Eco-modulation as a driver for eco-design: a dynamic view of the French collective EPR scheme

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Abstract:	Extended Producer Responsibility (EPR) systems have been criticized to provide little incentive for producers to eco-design. To this end, an incentive scheme, called eco-modulation, based on modulated product fees according to their level of eco-design has recently been introduced. This paper provides a comprehensive analysis of the introduction of this scheme as part of the collective EPR system in the WEEE sector in France and discusses the impacts of this policy instrument on product design (direct effects) and collective action and innovation (indirect effects). From a theoretical standpoint, we consider policy instruments in our research as part of complex policy mixes and within adaptive policy-making, i.e. on how these mixes evolve over time to adapt to complex and changing issues and collective dynamics. In this perspective, we stress that, while eco-modulation has shown little direct impact, important indirect effects can be identified. We argue that framework conditions, i.e. how the EPR system is organized and conducted in practice, explain better the occurrence of such indirect effects rather than the policy instrument in itself. In this perspective, the paper provides insights on the role of Producer Responsibility Organizations (PRO) in linking individual and collective producer responsibilities and organizing collective action. Moreover, it shows that implementing such a policy instrument requires intense dialog with stakeholders to advance its acceptability, a collective organization to organize its monitoring and deployment, and careful integration with other instruments within a coherent and adaptive policy.

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Highlights

- Eco-modulation has little direct effect in the short term but may have important indirect effects when combined with other instruments
- Eco-modulation implementation should be considered over the long term
- PROs play a key role in the implementation, support and evolution Eco-modulation
- Eco-design requires collective support that can be provided by PROs

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Abstract

Extended Producer Responsibility (EPR) systems have been criticized to provide little incentive for producers to eco-design. To this end, an incentive scheme, called eco-modulation, based on modulated product fees according to their level of eco-design has recently been introduced. This paper provides a comprehensive analysis of the introduction of this scheme as part of the collective EPR system in the WEEE sector in France and discusses the impacts of this policy instrument on product design (direct effects) and collective action and innovation (indirect effects). From a theoretical standpoint, we consider policy instruments in our research as part of complex policy mixes and within adaptive policy-making, i.e. on how these mixes evolve over time to adapt to complex and changing issues and collective dynamics. In this perspective, we stress that, while eco-modulation has shown little direct impact, important indirect effects can be identified. We argue that framework conditions, i.e. how the EPR system is organized and

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1. Introduction

Encouraging producers to design for the environment is one of the key issues in the transition towards a circular economy (Bakker et al. 2014; Ellen MacArthur Foundation, 2015; Franco, 2019; Guldmann and Huulgaard, 2020). Extended Producer Responsibility was originally introduced with this transition in mind, the idea being to make producers responsible for the end of life of the products they placed on the market in order to encourage them to take environmental impacts into account from the design stage (Lifset, 1993; Turner and Pearce, 1993; Lindhqvist, 2000; OECD, 2001; Tojo, 2004).

However, in practice, EPR has led to collective systems that provide little incentive for producers to eco-design (Tojo, 2004; Walls, 2006; Van Rossem, 2008; Mayers et al. 2011; Mayers et al. 2013). The main challenge of collective systems is that, in most cases, producers delegate their obligations to Producer Responsibility Organizations (PROs) by paying fees that are calculated according to each producer's share of products placed on the market and that do not take into account product design.

With constant waste generation becoming an ever more pressing issue, the European Commission is seeking to incorporate better incentives into EPR policies, following mainstream economists' recommendations according to which public action consists in correcting market failures by introducing incentive mechanisms (e.g. Laffont and Tirole, 1993; Hahn, 2000). It will therefore soon be mandatory to adjust producers' fees according to product design (i.e. to modulate fees), as provided for in Directive 2008/98/EC (European Commission 2017) and the EU action plan for the circular economy[1] which reinforces the implementation of eco-design (Kunz et al. 2018). Mechanisms for differentiating fees exist in various countries in the packaging sector (Eunomia 2020). However, very little work is devoted to their effectiveness and implementation, especially for more complex products such as in the waste electrical and electronic equipment (WEEE) sector, where environmental impacts are high and could be improved through appropriate eco-design strategies (Atasu, 2019).

This paper provides a comprehensive analysis of the introduction of a fee differentiation mechanism known as "eco-modulation" scheme as part of the EPR policy in France[2]. Our study is based on two approaches in the literature on policy instruments. First, to go beyond the normative debate on whether "command and control" instruments or market-based instruments may be more effective in stimulating economic actors to innovate for better environmental performance, De Rio et al. (2010) propose a comprehensive approach to analyzing the framework conditions within which instruments are embedded. Howlett also points out that "the kind of precision required" for maximizing instrument design choices "will never be achieved […] because the utility of the instruments themselves, […] is heavily context dependent" (Howlett, 2004). This suggests that we should not only focus on the optimal design

[1] Closing the loop - An EU action plan for the Circular Economy - COM(2015) 614 final https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52015DC0614

[2] For a historical study of the electronic waste sector in France, we can refer to Micheaux's thesis (2017), which demonstrates the value of collective organization and the role of PROs in France in the development of waste management.

choices of an instrument, but also on its interaction, complementarities and conflicts with the existing system (Howlett, 2004). In complex policy problems, new policy design focuses on "bundles or portfolios of tools and the interactive effects" (Howlett, 2015). In doing so, it is not relevant to evaluate an instrument in isolation, but it should be seen in the context of an overall policy.

