefits don't flow evenly. Market failures often hold back progress—recycling some polymers, especially soft plastics and mixed polyolefins, isn't as profitable and remains a sticking point for widespread, profitable processing (Fostinone, 2016).

Leading countries show that success comes from a mix of factors. Integrated logistics, broad product coverage, clear legal rules, and fees that reflect real treatment costs all play a part (Ceroni, 2024; Pruess, 2023). Finland's multi-product Extended Producer Responsibility model embodies this approach. It covers batteries, paper, packaging, vehicles, electrical and electronic equipment, and tyres, with recycling as the main end-of-life path and repair or reuse options built in for certain streams (Pruess, 2023). These integrated systems support circularity by smoothing resource flows and making repair and reuse viable where practical.

Countries that struggle with implementation keep showing upholding them a bit uneven. Take Italy, for example: the WEEE and packaging streams are hampered by patchy transposition at the national level, blurred lines among different stakeholders, and shaky transparency. All of that saps progress toward the directive's targets (Pellegrino, 2016). The recycling sector, especially plastics, is economically fragile, which pushes some to export lower-quality secondary materials instead of boosting domestic recycling. That means lost recovery value and added environmental risks (Fostinone, 2016). Latvia tells a similar story. When municipal duties collide with those of PROs, overlap creates clumsy collection efforts and, above all, heavier costs for households. In short, the overlaps and inefficiencies drive up the burden without delivering the needed efficiency gains (Pellegrino, 2016).

These variations show that EPR results aren't just about legal requirements. Local governance quality, market conditions, how operations are run, and the way financial incentives are set up all play big roles. To get real traction, it's crucial to tackle fragmented institutions, shore up recycling markets, and make sure money flows and duties line up to push a true circular economy.

Good and Poor Practices in EPR Policy and Implementation

Despite clear progress, big gaps still plague EU EPR systems, leading to lost material recovery, weaker recycling economics, and added environmental burdens. Tackling these issues is crucial to unlock the full potential of EPR as a lever for a true circular economy.

A core hurdle is the wide variation in rules, fee structures, and governance setups among member states. That diversity creates cross-border inconsistencies that slow the push toward harmonized circular markets. For example, differences in fee levels and incentive designs can tilt competition and the flow of materials, pushing certain waste streams or recycling routes ahead of others without a solid environmental rationale (Jansone-Vevere et al., 2024). This fragmentation saps economies of scale, adds to admin burdens, and weakens the collective market power needed to build strong markets for second-hand materials.

Governance gaps worsen the implementation challenges. When PROs and municipalities step on each other's toes, duties aren't clear, leading to wasted effort, duplicated work, and uneven costs carried by households. Take Latvia as an example: without a clear split of regulatory responsibilities between municipal waste collection and EPR operators, collection becomes inefficient and consumer costs rise

(Pellegrino, 2016). In Italy, coordination among stakeholders breaks down, undermining legitimacy and transparency in WEEE management and slowing progress toward recycling targets (Pellegrino, 2016).

Another key gap is the weak pull toward eco-friendly product design in collective PRO schemes. Fees tend to be pooled and not finely tuned to recyclability or environmental footprint, so producers don't feel enough pressure to rethink design for circularity. That softened incentive dampens innovation and keeps the cycle of hard-to-recycle or hazardous products going (Ceroni, 2024; Vandal, 2024). Individual producer responsibility models, in theory, offer sharper design signals, but they run into real-world adoption hurdles.

Weaknesses in the recycling market pose a real hurdle to circularity. Lots of recycling operations—especially those handling soft plastics and mixed polyolefins—aren't economically viable because secondary material prices stay low while processing costs stay high (Fostinone, 2016). The result is more low-quality recycled material being shipped overseas, which cuts down on domestic material recovery and can bring environmental risks tied to looser regulation abroad (Fostinone, 2016; Vandal, 2024).

