Original Research Article

Governance Design and Implementation in Textile Extended Producer Responsibility: A Comparative Analysis

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ABSTRACT

Extended Producer Responsibility (EPR) laws have been implemented in several countries as a policy response to the rapid growth of textile consumption and waste, yet textile EPR systems vary widely in design, governance, and transparency. This paper develops a structured comparative framework to examine how differences in policy structure influence implementation quality and reported outcomes across international textile EPR systems. While much of existing literature focuses on general EPR principles or country-specific case studies, this study provides a systematic cross-country comparison of textile EPR governance and performance. Using an author-created comparative policy analysis, this study develops an Implementation Quality Index (IQI) and an Outcomes Index (OI) to evaluate textile EPR systems in France, the Netherlands, Sweden, Hungary, and Australia. This dual-index framework separates governance design and reported policy outcomes, recognizing that many textile EPR systems are either too recent or insufficiently transparent to support a reliable comparison based solely on performance data. The analysis focuses on five key design patterns: governance centralization, product scope breadth, eco-modulation strength, enforcement clarity, and Producer Responsibility Organization (PRO) transparency. Outcome indicators are assessed where sufficient public data is available. By evaluating implementation design and reported outcomes separately, the IQI and IO demonstrate that stronger results are associated with centralized governance, broad product scope, differentiated fee structures, clear enforcement mechanisms, and transparent reporting practices, which offers practical insights for policymakers designing or reforming textile EPR systems.

Keywords: Sustainability Governance; Circular Economy; Textile Recycling; Waste Policy; Regulatory Enforcement

INTRODUCTION

The rise and expansion of fast fashion has significantly increased textile production, consumption, and waste, putting pressure on existing waste management systems (1). In response, Extended Producer Responsibility (EPR) was created as a policy tool designed to shift responsibility for textile end-of-life management from municipalities to producers themselves (2). While EPR has been widely applied to sectors such as packaging and electronics, textile EPR systems remain relatively new and unevenly implemented across countries, and systematic comparative evaluation of their design and performance remains limited. Existing research has primarily focused on general EPR policy principles or individual national case studies, leaving limited comparative analyses of how differences in governance

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structures and policy design influence implementation quality and measurable outcomes in textile EPR systems (3). This study's literature review therefore examines several key areas: the evolution of the modern textile industry and the rise of fast fashion, the development of Extended Producer Responsibility as a regulatory framework, emerging research on textile-specific EPR systems, and comparative policy developments in France, the Netherlands, and other countries implementing textile stewardship programs. Since France has operated the most mature textile EPR system and provides the most comprehensive publicly available performance data, it is examined in greater detail as a reference case within the comparative analysis.

This paper examines variation in textile EPR implementation across selected countries using two author-constructed indices: the Implementation Quality Index (IQI), which evaluates key institutional and regulatory features of textile EPR systems, and the Outcomes Index (OI), which evaluates publicly reported performance indicators where sufficient data is available. The use of structured scoring frameworks to evaluate EPR performance builds on prior research assessing producer compliance in packaging EPR systems, where indicator-based criteria are scored and weighted to generate comparative implementation assessments (4). Separating policy design from reported outcomes allows systems with strong institutional frameworks but limited data transparency to be evaluated without conflating missing reporting with poor performance. By applying this framework across multiple national systems, the study provides comparative insight into which policy design features are most consistently associated with stronger implementation and transparent outcome reporting.

LITERATURE REVIEW

Textile industry

Before the rise of fast fashion in the 1990s, the textile and apparel industry operated with slower production cycles and more stable consumption patterns, constrained by labor-intensive manufacturing and slower distribution systems. Clothing production followed slow, seasonal cycles, with most brands releasing two collections per year, and consumers would purchase clothing with the expectation of wearing them repeatedly over time (5). From the 1960s through the 1980s, textile production in the United States was supported by government tariffs, quotas, and subsidies, which created a stable economic environment that did not need constant innovation and turnover to be profitable (6).

Technological developments and globalization gradually expanded production capacity, but a major shift occurred in the late 1980s when supply chains became buyer-driven and responsiveness to consumer demand became critical (7). To maintain a competitive market, firms outsourced from lower-cost countries and adopted just-in-time manufacturing and quick-response strategies (6). By the early 2000s, the industry had shifted into what is now known as fast fashion, characterized by rapid production cycles, real-time data-driven design, and significantly increased consumption (7). Global clothing production doubled between 2000 and 2014, and the average western consumer began buying 60% more clothes, but keeping them for about half as long as they would have 15 years prior (8). Fast fashion brands began introducing between 50 and 100 mini collections each year, with major firms like Zara updating their in-store selections every 15 days (5). This also increased the negative environmental impact, because as garment quality decreases and trend cycles shorten, most clothing is being landfilled or incinerated instead of reused or recycled (9).

General EPR Laws

To combat the increasing volumes of waste and pressure on municipal waste management systems caused by changing consumer habits, Extended Producer Responsibility (EPR) laws were created. Early applications focused on high-volume, short-lived products such as packaging, where rising consumption and disposal rates quickly overwhelmed local waste systems and exposed the limits of publicly funded waste management. At the time, fast fashion had not yet emerged as a major policy concern, as the global shift toward accelerated clothing consumption would only intensify in the following decades.