In this sense, the French case is interesting not only because France was a pioneering country in experimenting eco-modulation, but also because this incentive scheme is part of a broader collective organization—i.e. EPR schemes—in which PROs play a key role. Indeed, we will see that in France EPR schemes are regulated through collective governance involving PROs, public authorities, individual producers, consumer representatives and other waste sector stakeholders.

Second, in addition to the attention given to complex policy mixes in the literature, another research stream focuses on a dynamic view of policy-making, i.e. on how these mixes are transformed over time (Grabosky, 1994; Gunningham et al. 1998 [Howlett, 2004]). In this perspective, besides the concept of bundles, we mobilize a second concept known as "adaptive policy-making". The origin of this concept can be attributed to Dewey, who proposed that "policies [should] be treated as experiments, with the aim of promoting continual learning and adaptation in response to experience over time" (1927 [Swanson, 2010]).

This concept is most relevant in highly dynamic sectors where technology is changing rapidly. Such sectors need policy designs to be more flexible in order to foster and monitor innovation. This is the case in the electronics sector, where a major challenge is to reduce environmental impacts through the eco-design of products. This approach requires that "learning and adaptation of the policy be made explicit at the outset and the inevitable policy changes become part of a larger, recognized process" (Walker and Marchau, 2003 [Swanson, 2010]). Policies must be designed to allow revisions and updates. By deconstructing the way eco-

modulation has been set up and the regulatory framework applicable to this tool, we will reveal the adaptability and potential for development of this tool within the broader French EPR policy.

Indeed, these two concepts provide a contextualized assessment of eco-modulation performance. At first glance, eco-modulation seems to have had very few direct effects on encouraging producers to eco-design their products. But taking a more adaptive and dynamic view of policy-making, to what extent does it change the whole assessment? Are there any indirect effects, i.e. effects that occurs as a result of broader framework conditions such as the organization of the EPR system and adaptive policy making in which eco-modulation takes place? What we call indirect effects is equivalent to the term “spillover” used by economists, which can be defined as an event resulting from an economic measure in an initially unrelated context (Görg and Greenaway, 2001).

This paper analyzes the French WEEE sector case, which illustrates adaptive policy-making based on collective governance and responsibility. Our research focuses on the collective aspect and possible results. We first want to give a comprehensive analysis of the French EPR system and insights on eco-modulation implementation. Second, we explore the extent to which framework conditions may stimulate collective innovation, which led us to the following question: Beyond the direct effects of eco-modulation, what are the indirect effects produced by the collective strategy implemented in France? This question implies going beyond a narrow view of public action based solely on considering the direct effects of incentives to encompass broader theoretical discussions concerning the conditions of collective action. In this perspective, this paper echoes a recent analytical opening by Atasu that revisits the assumption that collective systems generate less incentive for eco-design (Atasu, 2019).

2. Material and methods

In keeping with Howlett and authors of the new design policy framework, we took a broader approach to the assessment of eco-modulation. To consider the whole picture, we conducted a longitudinal qualitative study with several actors in the e-waste value chain (PROs, producers, recyclers) with a focus on their long-term strategies. Longitudinal analysis is well adapted for case studies as it enables to explore "the contexts, content, and process of change together with their interconnections through time" (Pettigrew, 1990). We followed the five-stage research and dissemination process presented by Stuart et al. (2002), see Figure 1.

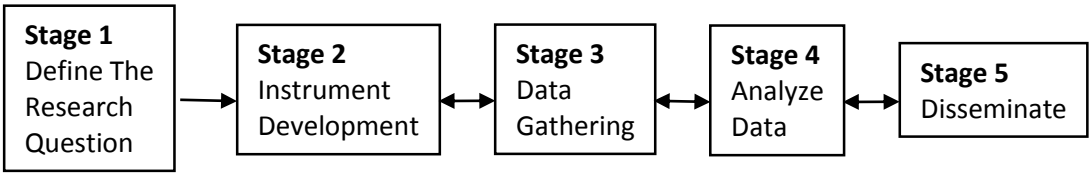

Figure 1: The Five-Stage Research and Dissemination Process (Stuart et al., 2002) with back and forth steps

Stage 1: The research question is: Beyond the direct effects of eco-modulation, what are the indirect effects produced by the collective strategy implemented in France?

Stage 2: Interviews and document analysis concerning all stakeholders in the WEEE were used to conduct the longitudinal study.

Stage 3: For data collection, we carried 68 interviews over five years in order to understand the French model's governance dynamics (see Table B.2 for more details on the interviews). We interviewed actors from the public sector, PROs, producers and recyclers to understand the effects of the EPR framework regulation on their experience of eco-modulation. In parallel to these interviews, we were able to access in-house documents belonging to a PRO known as ecosystem®, including a survey on the acceptance of eco-modulation by its members[3]. We also monitored the work of the European Commission and the French government on EPR systems.