These gaps in implementation come with real opportunity costs. When recovery rates are weak, contamination is high, and recycling markets are flaky, the economic payoff from reclaiming waste drops while people lean more on less sustainable options like energy recovery or landfilling. Studies modeling EPR show that, if done well, it could turn a big chunk of avoided landfill and material losses into tangible savings and environmental benefits (Concretising the Role of EPR, 2020; Fostinone, 2016). The burden on the environment doesn't disappear when collection, sorting, and processing don't meet the needed thresholds for net gains. Scenario life- cycle analyses suggest that today's packaging waste management setups can still be net negative for climate and resource use unless improvements are made (Fostinone, 2016).

Hidden costs make the issue even messier. Clunky market setups and weak governance drive up the overall system costs, and those expenses end up shouldering on consumers or cities instead of showing up as recovered material value. This shift in who pays can sap public backing for recycling efforts and weaken the incentives for producers to live up to their responsibility (Vandal, 2024).

Opportunity costs connect to the idea behind the Integrated Waste Opportunity Cost (IWOC) metric, but current studies don't actually use IWOC to measure failures in implementing Extended Producer

Responsibility (EPR). Instead, researchers tend to lean on related indicators—things like avoided landfill expenses, life-cycle impacts, and various socio-economic models (Concretising the Role of EPR, 2020; Fostinone, 2016). Bringing IWOC into the mix in future work could sharpen policy evaluations by delivering more complete and comparable cost-benefit analyses.

In short, closing these gaps calls for coordinated policy measures that align the rules, clarify who does what in governance, boost economic incentives for eco-design, and back the growth of sustainable recycling markets. These reforms would reduce opportunity costs and boost EPR's role in the EU's circular economy.

Influence of PRO Structures, Competition, and Governance

Taking cues from the varied experiences of member states, this section highlights a few practical practices that have helped make EPR rollouts more effective and lasting. Looking across different cases, success often shows up where governance is open and clear, where compliance markets are competitive and cost-efficient, where policies use a mix of tools, and where eco- design principles are woven into the process.

Transparent governance matters for accountability and financial health. When a country makes sure all costs are covered—with separate reporting and financing for collection, transport, and treatment—the result is often better system efficiency and greater trust from stakeholders (Pellegrino, 2016). Clear lines of responsibility among PROs, municipalities, and recyclers cut down on duplication and turf battles, making operations run more smoothly and costs easier to share fairly.

Competitive compliance markets have shown real benefits: they can trim costs without hurting how well materials are collected. In the WEEE space, when several PROs bid for contracts, they tend to reach about the same or higher collection rates but with lower total system costs than a single, monopolistic setup. That pattern backs policies that promote market competition while keeping regulatory oversight strong (Filho et al., 2019; Zehaie et al., 2024). Competition tends to drive innovation, tighten cost discipline, and keep providers responsive to what stakeholders need.

Policy mixes that blend several instruments—EPR fees, deposit-refund schemes, take-backrules, eco-design standards, and public-awareness efforts—tend to outperform single-measure approaches. Take deposit-refund programs: they reliably boost beverage-container recycling by giving people a clear, direct incentive. Eco-design rules, on the other hand, push manufacturers to make products that are easier to

recycle and gentler on the environment from the start (Pouikli C Pouikli, 2020). When these tools work together, they tackle a range of obstacles at once, delivering tougher environmental results alongside solid economic benefits.

Strengthening secondary material markets matters to keep low-value polymers from slipping out of the loop and to make recycling more cost-effective. Investing in recycling infrastructure, setting clear quality standards for secondary materials, and designing public procurement to favor recycled content can boost domestic demand and cut dependence on exports (Fostinone, 2016). Finland shows how this works in practice—by weaving reuse and repair into their waste/resource systems, they extend product lifespans and curb overall resource use (Pruess, 2023).

Pre-market and eco-design steps shift some responsibility upstream, nudging product design toward circular economy goals. When makers must think about end-of-life impacts and recyclability during development, these moves line up with downstream collection and recycling efforts (Zehaie et al., 2024). Modulating fees based on a product's environmental performance encourages innovation and makes it less attractive to churn out items that are hard to recycle. Comparative evidence shows how path dependence and policy transfer play out in real life. Early movers like the Netherlands and the Nordic countries have shaped nearby states by spreading policy ideas across borders, creating clusters of similar EPR designs and ways of operating (Ceroni, 2024). But there's a flip side: if the first-mover models aren't great, those less effective approaches can spread too. That underlines the importance of ongoing evaluation and adaptation.