Thomas Lindhqvist, who introduced the concept in 1990, defines EPR as a policy approach that extends producer responsibility across the product life cycle, particularly for take-back, recycling and final disposal" (10). EPR is based on Digital Product Passport (DPP), which is a digital data tool that stores lifecycle information like materials, origin, environmental impacts, and repair and reuse option. However, DPP is not a policy instrument on its own and can be costly and complex to implement (11).

By the early 2000s, organizations like the OECD identified EPR as a key policy response to growing

waste streams (2). To successfully implement EPR policies, the allocation of responsibility and determining the "producer" must be shared between all actors of the supply chain. Most systems define producers as those who place the products on the market, especially those with the greatest control over product design and material choice, since design decisions influence end-of-life outcomes (2, 3). This definition not only improves collection and recycling rates but incentivizes producers to consider environmental designs in products as well. In the textile sector specifically, design decisions like fiber composition and garment construction could affect recyclability and reuse potential, as well as compensation for producers (12).

EPR systems rely on various economic instruments, including fees, taxes, and subsidies, but face challenges with free-riding, where non-compliant producers avoid financial responsibility (3). This has cost programs a substantial amount, as shown by Germany's packaging system which lost hundreds of millions of euros annually due to free-riders (10). Rather than converging on a single model, EPR systems have evolved into complex policy mixes involving responsibility allocation, market structure, and policy instruments (13). Many systems operate through Producer Responsibility Organizations (PROs), which may be centralized or competitive, creating long-term institutional path dependencies (13). This rigidity explains why countries with established EPR programs often show consistent implementation patterns over time.

However, EPR implementation is significantly different across countries, and comparative studies have found that in developed countries, producers often take on greater financial responsibility, while physical collection and recycling are handled by specialized agencies. Conversely, producers in developing countries may have both financial and operational roles, "especially in the presence of an active informal sector in recycling" (14). In the United States, EPR adoption is state-led and has followed a more fragmented path, delaying mandatory implementation at the state level (15). The variations surrounding EPR laws show how cooperative and context-dependent they are, relying on producers, governments, retailers, and consumers to work together to function effectively (2).

Textile EPR

While EPR has been widely applied in sectors such as packaging and electronics, its application to textiles introduces additional governance challenges due to material complexity, global supply chains, and rapidly changing consumption patterns. The volume of post-consumer textiles has grown rapidly, while systems for managing this waste stream have struggled to keep up. In the United Kingdom alone, the cost of managing textile waste is estimated at approximately £82 million each year, mostly due to the need for separate collection systems for household textiles (1). These challenges occur across many countries, with research showing that sector-specific barriers—like lack of incentives, specific regulations, and knowledge—can limit the transition to circular textiles (16). Effective EPR implementation requires adequate collection, sorting, and recycling practices (16).

At the end-of-life stage, textiles are particularly difficult to process due to blended fibers and complex material compositions, limiting recycling options and resulting in high rates of landfilling and incineration (1). This has resulted in landfilling and incineration remaining the dominant disposal methods, which together account for roughly 73% of global end-of-life clothing disposal (1). This complexity makes it more difficult for textile EPR laws to deliver the same recycling outcomes seen in other sectors like packaging or electronics. Even so, early evidence has shown that EPR schemes can improve outcomes, with programs reporting an average 13% increase in post-consumer textile collection despite the sector's structural challenges (17).

The global nature of clothing further complicates implementation. Large volumes of used textiles are exported across borders, often through informal markets, reducing transparency and complicating the tracking of end-of-life outcomes (18). Clear definitions of producer responsibility, which encompass financial, legal, and informational obligations, become especially important and are usually managed through PROs (19). Scholars also note that the design of textile EPR determines the effectiveness of the law. Collective systems can reduce costs but may weaken incentives for eco-design and innovation, while free-riding remains a persistent challenge (20, 21). Even though EPR has proved to be effective at increasing recycling rates and generating financial flows for waste management, its ability to influence upstream design decisions in the textile industry is more limited.

Researchers have also found additional barriers including limited demand for recycled textiles, insufficient implementation of circular business models, high costs, and limited short-term economic benefits restrict investment in textile innovation (16).

As a result, recent research emphasizes the need for combined policy instruments such as eco-modulated fees, minimum recycled content requirements, and stronger design regulations to add onto basic take-back obligations (18, 21). Information-based instruments are also necessary, but difficult to implement given the international textile value chain and lack of transparency around environmental and social costs (21). All these instruments show why textile EPR is more complex than EPR in other product sectors, and why policymakers continue to test hybrid and evolving systems rather than adopting a single, standardized model.