[3] The survey is confidential. As we did not conduct the survey ourselves and were only able to see the results, we were not able to analyze the method and cannot provide the survey instrument.

At both European and French levels, we were able to participate in workshops bringing together all the stakeholders on the major issues in the EPR sectors, such as the modulation of producers' fees. The large interview panel allowed us to use data source triangulation (Patton, 1999). The information gathered from the interviews and workshops were completed with secondary sources.

Stage 4: Data analysis of the interviews and workshops is described in Table 1. A cross-reference code links some findings to the original data sources. We also analyzed data from secondary sources: French regulations and their evolution to reconstruct the implementation of the EPR principle in France and the context of eco-modulation, studies at national and European levels to understand the rationale behind policy choices, literature search on the key words: EPR and eco-design incentives, policy mixes and adaptive policy-making (see Table 1). The duration of the study allowed us to conduct back and forth between stages to refine the results.

Stage 5: The article was submitted to the reviewers of the Journal of Cleaner Production, which helped to improve the presentation of the method and results.

Table 1: Table summarizing key elements of the methodology.

Document	Description	Type	#
Interviews	Semi-directive interviews with actors from ecosystem®, producers, other actors in France and Europe involved in EPR. Face-to-face or by phone. Note-taking on the fly with no recording. Detailed report drafted immediately after the interview.	All stakeholders	68
		PRO	25
		Producer/distributor/federation	15
		Public actor/representative	4
		Consultant	4
		Research	8
		Recycler	7
		Social economy	4
		Journalist	1
Interviews and notes during visits	Visits to recycling sites from 1/2 day to 1 day. Note-taking on the fly with no recording. Detailed report drafted immediately after the visit and meetings.		13
Interviews and reports at conferences	Note-taking on the fly with no recording. Detailed report	CWIT 2015, Pollutec 2015, World efficiency 2015, J3P 2015, ProSUM 2016,	≥15

	drafted immediately after the conference.	Workshop on EPR European Commission 2019, EPR International Forum 2019, etc.	
Studies/reports/information documents/guides on the waste sectors in France and abroad	From actors in France and abroad (PRO, French environmental agency, federation of recyclers or producers, consulting firms, associations, NGOs, universities, etc.)		≥20
Legal documents	Specification documents, French laws, French parliamentary reports, EU directives, reports/guides from the European Commission, etc.		≥30
Confidential documents	In-house documents (survey) Documents revealing information on external actors		≥5
Literature search	- EPR and eco-design incentive(s) - Policy mix(es) - Adaptive policy-making		≥20

The paper proceeds as follows. First, we will explain the specificities of the EEE (Electronic and Electrical Equipment) sector that generate difficulties in differentiating fees. Next, we will present our results on the French case. Our analysis distinguishes between direct and indirect effects. We show that eco-modulation has little direct impact, but we identify indirect effects that reveal the potential of collective organizations and the role of PROs. This will lead us to investigate the activities of PROs and their role in linking individual and collective responsibilities. In parallel, we will discuss the potential of eco-modulation within a broader EPR policy.

3. Background

3.1. An introduction to eco-modulation and the specificity of the EEE sector

One solution to the limitation of weight-based proportional allocation mechanisms in collective systems that is regularly mentioned in the literature is the establishment of individualized cost allocation mechanisms (Mayers et al. 2013; Gui et al. 2013; Gui et al. 2016b; Atasu 2019).

Different mathematical models were proposed in the EPR literature (Mayers et al. 2013, Pires et al. 2015). The authors call for more testing of their models in future work. Eco-modulation is an example of an individualized mechanism, as it differentiates producers' fees according to their eco-design actions.

Fee differentiation has long been recognized as an incentive to improve product and packaging design (Bio by Deloitte 2014, OECD 2016, Eunomia 2020). First models concerned packaging and appeared in various countries shortly after the implementation of EPR packaging legislation (e.g. Germany [Mayers, 2007], France [Cour des comptes, 2015]). Packaging producers had to finance waste management not only according to the number of packages placed on the market, but also according to the average weight, the type of materials and their recyclability.

In France, fee differentiation has been implemented for far more than packaging, including furniture, textiles and footwear, paper, batteries and EEE. Most of the criteria chosen in France concern the type of material and its recyclability. For example, furniture made of more than 95% FSC[4]- or PEFC[5]-certified solid wood, without upholstery, benefits from a "bonus", i.e. a fee reduction of about 15%[6]. However, criteria can also be related to consumer awareness. An 8% bonus is granted for packaging with comprehensive sorting instructions[7], for example. Criteria can even concern product durability. Producers of tee-shirts, jeans, sheets or sweaters, for

[4] The Forest Stewardship Council is an organization that works to promote the sustainable forestry worldwide by setting standards in addition to managing certifications and accreditations.
[5] The Programme for the Endorsement of Forest Certification is a global alliance of national forest certification systems.
[6] https://www.eco-mobilier.fr/wp-content/uploads/2018/09/guide_eco_participations_2018_v11-1.pdf (last downloaded June 12, 2019).
[7] https://www.citeo.com/sites/default/files/2017-10/Tarif2018_Citeo_Emballages_sept2017_0.PDF (last downloaded June 12, 2019).

example, can benefit from a 75% bonus if their products meet the criteria of dimensional stability (less than 5%, ISO 5077 standard) and wash resistance of the dyeing process[8].