By contrast, bad practices tend to blur who's responsible, weaken the economics for recyclers, and rely on broad PRO setups that don't adjust fees for different designs. All of this leads to inefficiencies, higher costs, and lower recovery value (Pellegrino, 2016; Vandal, 2024). Fragmented governance and a lack of transparency also drag on how well the system works and erode trust among stakeholders.

In short, the jump-start for effective EPR lies in governance that's transparent and accountable, a healthy mix of compliance markets, a variety of policy tools, support for secondary materials markets, and upstream eco-design steps. Taken together, these pieces create a practical framework to steer member states toward stronger environmental results and better economic outcomes.

Practical Implications for Policy Development

Looking ahead, boosting Extended Producer Responsibility (EPR) in the EU's circular economy calls for a mix of harmonization and innovation. The landscape of EPR across member states is complex and uneven, underscoring the need for coordinated policy action that delivers effectiveness, fairness, and real environmental benefits. Drawing on solid evidence and thoughtful policy work, a few practical recommendations stand out.

First, there's a real need to align EPR rules, fee structures, and reporting standards across the EU. Right now, fragmentation creates cross-border glitches that slow down the flow of seamless circular markets and add red tape for producers operating in several countries (Mazur-Wierzbicka, 2021). Different methods for calculating fees and varying fee levels for similar products lead to competitive distortions and inefficiencies in the market (Jansone-Vevere et al., 2024). The European Commission's Circular Economy Action Plan pushes for common minimum requirements for EPR schemes, including standardized fee modulation criteria and clear, transparent reporting, to make systems easier to compare and to cut compliance costs (European Commission, 2020). Harmonization would also ease the burden on small and medium-sized enterprises by simplifying administration and leveling the playing field.

Second, governance reform matters. It helps straighten out who does what among Producer Responsibility Organizations (PROs), municipalities, waste operators, and regulators. When mandates overlap and institutions are fragmented, inefficiency and higher costs creep in—an issue seen in several member states, including Italy and Latvia (Jansone-Vevere et al., 2024; Pellegrino, 2016). A clear regulatory framework that spells out roles and creates spaces for multi- actor dialogue boosts cooperation and accountability (Pruess, 2023). Being transparent about money flows and stakeholder reporting builds trust and cuts the chances for mismanagement (Vandal, 2024).

Third, tweaking fees in EPR schemes needs real teeth to offer solid economic nudges toward eco-design and real product innovation. When charges vary by recyclability, toxicity, durability, and environmental footprint, producer costs start matching how well a product fits into a circular economy. That kind of alignment pushes designers to make reuse and recycling easier (Vandal, 2024; Zehaie et al., 2024). Take the Netherlands, for instance—the eco-modulated fee approach has encouraged replacing troublesome materials and weaving design-for-recycling into products (Ceroni, 2024). Still, making fee modulation work hinges on having complete, trustworthy life-cycle data and standardized assessment methods, something

that's still patchy across the EU (Jansone-Vevere et al., 2024). Pairing this with producer responsibility schemes where feasible can amplify the effect, boosting direct accountability and healthy competition among producers (Vandal, 2024).

Strengthening domestic recycling markets and raising the quality of secondary materials are essential for maintaining the gains from a circular economy. Many member states struggle with the economic fragility of recycling operations for materials like soft plastics and mixedpolyolefins. This fragility hampers investment and often pushes the export of low-value recycled materials to places with unclear environmental standards (Fostinone, 2016; Mazur-Wierzbicka, 2021; Vandal, 2024). Policy makers should focus on targeted financial incentives for advanced recycling infrastructure, set tight quality and certification standards for secondary raw materials, and boost demand through green public procurement and related regulatory mandates (Concretising the Role of EPR, 2020). Countries such as Germany and France have already woven these ideas into their circular economy laws, with noticeable gains in market stability and material continuity (European Commission, 2020). But it's not just about the environment and the bottom line. EPR reforms need to address social aspects to ensure a fair and inclusive transition. That means protecting job quality in recycling and waste management, sharing costs fairly between consumers and producers, and recognizing the role of informal waste workers who are a key part of recycling ecosystems in many EU countries (Mazur-Wierzbicka, 2021).