France

France is the most established textile EPR system, and the one most frequently noted as a reference model for textile waste governance. The French textile EPR policy was implemented through Article L-541-10-3 of the Code de l'Environnement and came into effect on the 1st of January 2007, making France one of the earliest adopters of mandatory producer responsibility for textiles (20). This legislation enforces all producers—including manufacturers, importers, and distributors—placing new textiles, clothing, linen, and footwear on the French market to be responsible for their product's end-of-life management. Producers can fulfill this obligation by either joining a PRO or establishing an approved individual take-back system, although the majority choose the PRO's collective compliance (20).

The French system is centrally organized through a single PRO, originally known as Eco TLC, but now as ReFashion. By 2013, Eco TLC represented over 93% of the textile industry, with the remaining 7% being free-riders (22). By 2016, the PRO collected thousands of financial contributions from members, placing approximately 564,000 tons of textiles on the French market that were then used to support collection, sorting, and valorization of post-consumer textiles (20, 23). France's textile EPR system has shown measurable improvements in collection and recovery, as post-consumer textile collection has increased by an average of 13% annually since implementation, with a 300% increase from 65,000 tons in 2006 to 210,000 tons in 2016 (20). By 2018, the collection rate for clothing, household textiles, and footwear reached 38%, exceeding typical collection rates in many other regions (23). Of the collected textiles, roughly 58–60% are directed toward reuse, 25–33% toward recycling, and the remainder toward energy recovery or disposal (22, 23). Given that the textile industry is generally dominated by landfilling and incineration, these shifts prove just how effective France's textile EPR laws are.

Not only has EPR benefited environmental outcomes, but it has also created social and economic benefits by creating jobs and providing sorting operations with financial incentives. France has also invested in both mechanical and chemical textile recycling infrastructure, although fiber complexity and blended materials continue to limit large-scale closed loop recycling (24). The French system has integrated incentives and penalties to encourage circular design and product sustainability. Product durability bonuses range from €0.07 to €0.70 depending on volume, as eco-labeled products receive €0.03 to €0.30 bonuses, and recycled materials sourced via approved PROs are compensated at €500 to €1,000 per ton depending on whether recycling is open or closed loop (12). Penalties then apply for products containing metalloplastic fibers or electrical components (12).

In more recent years, France has also introduced the Anti-Waste and Circular Economy Law (AGEC), which expanded the scope of producer obligations beyond waste management alone. Under AGEC, companies placing products on the French market must publish detailed product information on material composition, recyclability, microfiber release, hazardous substances, and recycled content, enhancing transparency across the value chain (25). The law also introduced eco-modulation mechanisms that reward or penalize producers based on environmental performance, including durability and recycled material use, and prohibits the destruction of unsold goods in favor of reuse or recycling (25). France has also advocated for stronger international rules on textile waste exports under the Basel Convention to improve transparency in global second-hand clothing markets (26).

The French system proves how a well-established and regulated textile EPR scheme can improve collection rates, support reuse and recycling markets, and generate social benefits. However, it also warns future implementers by showing structural trade-offs, specifically the reliance on collective compliance models that require additional components, such as eco-modulation and transparency requirements, to strengthen upstream design incentives (20, 23). Compared with newer systems such as the Netherlands, France's long implementation period and centralized PRO structure provide one of the most mature examples of textile EPR governance.

The Netherlands and Other Countries

Following France, the Netherlands represents one of the most recent, structured implementations of textile EPR, although its system is comparatively new and outcome data is still limited. Dutch textile EPR was formally implemented in July 2023, requiring producers to report the quantities of textiles placed on the national market, establish free-of-charge collection systems for consumers, and ensure that a defined share of collected textiles is prepared for reuse and recycling, including fiber-to-fiber recycling processes (12, 27).

The Dutch system also includes an EPR fee of €0.24 per kilogram beginning July 1, 2025, following an initial transition period with no fee (12). However, the Netherlands' textile market structure complicates EPR implementation. Domestic textile production is mostly limited to carpets, while nearly all other textiles are imported (19). The product scope of textiles is categorized into consumer clothing, workwear, and household linen, which simplifies reporting but may not show complex material levels which can be important for recycling outcomes (19).

At the same time, the Netherlands has invested in upstream policy instruments. In 2020, the Dutch standards authority introduced NTA 8195, a national standard for circular textile products that emphasizes demonstrable use of recycled yarns, transparent supply chain management, and design for circularity principles (19). This complements their already existing downstream EPR obligations with voluntary design guidance. However, end-of-life management remains fragmented, as municipalities hold the legal responsibility for separate textile collection, which is typically outsourced to private actors for a fee due to the value of collected textiles (19). Despite these policies, recent research shows that less than 5% of textiles in the Netherlands are recycled, and only around 1% undergo closed loop recycling (25).

Beyond the Netherlands, broader European data suggests that textile EPR schemes remain uneven and experimental. Nordic countries, for example, have traditionally utilized downstream techniques like collection, reuse, and recycling, over upstream design requirements (22). While many Nordic business models have the potential to influence design for durability and recyclability, these are only strong when take-back, leasing, or resale models are operated directly by brands. When third-party actors take on these activities, upstream design incentives are weakened. Research further suggests that mandatory EPR schemes are most effective at increasing collection rates, while voluntary or individual EPR schemes tend to generate stronger incentives for design improvements, though at smaller scale (22).