Identifying these criteria is a real challenge, particularly in the e-waste sector because the products are very complex (Walls, 2006; Mayers et al. 2013). This is one reason why there are very few examples of fee modulations in this sector. Besides France, producers in Spain that comply with the standard [IEC TR 62635:2012] proving the recyclability of their products may benefit from lower fees [ADEME, 2016]).

In France, eco-modulation in the EEE sector was implemented in 2010[9]. Our analysis of the French case reveals that the existence of a link between the modulation of fees and eco-design is not straightforward. Since EEEs are highly designed and engineered products (Walls, 2006) that are subject to rapid obsolescence, it is difficult to determine stable criteria for the long term. In addition, it is not clear whether fees should encourage the development of recyclable and/or sustainable products (maintenance, repair) (Huang et al. 2019). Identifying eco-design criteria that offer the most environmental benefits is a major challenge that requires among other things more transparent life cycle assessment results (Astrup et al. 2018) or a cradle-to-cradle diagnosis (Bjørn and Hauschild, 2013) in order to avoid pollution transfers between life cycle stages and locations. As Atasu has highlighted, the durability-recyclability trade-off is not clearly established due to a lack of empirical research (Atasu, 2019).

The increasing emphasis on the circular economy "as an overall strategy for end-of-life strategies" (Pigosso et al. 2015) does not make things any easier. The interviews and the workshops we attended revealed that stakeholders in the EPR sectors disagree as to whether

[8] https://www.ecotlc.fr/ressources/Documents_site/Eco_modulation_textile_declarations.pdf (last downloaded June 12, 2019).
[9] Annex to the Decree of December 23, 2009 published in Official Journal no. 4 of January 6, 2010.

eco-modulation criteria should cover waste prevention. In France, the government decided to introduce criteria linked to the extension of the life span of electrical products in order to incentivize producers to design durable products and to engage in the circular economy transition[10] (e.g. the criterion on the availability of spare parts for a period of 10 years). The government's view was reaffirmed through the law on the circular economy passed in 2020 extending the principle to other categories of products[11]. In this respect, eco-modulation is becoming an economic instrument to support multiple design strategies that can help close resource flows: repair and maintenance; reuse and redistribution; renovation and reconditioning; recycling. Design strategies thus tend to cover multiple objectives: incorporating recycled materials, extending life-time usage, facilitating recycling and dismantling, improving repairability and maintainability, eliminating pollutants, and so on.

Assessing the direct effects of fee differentiation on producer decisions is a huge challenge as many factors come into play (time of use by the consumer, rapid technological change, changing market shares). In other words, a traditional "all things equal otherwise" analysis is not relevant when evaluating eco-modulation's effectiveness because design changes are constant and not necessarily related to eco-modulation incentives. In keeping with Howlett and the new policy design orientation, it is not relevant to evaluate eco-modulation as an isolated instrument; it must be considered instead in the context of the EPR framework.

3.2. The collective organization of the French EPR system

PROs are collective organizations that are regulated to a greater or lesser degree by the national government or, at subnational level, by states and provinces depending on the

[10] Specifications annexed to the Decree of December 2, 2014 on the approval procedure and specifications for PROs in the electrical and electronic household equipment waste sector pursuant to Articles R. 543-189 and R. 543-190 of the French Environment Code.
[11] Law 2020-105 of February 10, 2020 on Anti-Waste and Circular Economy.

country. In France, PROs are at the heart of national EPR legislation, which gives them a particular role compared to other waste sector stakeholders and an intermediate status between the public and private sectors. Under French law, PROs can only be created and governed by producers. Furthermore, they have a specific legal status: they are private non-profit companies with a public mission statement. Their missions are defined in a legal specification document for a period of six years. The WEEE management system in France is organized by two PROs: ecosystem® (from the merger of Eco-Systèmes and Recylum) and Ecologic.

The role of PROs is to assume their members' EPR obligations and achieve the objectives negotiated with the State. A particularity of the French system is that, in addition to recycling targets, the State defines the rules that will guide the action of PROs after a single participatory decision-making process involving several stakeholders (NGOs, consumer associations, producer and recycling organizations, public authorities). Stakeholders are organized into an accreditation commission. The missions and objectives of the PROs, defined in the legal specification document, are negotiated and discussed every six years in the accreditation commission before the State's final decision. The mission statement establishes and defines the relationships that PROs must maintain during their six years' accreditation period with local authorities, various operators (in charge of collection points, transport, treatment), social economy actors, the EPR coordinator that coordinates the PROs of WEEE, public authorities and their members. Figure 1 below represents the different contracts that PROs have to establish with these stakeholders. First, their legal accreditation authorizes them to establish membership contracts with producers. Second, in order to carry out their mission, they must establish contracts with processing operators to last at least three years. Third, they must establish financial agreements with communities to offset the costs of collection. Last, they are obliged to support the social economy by agreeing to make available to them reusable waste.

The specificities that can be highlighted are the minimum duration of contract with treatment operators and the association with the social economy.