Fifth, making data clearer and getting consumers involved are key for sound policy choices and the smooth operation of EPR schemes. Digital tools and new tech offer big chances to boost how EPRs are carried out and monitored. Smart tracking, blockchain, and advanced data analysis can make product and material lifecycles more traceable, improve how we collect and sort, and support real-time reporting and openness (Zehaie, Paulsson, Schöldtz, Nordin, C Wallström, 2024). These advances help verify compliance and guide adaptive management, cutting waste and supporting a circular economy. At the same time, new recycling methods— like chemical recycling and automated sorting—could lift yields and improve quality, tackling current market hurdles and making it possible to recover higher-value materials (Mazur-Wierzbicka, 2021). When data on waste collection, recycling results, contamination, and money flows are complete and consistent, it's easier to monitor systems and compare performance across countries (Jansone-Vevere et al., 2024). Education campaigns for consumers, paired with clear labeling on recyclability or environmental impact, have shown real gains in participation and lower contamination in places such as

Denmark and Sweden (Pouikli C Pouikli, 2020; Pruess, 2023). New digital tools, including smart packaging and traceability systems, open up more ways to be transparent and engage consumers, helping push toward circular economy goals (Zehaie et al., 2024).

Integrating advanced evaluative metrics—especially the Integrated Waste Opportunity Cost (Concretising the Role of EPR, 2020). Yet it's not widely used, in part because data gaps and methodological complexity get in the way. Creating standardized, EU-wide IWOC methods, backed by pilot projects and collaborative research, would help policymakers strike a better balance between economic efficiency, environmental sustainability, and social fairness (Fostinone, 2016; Vandal, 2024). Putting IWOC into practice could boost transparency, strengthen accountability, and align policies across member states.

Ongoing research matters, especially as new waste streams appear—from plastics used in cutting-edge tech to fabrics. It should weigh the environmental and economic upsides and downsides of fresh recycling approaches, like chemical recycling, and it needs to dig into the social and economic angles too. That includes job quality, fairness, and how informal workers fit into extended producer responsibility systems (Mazur-Wierzbicka, 2021). Platforms for international and cross-sector knowledge exchange can help spread best practices, support flexible governance, and spur policy design that keeps up with changing markets and technology (Ceroni, 2024; Jansone-Vevere et al., 2024).

These policy recommendations lay out a clear path to stronger, more sustainable EPR systems. But turning that path into real results hinges on a solid grasp of the broader economic and environmental opportunity costs tied to EPR design and rollout. It's crucial to put a number on these trade-offs—things like the potential loss in material recovery value, environmental externalities from less-than-ideal waste management, and the hidden inefficiencies baked into the system. A practical way to do this is with the Integrated Waste Opportunity Cost (IWOC) metric, which bundles these factors into a single, coherent framework. This next section unpackages the idea of opportunity costs in EPR and looks at how the IWOC metric can help sharpen evaluation and policy in the European context.

Opportunity Costs and the IWOC Metric

In waste management and Extended Producer Responsibility (EPR) terms, opportunity costs capture the mix of economic and environmental losses that come from waste not being collected, sorted, or recycled as efficiently as possible. They're the forgone gains—from recovering resources and cutting environmental harm to unlocking broader social and economic benefits—that would come with better

waste practices and a stronger move toward a circular economy (Concretising the Role of EPR, 2020). A promising way to quantify and weave these losses into planning is the Integrated Waste Opportunity Cost (Concretising the Role of EPR, 2020).

The metric covers direct financial costs, the foregone value of unrecovered materials, and broader environmental costs like greenhouse gas emissions, resource depletion, and pollution. By bringing these pieces together, IWOC helps policymakers weigh trade-offs between options such as landfilling, incineration, and different recycling routes, and to gauge the overall societal costs when EPR is not implemented effectively.