Across the European Union, textile EPR development remains fragmented. Several countries have implemented complementary measures rather than full EPR systems. Belgium, for example, has reduced its value-added tax (VAT) to 6% for clothing and shoe repairs, while Norway has mandated separate textile waste collection to align with EU waste targets (25). Germany has strengthened its Circular Economy Law by introducing duties of care and reporting obligations to prevent the destruction of unsold goods, however an actual textile EPR scheme has not yet been implemented (27, 28). At the infrastructure level, the European Environment Agency estimates that the EU has sorting capacity for about 1.5 million tons of "used and waste textiles" each year, with labor-intensive sorting concentrated in countries such as the Netherlands and Poland for cost advantages (29). While mechanical and chemical recycling capacity is expanding, landfilling is still an issue in several countries, including Poland and Czechia (29).

Outside of Europe, international schemes further prove the limitations of voluntary approaches. Australia, the world's largest per-capita consumer of textiles, generates approximately 23 kg of textile waste per person annually, with less than 10% recycled or reused (30). The country's voluntary Seamless National Clothing Product Stewardship Scheme applies a voluntary 4-cent levy to clothing products, but its limited scope and partial stakeholder participation decrease its effectiveness (25). Similarly, despite being the largest global producer and a major importer of used textiles, Asian countries lack a comprehensive regulatory framework for textile waste management (25).

Studies and literature suggest that while textile EPR can significantly improve collection and generate financial flows for waste management, the outcomes depend on system design. Mandatory schemes tend to perform better in scaling collection, while strong upstream effects require eco-modulation, transparency, and design-oriented standards. The diverse approaches across Europe shows both the complexity of textile value chains and ongoing experimentation as policymakers balance environmental effectiveness, economic feasibility, and global trade practicalities.

Building on these differences in system design and policy strength, Table 1, *Trends in Household Textiles and Clothing & Footwear Consumption*, examines trends in household textile and clothing and footwear consumption

Table 1. *Trends in household textile and clothing & footwear consumption across selected European countries (2014–2022).*

Country	Average Chain-Linked Household Textile Consumption Overtime (in millions)	Average Chain-Linked Clothing & Footwear Consumption Overtime (in millions)	Laws Implemented	Change in avg.
France	**2014: €3,480.7** 2015: €3,541.6 2016: €3,551.3 2017: €3,531.9 2018: €3,463.1 2019: €3,501.0 2020: €3,284.1 2021: €3,493.1 2022: €3,153.7 **Overall slight ↓**	**2014: €43,674.1** 2015: €44,182.1 2016: €43,976.8 2017: €44,529.1 2018: €43.471.7 2019: €43,688.6 2020: €36,556.9 2021: €40,288.0 2022: €42,746.9 **Overall slight ↓**	EPR, 2007 AGEC (Anti-Waste & Circular Economy), 2023	Textiles: -9.3% Clothing: -2.1%
Netherlands	**2014: €1,646.7** 2015: €1,728.3 2016: €1,751.9 2017: €1,831.4 2018: €1,939.5 2019: €1,964.1 2020: €2,037.8 2021: €2,246.1 2022: €2,285.4 **Overall ↑**	**2014: €15,484.6** 2015: €16,249.2 2016: €16,189.2 2017: €16,799.4 2018: €16,802.3 2019: €17,053.2 2020: €14,479.9 2021: €16,493.3 2022: €18,639.6 **Overall ↑**	EPR, 2023	Textiles: +38.8% Clothing: +20.4%
Germany	**2014: €7,245.1** 2015: €8,042.9 2016: €8,170.0 2017: €8,371.9 2018: €8,054.2 2019: €8,164.4 2020: €8,591.5 2021: €8,023.6 2022: €8,375.1 **Overall ↑**	**2014: €69,810,0** 2015: €67,756.9 2016: €69,139.2 2017: €70,629.8 2018: €68,597.1 2019: €67,946.7 2020: €59,768.4 2021: €52,260.2 2022: €68,780.1 **Overall slight ↓**	No textile EPR	Textiles: +15.6% Clothing: -1.5%
Sweden	**2014: €1,047.3** 2015: €1,107.3 2016: €1,192.6 2017: €1,279.0 2018: €1,299.1 2019: €1,358.3 2020: €1,530.8 2021: €1,775.3 2022: €1,612.6 **Overall ↑**	**2014: €8,695.2** 2015: €9,105.9 2016: €8,563.1 2017: €8,296.0 2018: €8,655.8 2019: €8,835.8 2020: €7,950.2 2021: €8,997. 2022: €9,132.6 **Overall ↑**	No textile EPR	Textiles: +54.0% Clothing: +5.0%

Data source: Eurostat.

over time across selected European countries. France, a country with years of mandatory textile EPR data and implementation, is compared with countries that later adopted EPR or even still have not yet put EPR in place. The data, sourced from Eurostat, helps contextualize how consumption patterns evolve under different regulatory environments. Over the course of 8 years, the data captures a sharp decline in 2020, most likely caused by COVID-19 disruptions meaning reduced demand for textiles such as workwear and school-related clothing. There is then a partial rebound in the following years as consumption patterns normalized.