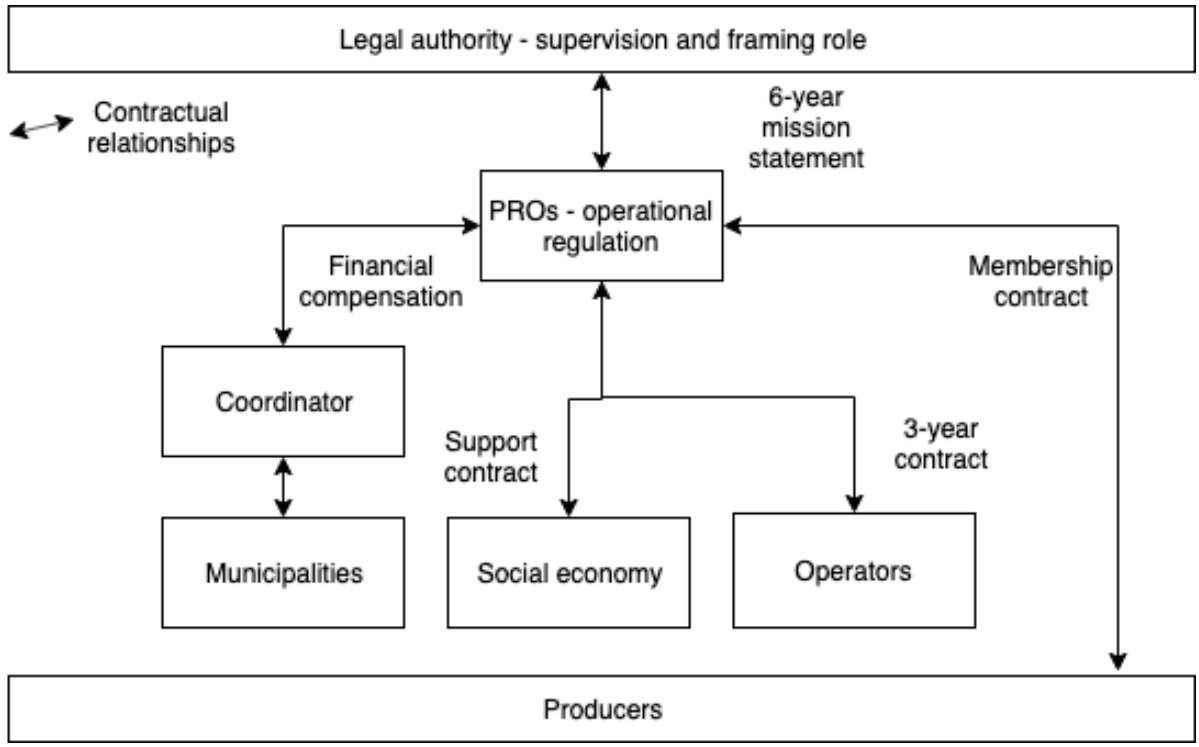

Figure 2: Overview of contracts that structure the WEEE sector in France as of 2019.

According to the European e-waste Directive (Directive 2012/19/EU), producers must either develop an individual waste management system or subscribe to a collective system. To benefit from economies of scale, most producers have decided to join a group plan by paying a membership fee. In France, PROs cannot set the amount of the fee without the State's agreement. Since 2010, the financing of electronic waste management has evolved because the French government has imposed a modulation of the fee to be applied by PROs to their members.

The French approach to eco-modulation is based on a bonus/malus system. Depending on whether or not producers meet predefined criteria (we will see later how they are chosen), they can either receive a bonus, i.e. a reduction in their fee, or be subject to a malus, i.e. an

increase in their fee. The criteria for maluses target practices that are no longer justified in the light of current knowledge and technologies. Maluses are a kind of penalty that aim to encourage the spread of good practices reachable by producers. On the other hand, the criteria for bonuses target ambitious good practices. Thus, bonuses reward pioneering producers. This raises the question of how the criteria are defined and how the bonus and malus rates are set. The criteria cannot be too numerous from the outset nor the rate too high to risk rejection of the measure as soon as it enters into force. We will now look at how the bonus/malus criteria and rates have been gradually introduced into the French WEEE sector through an adaptive policy.

4. Results and discussion

4.1. Eco-modulation implementation in France: two phases

4.1.1. First step: setting up a revisable and adaptive scheme (2010-2015)

Our interviews enabled us to reconstitute the history of the eco-modulation system's implementation. Between 2008 and 2009—prior to its implementation in 2010—intensive discussions took place between stakeholders under the leadership of the State. Indeed, a key feature of eco-modulation implementation is that the criteria were chosen by all the stakeholders on a consensual basis (R3, PRO10, PRO11). Early discussions were rather conflictual, but the various actors gradually tended towards a shared vision of what eco-design is. The eco-modulation system was designed to be dynamic and above all to allow revisions at the changeover between accreditation periods (every six years). For the first phase, the scope of the criteria was deliberately limited because this was an unprecedented new experience.

This first phase introduced only six criteria[12], based on European Eco-labels (Joltreau, 2018). Each criterion concerned only one type of product with a relatively high market share: equipment with refrigerants, vacuum cleaners, laptops, televisions, and lamps.