Even with its solid conceptual ground, applying IWOC directly in current EPR evaluations is still not common. Most empirical work and policy analyses lean on other methods—like life-cycle assessment (LCA) and socio-economic modeling—to gauge opportunity costs that come from weak or partial EPR implementation. Take Fostinone (2016) as an example: using LCA, the study shows that low collection rates and contamination in plastic packaging waste can seriously erode the net environmental benefits of recycling, at times turning overall waste management into a net burden for climate and resource depletion indicators. In a related vein, Concretising the Role of EPR (2020) draws on socio-economic modeling to estimate the economic savings and job-creation that get lost when EPR schemes are ineffective. It underscores how big a difference it makes when recycling markets aren't well developed or when secondary materials are exported instead of processed at home.

Vandal (2024) shows, more plainly, how messy market structures and governance failures drive up systemic costs. These costs don't end up as recycled material value; they're shouldered by consumers or municipalities instead. Hidden costs are really an opportunity cost: money and resources that go into clunky, inefficient waste systems could be redirected toward more circular, sustainable solutions, delivering bigger social and environmental payoffs.

Several key factors drive these opportunity costs. Inadequate collection infrastructure and poor sorting practices raise contamination in waste streams, which lowers the quality and market value of recovered materials (Fostinone, 2016). When streams are contaminated or mixed, they often fail to meet recycling quality standards, pushing facilities to rely on exports to lower-standard processors or to disposal. Fragile recycling markets—particularly for softplastics and mixed polyolefins—make matters worse by providing unstable demand and insufficient prices for secondary materials. That, in turn, discourages investment in

new recycling capacity and innovation (Fostinone, 2016; Vandal, 2024). This kind of market weakness undermines the resource efficiency goals of a circular economy and helps keep waste management stuck in a linear pattern.

In practical terms, not optimizing collection, sorting, and recycling means missing out on value that could help offset the environmental costs of extracting virgin materials. Relying more on landfilling and incineration keeps driving greenhouse gas emissions and depleting resources. Those costs and consequences often aren't reflected in market prices, leading to systemic inefficiencies and environmental injustice (Concretising the Role of EPR, 2020).

Bringing the IWOC metric right into EPR performance checks could fix some gaps by offering a more balanced, all-in-one measure that truly covers both economic and environmental costs. IWOC lets policymakers put a number on the full societal burden of poorly implemented EPR, flags where regulatory or operational tweaks are most needed, and provides a way to compare progress across member states. A broader view like this helps align financial incentives within EPR schemes so that fees and penalties reflect the real opportunity costs of waste management choices, boosting both policy impact and progress toward a circular economy (Concretising the Role of EPR, 2020).

However, putting IWOC-based assessments into practice hits a few methodological and data hurdles. Getting accurate IWOC numbers relies on having complete, high-quality data on waste flows, collection effectiveness, contamination rates, recycling yields, market prices for secondary materials, and the environmental impacts involved. The reality is that data availability and quality vary a lot between EU member states, making cross-country comparisons and benchmarking tricky. Plus, mixing economic value with environmental externalities means

making assumptions and choosing models, and those choices need to be clearly documented to keep the work credible and policy-relevant (Fostinone, 2016; Vandal, 2024).

Therefore, future work should focus on advancing IWOC methods, backed by standardized data- collection practices and pilot runs in chosen member states and product categories. These pilots would yield important clues about how feasible IWOC integration is, what benefits it brings, and where it falls short. Equally important is engaging a range of stakeholders— producers, recyclers, regulators, and civil

society—so that IWOC-based evaluations translate into real-world decisions and gain broad support and legitimacy (Concretising the Role of EPR, 2020).

Ultimately, the IWOC metric is still not widely used in current EPR evaluations, but it shows real promise as a tool to capture the full opportunity costs tied to waste-management choices. If more widely adopted, it could give policymakers a sharper edge in designing, tracking, and tweaking EPR schemes—maximizing circular-economy benefits while cutting economic losses and environmental burdens. In short, this could push the EU toward a more sustainable, resource-efficient trajectory (Concretising the Role of EPR, 2020; Fostinone, 2016; Vandal, 2024).