Despite pandemic-related influences, France stands out as the only country in the sample to show an overall decline in both household textile and clothing consumption over the observed period. While this trend cannot be attributed to EPR alone, the presence of a relatively long-standing, mandatory textile EPR framework suggests that producer regulations may play a role in moderating consumption growth alongside broader behavioral and economic shifts.

Methodology Foundation

Researchers examining producer compliance within packaging EPR have applied a criterion-based approach to evaluate effective implementation and compliance. In the study, relevant indicator criteria are chosen from existing research papers and assessed using a standardized scoring scale from 0 to 2 (4). The criteria are then grouped and weighted according to their relative importance between efficiency, availability, accuracy, transparency, and sustainability, with higher weights reflecting greater influence on achieving effective compliance (4). Finally, the scores are combined with respective weights to achieve an overall EPR compliance score (4).

METHODS AND MATERIALS

Building on the criterion-based evaluation frameworks used in prior EPR compliance studies, this research uses a structured, comparative index to assess the performance of textile EPR systems across selected European countries. Using country-level consumption and policy data, the analysis examines how the presence and design of textile EPR schemes are associated with changes in market behavior and waste-related trends over time. By adapting established evaluation principles to a broader policy and economic context, this approach enables systematic cross-country comparison of textile EPR effectiveness.

Scoring Rubric for IQI and OI

To operationalize the comparative framework, two author-constructed indices were developed: the Implementation Quality Index (IQI) and the Outcomes Index (OI). The IQI captures the strength of policy design and governance structures even when KPI data is incomplete, while the OI captures reported performance based only on publicly available outcome indicators where they exist. Separating these indices allows systems with strong policy design but limited reporting transparency to be evaluated without treating missing outcome data as a policy failure.

For both indices, indicators were scored on a standardized 0–5 scale using a predefined rubric. A score of 0 indicated absent, minimal, or highly fragmented evidence, and a score of 1 reflected very weak or largely undeveloped evidence. Scores of 2 and 3 represented limited or early-stage evidence and moderate evidence with some structurization but notable gaps. Higher scores displayed stronger performance, with a score of 4 indicating strong evidence with consistent legal or reporting support, and a score of 5 reflecting highly developed, mature, and consistently documented governance or performance.

The IQI is calculated as the equally weighted average of five implementation patterns: governance centralization, product scope breadth, eco-modulation strength, enforcement clarity, and transparency of PROs. The OI scores reflect the depth, consistency, and transparency of publicly reported outcome indicators, including collection, reuse, recycling, and landfill diversion rates, as well as evidence of enforcement and multi-year reporting. The Combined Index (CI) is then calculated by applying a weighted summation of IQI by 0.7 and OI by 0.3, reflecting the emphasis on governance and implementation quality as paving the way for measurable outcomes.

The IQI includes five countries: France, the Netherlands, Sweden, Hungary, and Australia. These countries were chosen to display a variation in governance structure, policy maturity, and data availability across textile EPR systems. For the OI and the Combined Index (CI), scores are solely presented for France and the Netherlands, because their KPI reporting was sufficiently detailed and consistent to support a comparison.

Several scoring decisions illustrate how the rubric was applied in practice. France received a score of 5 for eco-modulation strength in the IQI, as producers including pre- or post-consumer recycled fibers in their

products receive discounts on tariffs, and non-compliant producers must pay fees depending on the product. The Netherlands received a score of 4 on OI because a standardized PRO discloses yearly KPI and is reasonably transparent, but their system is newer and has fewer years of consistent reporting compared with France. Further, Australia received a lower score of 2 for enforcement clarity in the IQI, reflecting the voluntary nature of its textile stewardship approach and the absence of the mandatory compliance mechanisms seen in France and the Netherlands.

Scoring decisions were informed using publicly available policy documentation, including national government policy reports, PRO publications, regulatory databases, and comparative policy analyses. Information on all countries regarding policy structure, product scope, eco-modulation mechanisms, and fee structures was primarily derived from policy summaries such as the Carbonfact Textile EPR Policy Overview database, which compiles international textile EPR frameworks. Specific details on the French eco-modulation fee structure and incentive mechanisms were supplemented using technical documentation from Global Measure's analysis, and KPI rates were drawn from official monitoring dashboards including ADEME (the French Republic's Ecological Transition Agency) and ReFashion. Dutch outcome data was taken from government publications such as the Policy Program for Circular Textiles and supporting European Environment Agency reports. Further, data on Australia's voluntary stewardship system and its proposed four-cent per-garment levy was sourced from international policy assessments including WRAP's global textile EPR status reports. No formal inter-rater reliability test was conducted, which should be considered a limitation of the study. However, robustness was supported through sensitivity analyses using alternative index weightings and index combinations.