The initial criteria targeted specified problematic substances and materials (see Table B.3, *Criteria for modulating the contribution of the first implementation period,* and Table 2 below for examples of criteria). If plastic parts weighing more than 25 grams contained brominated flame retardants, for example, the producer would pay 20% more than if they did not. The objective was to encourage producers to use fewer hazardous substances in their products. A necessary consequence was that PROs had to inform their members and develop teaching skills to help them understand each criterion.

Table 2: Examples of criteria in the first phase (2010-2015).

Equipment	Modulation criteria	Modulation
Equipment with refrigerants	Presence of refrigerant with GWP[13] > 15	+ 20%
Vacuum cleaner	Presence of plastic parts > 25 g containing brominated flame retardants	+ 20%
Telephone	Absence of a universal charger	+ 100%
Lamp	LED light only	- 20%

4.1.2. Second step: scaling up and encouraging prevention and durability (2015-2019)

[12] Annex to the Decree of December 23, 2009 approving an organization for the removal and treatment of electrical and electronic household equipment waste pursuant to Articles R. 543-189 and R. 543-190 of the French Environment Code, published in Official Journal No. 4 of January 6, 2010 and in Official Bulletin No. 2010-01 in the list of texts published in the Official Journal.
[13] Global Warming Potential.

As these criteria were increasingly mastered by producers, additional criteria were added in the most recent agreement (2014)[14] to cover more products (13 categories in all, see Table B.4, *Criteria for modulating the contribution of the second implementation period,* and Table 3 below for examples of criteria). These criteria are the result of in-depth discussions between all stakeholders (R3, PRO2, PRO10). What is new is that most of these more recent criteria concern environmental aspects beyond the end of life, i.e. prevention and life extension. Producers of washing machines and dishwashers, for example, can benefit from a 20% discount per product fee if they are able to supply spare parts for at least 11 years. Other criteria include the provision of technical documentation for authorized electrical repairers, the incorporation of post-consumer recycled plastic, mutually compatible software updates, the absence of paint and coatings incompatible with the recycling and reuse of plastic parts, and the ability to completely dismantle the product with standard tools available on the market.

Table 3: Examples of criteria in the second phase.

Equipment and modulation	Modulation criteria	Price (€ excl. VAT)[15][16]
Washing machine Dishwasher - 20%	Provision of essential parts for equipment use for 11 years	8.33 6.67
	or Incorporation of post-consumer recycled plastic (minimum of 10%)	
Vacuum cleaner + 20%	Presence of plastic parts > 25 g containing brominated flame retardants	0.83 1
	or Failure to provide technical documentation for authorized electrical repairers	

[14] Specifications annexed to the Decree of December 2, 2014 on the approval procedure and specifications for PROs in the electrical and electronic household equipment waste sector pursuant to Articles R. 543-189 and R. 543-190 of the French Environment Code.

[15] Rates applied by the ecosystem® PRO.
[16] Original price in black. Modulated price in color.

	or Unavailability of essential spare parts for equipment use	
Laptop - 20%	Absence of paint and coatings incompatible with recycling and reuse on plastic parts > 100 g	0.42 0.34
	and Incorporation of post-consumer recycled plastic (minimum of 10%)	
	and Product upgrade with standard tools, including memory drives, chips and cards	
Telephone + 100%	Lack of standardized connections (charger and other connections)	0.02 0.04
	or Lack of mutually compatible software updates, essential for basic use of the device	

Producers have found it difficult to take these new criteria into account (PRO2, PRO11, Prod5). According to both PROs, the complexity of this second phase is due to the greater variety of criteria following the introduction of new criteria, and on the scope of modulation, which now concerns more products (18 compared to six previously).

4.2. Effects of the first years of eco-modulation experiment

This first experiment was very interesting to analyze as it had no precedent in the WEEE sector. This section analyzes the limited direct effect of eco-modulation while highlighting a positive impact: i.e. the measure's social acceptance by stakeholders.

4.2.1. Few direct effects: weak economic incentive

Modulation represents a very small portion of the price of a product. The most striking example is that of mobile phones. Both PROs apply a fee of €0.02 per mobile phone[17], so even if a 100%

[17] Scale of fees applied by Ecologic: https://www.ecologic-france.com/images/Ecologic_-_Bareme_EEE_menagers_au_01032017.pdf

malus applies to producers who do not comply with the modulation criteria, this amount represents only €0.02 per product placed on the market. This penalty is insignificant compared to the price of a new smartphone. The situation of packaging is quite different, however. As packaging does not have a substantial price value, a 50% malus can significantly change the price of the package. A 50% discount on the fees for a plastic water bottle represents about 1.6% of the product price[18], for example. In France, modulated fees have proven to increase the use of better eco-design packaging (Eunomia 2020).

With the recent Circular Economy Law in France (2020), the mechanism should be amplified. When the objectives are not achieved, the Law suggests increasing the level of modulations and allows modulation rates higher than 100% of the fee, but not exceeding 20% of the selling price of the product. For mobile phones, a modulation of 10,000% would be equal to €200.