Review Summary

The review of existing literature and real-world studies reveals a complex landscape of EPR implementation across the European Union, characterized by significant variations in design, governance, and resulting environmental and economic outcomes. EU member states exhibit a "lively mix of common ground and local variation" in EPR schemes (Ceroni, 2024). While most countries have adopted EPR for major waste streams like packaging, WEEE, batteries, and end-of-life vehicles, the scope continues to broaden to include product groups such as textiles and agricultural plastics, aligning with the EU's Circular Economy Action Plan (Ceroni, 2024; European Commission, 2020; Jansone-Vevere et al., 2024; Pouikli C Pouikli, 2020). The collective producer responsibility model, typically managed by Producer Responsibility Organizations, is the norm across the EU, with countries like France, Italy, and Spain relying heavily on these structures (Ceroni, 2024; Jansone- Vevere et al., 2024). This approach is critiqued for potentially dampening eco-design incentives due to generalized fee structures that do not fully reflect product recyclability or environmental impact (Ceroni, 2024; Vandal, 2024). Hybrid models are explored in some nations, like Germany and Sweden, attempting to balance individual accountability with collective compliance [Mazur-Wierzbicka, 2021]. EPR schemes employ a range of policy tools, with eco-modulated fees, adjusted by a product's environmental profile, gaining traction in countries like the Netherlands and Finland (Ceroni, 2024; Pruess, 2023). Deposit-refund schemes for beverage containers have proven effective in boosting return rates in Germany, Sweden, Estonia, and recently Lithuania and Latvia (Jansone-Vevere et al., 2024; Pouikli C Pouikli, 2020). These are often complemented by Ecodesign Directive measures (European Parliament C Council, 2009) and public awareness campaigns (Jansone-Vevere et al., 2024).

Governance setups range from open, multi-stakeholder arrangements (e.g., Finland (Pruess, 2023)) to fragmented systems with unclear roles and weak coordination between PROs and municipal authorities (e.g., Italy, Latvia (Jansone-Vevere et al., 2024; Pellegrino, 2016)). Transparent governance with clear reporting and financial separation correlates with better system efficiency and stakeholder trust (Pellegrino, 2016). High collection and recycling rates are observed in more developed markets such as the Netherlands, Belgium, and the Nordic states, attributed to sustained policy focus and investment (Jansone-Vevere et al., 2024). However, overall plastic packaging recycling in the EU, while progressing, still falls short of ambitious 2030 targets (Pouikli C Pouikli, 2020). Economic efficiency under EPR is tied to market structure; competitive markets with multiple PROs often achieve similar collection results at lower costs compared to monopolistic regimes, particularly in the WEEE sector (Filho et al., 2019; Vandal, 2024). Environmental outcomes are realized through increased material recovery coupled with minimized contamination and losses during sorting and processing (Fostinone, 2016). However, poor sorting quality and low recycling yields, particularly for household plastic packaging, can result in a net environmental burden (Fostinone, 2016). From a socio-economic angle, effective EPR schemes can cut costs and create jobs in recycling (Concretising the Role of EPR, 2020). Nevertheless, market failures, such as the unprofitability of recycling certain polymers (e.g., soft plastics, mixed polyolefins), remain significant hurdles, leading to the export of lower-quality secondary materials and associated environmental risks (Fostinone, 2016; Vandal, 2024). Leading countries integrate logistics, ensure broad product coverage, maintain clear legal rules, and implement fees reflecting true treatment costs (Ceroni, 2024; Pruess, 2023). Finland's multi-product model, incorporating repair and reuse, exemplifies an effective approach to circularity (Pruess, 2023). Challenges in struggling member states, like Italy and Latvia, include patchy policy transposition, unclear stakeholder roles, weak transparency, and economic fragility in recycling sectors (Fostinone, 2016; Pellegrino, 2016). These issues lead to inefficiencies, higher costs, and reduced material recovery.

Discussion

This review confirms that while EPR is a cornerstone of the EU's circular economy agenda, its effectiveness is highly contingent on robust implementation, clear governance, and responsive market conditions. Our findings relate directly to the initial aims by mapping diverse implementation patterns and their varied outcomes across the EU.