Many European countries' textile Extended Producer Responsibility (EPR) schemes are newly introduced, voluntary, or in early implementation phases, resulting in limited or inconsistent publication of outcome-based key performance indicators (KPIs). Missing outcome indicators were left blank (treated as N/A), instead of being converted to zero values, and a score of 0 is used only when a scheme exists but outcome disclosure is minimal or fragmented. For composite scores, an adjusted-weighting approach re-normalized the remaining weights to sum to one. Additionally, outcome reporting was assessed using graded reporting categories that reflect the depth, consistency, and transparency of publicly disclosed KPIs. This approach allows policy design quality to be separated from measured performance, so that countries are compared based on governance strength even if outcome data is incomplete. These methods are consistent with comparative environmental policy research where regulatory data availability and transparency vary as well.

RESULTS

Across the countries analyzed, implementation quality varies systematically with governance structure and policy design features. Centrally administered national systems demonstrate higher scores across governance, scope, fee design, and transparency indicators in this comparative study. France proves to be a consistent, high performing system, reflecting its centralized governance, broad product scope, structured eco-modulation framework, and relatively high levels of PRO transparency. The Netherlands similarly exhibits strong structural design and governance, though with more limited maturity in outcomes reporting, consistent with its more recent implementation timeline. In contrast, countries operating under voluntary, fragmented, or early-stage EPR frameworks tend to cluster toward the lower end of implementation quality, exhibiting weaker coordination, less comprehensive scope coverage, and limited enforcement clarity.

Where outcome data exists, combined scores reinforce these observations, suggesting that stronger governance and policy architecture are associated with the ability to create measurable performance outcomes. These patterns are summarized in Table 2, which compares IQI, OI, and CI scores across the countries analyzed. France demonstrates the strongest

Table 2. *Comparative scores for Implementation Quality Index (IQI), Outcomes Index (OI), and Combined Index (CI) across selected countries.*

Countries	IQI (Equal Weights)	OI	Combined
France	4.80	5.00	4.86
Netherlands	3.20	4.00	3.44
Sweden	2.20	-	-
Hungary	2.00	-	-
Australia	1.40	-	-

Figure: Isabella Dolan.

overall performance with a score of 4.8, while the Netherlands shows moderately strong implementation quality but slightly lower combined scores due to the shorter maturity of its EPR system and the smaller body of available performance data. Having been in place for over 15 years longer, the French system provides a broader picture of observable trends in KPIs, creating a more stable outcome assessment.

France also incorporates eco-modulation within its fee structure by linking producer costs to product design characteristics. Factors such as product durability, environmental certifications, and the use of recycled materials create differentiated fees, reinforcing incentives for upstream design improvements. This is shown in Figure 1, which presents the IQI scores across all countries included in the analysis, and highlight a clear separation between mature, centrally governed systems and newer or less formalized frameworks. Each country is placed in a ranked order to demonstrate their ability and performance of the five patterns in relation to the other countries. France ranks highest due to its long-standing regulatory framework and comprehensive policy design, while the Netherlands follows with a moderately strong institutional structure despite its more recent implementation. On the other hand, Australia ranks fifth with a score of 1.4, given EPR operates under a voluntary scheme with no specified PRO, and therefore does not have extensive annual reports.

While the IQI captures differences in each country's framework design and quality, the inclusion of KPIs provides additional insight into how these systems perform in practice. Figure 2 therefore presents combined scores based on available performance indicators. Given that France and the Netherlands were the only countries with strong and available KPI data, other countries are excluded from this comparison. The results show France maintaining the highest overall score, while the Netherlands demonstrates slightly improved relative performance from 3.20 in Figure 1 to 3.44 in Figure 2, reflecting comparatively transparent reuse and recycling data from government and EEA reports.

Table 2 displays a combination of equally weighted, author-given scores for each analyzed country. The IQI is based on performance and available data on centralization of implementation, product scope breadth, eco-modulation, enforcement clarity, and PRO transparency. The OI, however, is only given for France and the Netherlands, due to lack of data and publicly available information from the other countries, and is calculated by collection, reuse, and recycling rates, as well as KPIs published by each country's PRO or government. Lastly, the IQI and OI scores were combined with weights of 0.7 and 0.3, respectively, to synthesize all scoring.

Figure 1 presents country-level IQI scores ranked across the analyzed systems, highlighting the distinction between centralized, transparent, and well-developed frameworks and those that are fragmented, less transparent, or recently implemented.

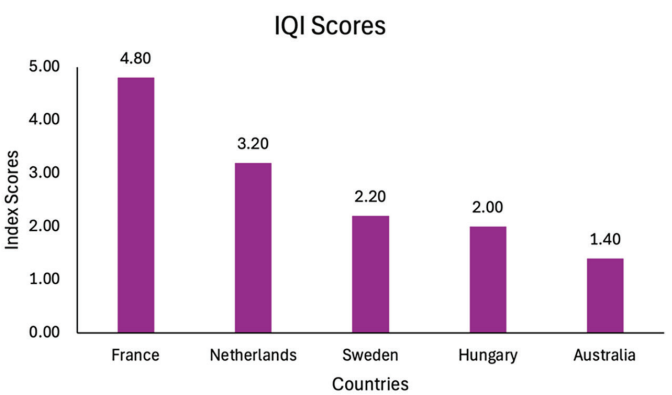

Figure 1. *Implementation Quality Index (IQI) scores across selected textile EPR systems. Country-level IQI scores are presented to compare governance design strength across France, the Netherlands, Sweden, Hungary, and Australia.*