Still, another weakness is that France does not represent a significant market share for certain producers. Why should global producers such as Apple or Samsung change their product design and offers when France only represents a tiny part of their revenues? As a result, the French malus of 100% concerning mobile phones that are incompatible with universal chargers did not prevent Apple from continuing to produce mobile phones with specific chargers.

4.2.2. A positive impact: the measure's social acceptance

One positive impact is the measure's social acceptance by stakeholders. From public authorities' point of view, the eco-modulation system is apparently simple to implement. The

Scale of fees applied by ecosystem®: https://www.eco-systemes.fr/uploads/documents/1_R%C3%A9glementation/1_DEEE/0_Bar%C3%A8me%20des%20%C3%A9co-participations%20en%20vigueur/Bareme_2018_HD.pdf

[18] The calculation is based on a water bottle that costs €0.30 with a fee (without modulation) of €0.0096 (Declaration manual, Eco-packaging, 2016, http://www.ecoemballages.fr/declarer).

complexity mentioned above is invisible for public authorities since they have transferred administrative and auditing costs to the PROs. The application of the differentiated fees to individual producers appears at the time of the producers' annual declarations of products put on the market to the EPR register, which are already mandatory. Furthermore, the PROs also monitor the application of these differentiated fees. Thus, for public authorities, the introduction of eco-modulation does not require the implementation of a new administrative scheme. This apparent simplicity results in a low implementation cost for the government. Furthermore, it is adaptable as it can be revised every six years (between two accreditation periods) to take into consideration lessons learned from experience.

The interviews revealed that, despite the complex application of some criteria, the implementation of French eco-modulation was relatively easily accepted due to the principle of consultation and multi-stakeholder discussions on the selection of criteria. “The criteria are relevant, realistic, and in line with the discussions” (Prod6). However, the choice of criteria is time-consuming for all participants, as the discussions can be rather lively (PRO2).

Even though the modulation scheme has been added to the existing reporting system, producers still face additional administrative burdens (Joltreau, 2018). This may discourage them from trying to obtain bonuses or avoid penalties. Indeed, the audits conducted by the PROs revealed, for example, that documentation proving eligibility for a bonus or exemption from a malus is difficult to find. “Searching for proof of the absence of flame retardants in our products made in Normandy is complex even though it is a practice that has been in place for a long time. In some cases, the effort to demonstrate compliance is not profitable for the company” (Prod5).

In this context, PROs have an important role to play in monitoring the eco-modulation system and helping their members understand the reporting criteria and procedure. During implementation of the French eco-modulation system, PROs conducted audits that were then used to teach members how to report correctly and thus encourage collective learning processes.

4.2.3. Next step: reinforcement of eco-modulation and deployment at EU level

To reinforce the impact of modulation, various studies have recommended that public authorities increase fees in order to provide an economic incentive (Didier and Sittler, 2014; Longeot and Blandin, 2016; Vernier, 2018). In addition, as the fee is visible on the price of a product, a greater difference between a product eligible for a bonus and a product penalized by a malus could have an impact on consumer choice and therefore be an additional incentive for producers to eco-design.

State approvals of PROs of WEEE end in late 2020[19]. In view of their re-approval, the question of renewing the criteria is important. Which ones should be removed and which ones should be added? To be able to answer these questions more precisely, an in-depth qualitative study is required to understand where producers are in their level of maturity in eco-design. The PROs have therefore launched a joint study, the findings being expected by 2021.

Finally, the impact of eco-modulation will remain very limited if no European policy is adopted. Producers do not have a national market share but sell in different European countries if not to say worldwide. This is expected to change as the modulation of producers' fees becomes mandatory under Community legislation, as provided for in Directive 2008/98/EC, which was

[19] With the COVID epidemic, the re-approval procedure has been delayed.

amended in 2018 (European Commission, 2017). In this context, it is essential to harmonize criteria at EU level in order to avoid multiple national requirements. Eco-modulation "will […] only work if the incentives and the criteria for defining good design are harmonized across EU Member States, since no producer will change the design of its products to satisfy the requirements of one single Member State" (Kunz et al. 2018). With this in mind, the European Commission mandated a study that provides recommendations for implementation based on current fee differentiation systems in Europe (Eunomia 2020).

4.3. Indirect effects due to collective organization

The direct effects of eco-modulation are not visible in the short term. As it is a new strategy, eco-modulation must be assessed over the long term, taking into account the regulatory and organizational framework within which the measure is implemented, and collective learning revealed in the course of action. “We can't say that it doesn't work, but it's not possible to quantify the effects yet. Looking for a result today would be misunderstanding the development cycle of a product in a company” (PRO 20). With this in mind, our study—based on qualitative information—reveals some interesting indirect effects of eco-modulation[20]. Indeed, the analysis of the interviews and the history of the implementation of eco-modulation both shed light on the measure’s incentive potential when carried out by a collective organization building up knowledge and competence.

Contrary to the common assumption that “collective EPR implementations mute incentives to design for the environment” (recently revisited by Atasu, 2019), the authors assume that collective systems can actually improve EPR performance and support eco-design. Not only

[20] As stated previously, by “indirect” effects we mean effects occurring as a result of the framework’s conditions, i.e. the EPR system.

does a collective organization allow for greater profitability, aggregation of waste that secures the supply of recyclers (Atasu, 2018) and a more efficient network (Gui et al. 2016a), but it also fosters collective knowledge and a better alignment between production and recycling. Indeed, collective systems can produce better results than individual systems by linking the activities of producers and recyclers, thus improving the link between product design and processing choices (Gui et al. 2018; Atasu, 2019).