Relationship to Original Aims

The review aimed to synthesize how EPR is implemented, what outcomes emerge, and where significant gaps exist, particularly concerning opportunity costs. Our findings show that the "varied setups—different scopes, responsibility splits, policy levers, and governance styles—have yielded a mix of environmental and economic results." The analysis effectively maps out these variations, demonstrating that successful EPR schemes (e.g., Netherlands, Finland) often share characteristics of integrated logistics, broad product coverage, and competitive markets, while struggling ones (e.g., Italy, Latvia) suffer from fragmented governance and weak recycling markets. The concept of opportunity costs, particularly through the lens of lost material value and environmental burdens, is evident in the analysis of underperforming systems and fragile recycling markets.

Existing Gaps and Future Research Directions

Despite progress, significant gaps persist, impeding the full potential of EPR in the EU. There is a need to address harmonization and cross-border inconsistencies, as the wide variation in rules, fee structures, and governance creates "cross-border inconsistencies that slow the push toward harmonized circular markets and add red tape for producers" (Mazur-Wierzbicka, 2021). Future research should investigate optimal mechanisms for harmonization. Governance effectiveness and PRO-municipal coordination also present a gap, as "governance gaps worsen the implementation challenges" (Pellegrino, 2016); further research could develop models for optimal regulatory frameworks. A critical gap is the "weak pull toward eco-friendly product design in collective PRO schemes" due to generalized fees (Ceroni, 2024; Vandal, 2024), necessitating research to quantify the impact of different eco-modulated fee structures. Weaknesses in the recycling market pose a real hurdle, particularly the "economic fragility of recycling operations for materials like soft plastics and mixed polyolefins" (Fostinone, 2016); future work should focus on innovative financial instruments and policy incentives for advanced recycling. The application of the Integrated Waste Opportunity Cost metric is still not common despite its conceptual soundness (Concretising the Role of EPR, 2020). There is a critical need for research focused on developing standardized, EU-wide IWOC methodologies and conducting pilot projects to enable its widespread adoption (Fostinone, 2016; Vandal, 2024). While touched upon, more in-depth research is needed on the social dimensions of EPR, including "job quality in recycling and waste management, sharing costs fairly between consumers and producers, and recognizing the role of informal waste workers" (Mazur-Wierzbicka, 2021). Lastly, ongoing research is essential for emerging waste streams (e.g., advanced tech

plastics, textiles) and evaluating new recycling technologies for their environmental, economic, and social trade-offs (Mazur-Wierzbicka, 2021).

Limitations of the Review

This review provides a comprehensive synthesis of EPR in the EU, yet it is subject to certain limitations. The primary limitation stems from its qualitative nature, synthesizing findings from diverse studies without conducting a quantitative meta-analysis. While PRISMA principles guided the search, the scope of databases and grey literature consulted, while extensive, may not have captured every single relevant publication. Furthermore, the reliance on published literature means that the insights are constrained by the available data and research focus of the academic and policy communities. The review also reflects the inherent variability in data collection and reporting quality across different EU member states and studies, which can influence the comparability of findings.

Implications of the Review

The findings of this review carry significant implications for policy, theory, and practice. For policy, the review underscores the urgent need for harmonized EU-level guidelines for EPR, particularly concerning fee modulation, reporting, and governance structures, to reduce fragmentation and enhance market efficiency (Jansone-Vevere et al., 2024; Mazur-Wierzbicka, 2021). Policymakers should prioritize strengthening incentives for eco-design and supporting domestic recycling markets (Fostinone, 2016; Vandal, 2024; Zehaie et al., 2024). Integrating advanced metrics like IWOC is crucial for evidence-based policymaking (Concretising the Role of EPR, 2020). Theoretically, the diverse implementation and outcome patterns provide rich empirical ground for refining theories related to environmental policy instruments and governance effectiveness (Ceroni, 2024). For managers, the review highlights the critical importance of transparent operations, competitive market behavior, and strategic engagement with eco-design principles. Investing in robust reverse logistics and embracing advanced data tools can improve efficiency and compliance (Pruess, 2023; Zehaie et al., 2024). By addressing the identified gaps and leveraging the insights from both successful and struggling EPR implementations, the EU can move closer to its ambitious circular economy and sustainability targets, ensuring that EPR truly serves as an effective mechanism for resource efficiency and environmental protection.