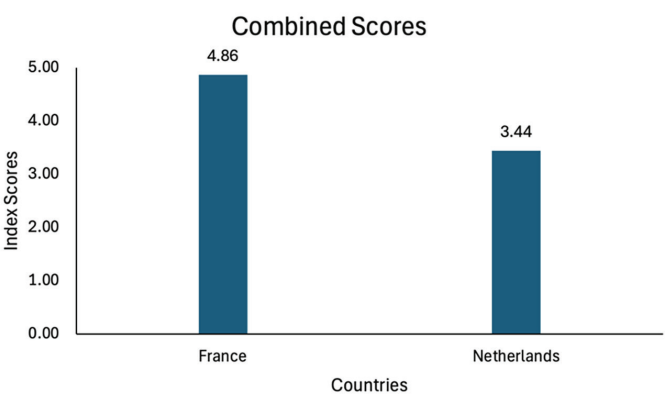

Figure 2. *Combined Index (CI) scores integrating implementation quality and reported outcomes. Combined scores are presented for France and the Netherlands, the only countries with sufficient publicly available performance data to support outcome evaluation.*

Figure 2 presents combined scores for France and the Netherlands, integrating the Implementation Quality Index (IQI) and Outcomes Index (OI). The composite score applies weighted contributions of 0.7 for IQI and 0.3 for OI, providing an overall assessment of the two most established textile EPR systems.

A sensitivity analysis using IQI and OI indicates that the core findings are robust to alternative methodological assumptions. Under Sensitivity Analysis A—which compares IQI with equal weights and weights given by the researcher (0.25, 0.25, 0.2, 0.1, and 0.2 for the analyzed patterns respectively)—relative system performance remains stable when comparing the equal and unequal weighting schemes, suggesting that the observed patterns do not depend heavily on the specific weighting choices applied. Sensitivity Analysis B—which compares and ranks countries for CI and equally weighted IQI—further shows that the inclusion of outcome indicators (where available) does not overturn the main governance-based conclusions. Instead, the addition of outcome data slightly reinforces the separation between higher-performing systems, as countries with both stronger governance structures and more mature outcomes reporting continue to perform consistently well. Together, these results suggest that the observed patterns reflect the structural attributes of EPR system design instead of the construction and weighting choices of the index.

DISCUSSION

These findings suggest that centralized national EPR systems, rather than fragmented or voluntary frameworks, are associated with stronger implementation quality in this review. Systems implemented at the national level may result in higher performance across governance coherence, reporting consistency, and enforcement clarity when compared to federal or municipally fragmented models. For example, France's EPR scheme is centrally administered with mandatory producer participation and a clearly defined national PRO, ReFashion, which supports standardized reporting practices, including the relatively regular publication of annual reports and system-wide KPIs.

On the other hand, Australia's textile stewardship framework operates on a voluntary basis, relying on industry uptake rather than legally binding producer obligations (27). Even within this voluntary model, policymakers have acknowledged the potential limitations of fragmented governance. When launching the Seamless scheme, Australia's Minister for the Environment stated that the program would be mandated if industry participation proved insufficient, emphasizing that regulation would follow in the absence of adequate voluntary (30).

This pattern between France and Australia reflects the coordination advantages associated with centralized systems. National governance enables standard reporting requirements, clearer allocation of responsibilities, and more consistent compliance oversight, which reduces administrative fragmentation and ambiguity. Fragmented systems often characterized by voluntary participation or decentralized municipal responsibility, on the other hand, tend to exhibit uneven implementation across jurisdictions, which limits both accountability and comparability. This distinction matters because centralization and system-wide coordination are foundational for effective textile EPR implementation, particularly in policy areas that depend on long term monitoring and standardized data collection.

The analysis also demonstrates the importance of product scope breadth in implementation quality. Systems that include a wider range of textile products—such as clothing, footwear, household linens, and professional textiles—tend to yield stronger overall performance than those with narrower or selectively defined scopes. For example, France's textile EPR product scope extends beyond clothing to cover footwear and household textiles, whereas other less developed systems, such as Australia's, limit producer responsibility to solely clothing (27).

Broader scope coverage decreases loopholes in regulation and limits opportunities for producers to externalize responsibility through product reclassification or exclusion. By ensuring producer responsibility across the full textile lifecycle, a more comprehensive scope design strengthens the environmental integrity of EPR frameworks and increases their waste diversion potential. This is significant because narrower scopes can weaken responsibility across the value chain, making it easier for environmental impacts to fall outside the regulatory system.

Additionally, eco-modulated fee structures are found to be one of the most influential policy instruments within higher-performing systems. Frameworks that incorporate differentiated fees based on product design characteristics like durability, recyclability, or fiber composition consistently outperform those relying on flat or voluntary fee schemes. France's system utilizes this approach by linking producer fees to a range of design

features, allowing producers to reduce costs through improved environmental performance rather than paying a single fixed rate.