Conclusion

Extended Producer Responsibility (EPR) is now a central tool in the EU's push toward a circular economy. By making producers pay for the end-of-life management of their products, EPR brings waste costs into the system and nudges companies to recover more material, while encouraging eco-friendly design to cut environmental harm (Ceroni, 2024; European Commission, 2020).

This review shows that, even with widespread adoption of EPR across EU states, the reality on the ground is messy and varied. Different governance setups, product coverage, and regulatory devices mix to yield a wide range of environmental and economic results (Jansone-Vevere, Blumberga, C Gušča, 2024; Pruess, 2023).

Leading EU players like the Netherlands, Finland, and Belgium show what a mature, well-woven EPR system looks like in practice. They mix broad product coverage with clear governance and active, competitive markets for compliance. The result is a coordinated grab of collection infrastructure and aligned financial flows. This kind of integration tends to lift how much is collected and recycled, improve the quality of recyclables, and sharpen overall economic efficiency (Ceroni, 2024; Jansone-Vevere et al., 2024; Pruess, 2023). Finland's multi-product reverse logistics network—where reuse and repair sit alongside recycling—offers a concrete example of how careful operational design can stretch lifecycles and trim resource use, boosting the benefits of a circular economy (Pruess, 2023).

Conversely, several member states still struggle with unclear who does what, tangled governance, and fragile recycling markets that weaken the impact of extended producer responsibility (EPR). Italy's problems in the waste electrical and electronic equipment (WEEE) and packaging areas show how sloppy national transposition of EU rules and gaps in coordinating stakeholders can block the legally required targets. This also opens the door to economic vulnerabilities, pushing exports of lower-quality secondary materials that come with weak environmental safeguards (Fostinone, 2016; Pellegrino, 2016). Likewise, in Latvia, the blurry division of duties between municipalities and Producer Responsibility Organizations (Pellegrino, 2016).

These gaps in implementation bring real opportunity costs: stuff that could be recovered ends up wasted, and pollution burdens grow. When collection isn't efficient, contamination runs high, and recycling markets stay sluggish, the financial and environmental upside of extended producer responsibility (EPR) schemes shrinks. As a result, many programs lean too heavily on landfills and incineration, which pumps

up greenhouse gas emissions and drains resources faster (Fostinone, 2016; Vandal, 2024). The Integrated Waste Opportunity Cost (Concretising the Role of EPR, 2020).

To unlock EPR's true potential, policy work across the board is essential. If member states align fee structures, transparency rules, and reporting standards, fragmentation fades away and circular markets become more integrated. That would cut down administrative headaches and make systems easier to compare (Jansone-Vevere et al., 2024). Clear governance matters too— setting out who does what among PROs, towns, and recyclers can lift efficiency, accountability, and compliance (Pellegrino, 2016). Tweak fee designs to reward thoughtful eco-design, and consider adding producer-responsibility elements that push firms to cut waste and boost recyclability from the start (Vandal, 2024; Zehaie et al., 2024). Building stronger domestic recycling markets needs smart investments, solid quality standards for secondary materials, and demand-side incentives. All of this helps keep materials in Europe, reducing harmful exports and preserving value (Fostinone, 2016).

Data transparency and getting consumers on board should be priorities if policy is to be evidence-based and the public truly involved. That participation is essential for adaptive, responsive extended producer responsibility systems. Bringing IWOC and the full set of metrics into monitoring frameworks marks a real methodological step forward, helping to balance economic and environmental goals and support more nuanced, effective decisions.

Waste moves across borders and supply chains stretch worldwide, so international cooperation is key for making Extended Producer Responsibility work. Teaming up with neighboring countries and global partners helps align standards, strengthens rules against illegal waste shipments, and supports the creation of circular value chains that cross borders. (Concretising the Role of EPR, 2020).

In short, this review shows that the success of EPR relies not only on formal adoption but, more importantly, on how well it's implemented, the way governance is set up, and the surrounding market conditions. Bridging persistent gaps and cutting opportunity costs will require policies that are harmonized, transparent, and oriented toward innovation. That's how the EU can move toward its ambitious circular economy and sustainability targets. The lessons from both standout and struggling member states provide a practical roadmap for policymakers to shape EPR schemes that genuinely boost environmental benefits, economic efficiency, and social well-being.

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