However, systems with flat fee structures, such as Hungary's textile EPR scheme, apply a fixed charge of HUF 145, approximately $0.42, per kilogram regardless of product design or environmental attributes (27). While simple, this approach weakens incentives for upstream design change, as producers face identical costs regardless of durability or recyclability. As a result, flat fee structures limit the capacity of EPR policies to influence product design and broader transformations for the circular textile industry. The eco-modulation differentiation is important to note because it is one of the few mechanisms that directly connects regulatory costs to design decisions made before products enter the market.

The results further indicate that enforcement clarity plays a key, decisive role in EPR. Systems with clearly defined penalties, audit mechanisms, and compliance procedures show stronger implementation quality than those where enforcement remains vague or inconsistently applied. France provides a clear example of a system with explicit enforcement rules, including financial penalties of up to €7,500 per non-compliant product, alongside additional enforcement tools such as market access restrictions that can effectively prohibit non-compliant products from being sold (31). Beyond direct effects, enforcement penalties can also carry reputational consequences, as non-compliance can negatively affect brand perception and sales.

Other systems, like the Netherlands, have yet to establish formal penalties for non-compliance, relying on producers to follow expectations without clearly specific punishments. This not only reflects early stages of implementation, but the absence of explicit enforcement weakens policy credibility by reducing perceived consequences of non-compliance. This pattern is important because credible enforcement shapes producer behavior by signaling that compliance is not optional and that free-riding carries tangible consequences.

Finally, PRO transparency appears to be a critical factor for both accountability and evaluative research. Systems that publish regular annual reports, standardized KPIs, and clear methodological documentation demonstrate higher implementation quality in this study than those with limited or fragmented disclosure practices. In France, KPI data over time is accessible through government platforms, allowing for the identification of trends to be inferred. While the national PRO, Refashion, has removed some earlier reports as the EPR scheme has evolved, annual reports from 2020 to 2024 still provide sufficient data to support outcome assessment.

In the Netherlands, KPI data can similarly be located through government sources, though comparable information is not consistently published directly by the PRO. This still contrasts with countries such as Sweden and Hungary, where only limited textile-related information is released through composite sources like the European Environment Agency. In these cases, the absence of country-specific PRO or government reporting restricts the ability to track performance over time or to draw conclusions about system effectiveness.

Transparency enables effective monitoring by regulators, supports stakeholder trust, and facilitates continuous system improvement. Additionally, the availability of reliable data is essential for assessing policy outcomes and refining EPR frameworks over time. Without accessible and consistent data, neither regulators nor researchers can evaluate whether EPR systems are functioning as intended.

At the beginning of this review, it was expected that implementation quality would vary primarily based on how long a textile EPR system had been in place, with more established schemes demonstrating stronger outcomes. One unexpected finding was the extent to which voluntary or fragmented frameworks struggled to report basic comparable performance data, regardless of stated policy ambition. This absence of consistent textile KPIs across many country's schemes suggests that many EPR systems remain at early or transitional stages of policy development even when the first textile EPR implementation was almost 20 years ago. Without reliable and accessible data, both policymakers and external researchers have limited ability to evaluate progress and identify areas for improvement. This suggests that textile EPR effectiveness is not only shaped by policy implementation, but by the extent to which systems are designed for transparency, accountability, and measurable performance.

Outcome indicator data remains limited across many textile EPR systems, largely because many schemes are relatively recent and still in early implementation phases. In practice, measurable outcomes typically emerge only after compliance systems, reporting infrastructure, and enforcement mechanisms have matured. This supports the conceptual separation between implementation quality and outcome indicators in this analysis. Rather than representing a compromise, the IQI/OI distinction

reflects the policy reality that effective outcomes are based on governance capacity, transparency, and enforcement. Strong governance therefore functions as a leading indicator of future performance rather than an immediate proxy for outcomes.

CONCLUSION

This study examined the implementation quality of textile Extended Producer Responsibility (EPR) systems across multiple countries, highlighting how governance design, product scope, eco-modulation, enforcement clarity, and transparency influence performance. While system maturity contributes to outcomes, the analysis demonstrates that centralized, well-coordinated frameworks with robust reporting and enforcement mechanisms are also necessary for effective EPR implementation. The study is limited by the availability of outcome data, which was only fully accessible for France and the Netherlands, which shows broader transparency gaps within textile EPR governance. Nonetheless, the findings suggest clear policy directions: harmonizing KPI reporting, requiring transparent PRO disclosure, strengthening eco-modulated fees, and clarifying enforcement obligations. Future research should expand outcome measurement across jurisdictions and assess long-term environmental impacts. Overall, this study contributes to the understanding of how governance design shapes the effectiveness of textile EPR systems and offers actionable guidance for policymakers seeking to strengthen circular textile economy frameworks.

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CONFLICT OF INTEREST

The author declares that there are no conflicts of interest related to this work.

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