In reality, eco-design is not an isolated activity based on the individual commitment of companies, but forms part of broader industrial and business ecosystems that make it possible. A specific feature of circular economy business models is that they are based on partnership and cooperation (Lewandowski, 2016; Lüdeke-Freund et al. 2019), and require the development of infrastructure and new skills in the value chain that do not exist in a linear economy (Ellen MacArthur Foundation, 2013; Bicket et al. 2014). Designing a new business model based on an eco-design approach implies changes in the value chain. Bearing this in mind, PROs should help to organize collective actions, especially in the EEE sector where products are very complex and subject to rapid change (Kang and Schoenung, 2004).

4.3.1. The consultation process and collective learning

One of the main contributions of eco-modulation in France is based on the consultation process that promotes collective knowledge and the mobilization of PROs to improve the value chain. The discussion on which criteria to choose was very productive and helped to create a dialogue that has been appreciated by stakeholders (OECD 2016, 249-256). It has also helped to align stakeholders' understanding of and interests in product design. Most importantly, recyclers were able to share information on concrete recyclability issues. “A good business sector is one where communication is abundant. Where we talk to each other more” (Re1). To

raise awareness among its members, the ecosystem® PRO invited producers to visit recycling sites to understand the difficulties of waste treatment. This illustrates one of Swanson's key principles for an adaptive policy, “multi-stakeholder deliberation”. The term implies “a collective and collaborative effort to examine an issue from different points of view in order to share learning and build consensus prior to taking a decision” (Swanson et al. 2010).

4.3.2. Role of PROs: linking individual and collective responsibility

PROs are key actors in the implementation of EPR legislation. For Røine and Lee, "PROs can be considered as an institutional innovation", that is as "a potential driver for technological change and innovation through subsidies and learning, as well as generally creating arenas for cooperation and focus on these issues" (2006). In some countries, such as in France, PROs have an influence on treatment choices by deciding where to direct the electronic waste they have collected. They can also encourage their members to eco-design by providing them with tools and guiding them in their design choices.

4.3.2.1. Development of tools and knowledge

An indirect effect of eco-modulation is that it has encouraged French PROs to develop practical tools to help their members comply with the new criteria.

An example is the online REEECYC'LAB tool developed by ecosystem®[21] to help producers (their members) assess the recyclability of their products. The high added value of the tool is that it is based on a significant data set relating to the entire sector. The data was collected by ecosystem® thanks to their central position between producers and recyclers. The tool uses a

[21] https://reeecyclab.eco-systemes.com/?locale=en

database ecosystem® has developed that refers to more than 60 materials and covers all operations, from the collection of equipment to the final destination of the materials. The tool also uses data collected following feedback from recyclers on processing difficulties related to the design of certain products. In practice, members enter information about the materials, components and assembly of their products. The REEECYC'LAB tool then assesses the product's recyclability and summarizes the results in a customized report identifying what could be modified to improve the product's recyclability. It proposes alternative design solutions, such as using more recyclable materials or fewer complex joints to facilitate recovery and also suggests using recycled plastic whenever possible.

There has been no study to assess the number of eco-design approaches initiated as a result of using the tool, though ecosystem® evaluates its tool through the informal feedback it receives from its members. When this tool came out, several producers with their own in-house tools appreciated the possibility of being able to compare their results and have been able to discuss the methodology with the PRO and subsequently upgrade their own tools. Communication about the tool and an explanation of its use helped to raise awareness among other members not interested in these topics. One of the producers we interviewed pointed out that the advantage of this tool lies in the comprehensive database that guarantees the robustness of the results and in the (external) legitimacy of a tool validated collectively, making it more credible among customers than an in-house tool. This producer considers that the collective approaches developed by ecosystem® are very useful. He also appreciated the training associated with the tool and encourages his design teams to use it (at the time of the interview, at least four teams had already used it) (Prod12).

It is unlikely that such tools, based on aggregated data, can be developed without the intervention of a collective organization because it is also unlikely that producers would want

to make such an effort to produce collective knowledge that benefits everyone. The indirect effects identified are related to the creation of collective knowledge to be shared. The understanding and appropriation of the criteria through the consultation process and the development of tools by the PROs are two examples. In the end, this knowledge and these tools benefit individual producers who will be sensitized to eco-design and supported in their project.

4.3.2.2. Producing common rules and encouraging collective action

An analysis of the activity of PROs in France suggests that they play a crucial role in linking individual and collective responsibility (for a full analysis see Micheaux, 2017). Indeed, in contrast to their usual description (Lindhqvist and Lifset, 2008; Van Rossem, 2008), French PROs have many tasks that go beyond the responsibility of financing and organizing waste collection and treatment. They are more than just "service providers to producers", but actually "embody the producers' community". They are responsible for "all the operational decisions taken regarding the way the scheme is run" (OECD, 2016, 249-256).

Since the first mission statement, the number of missions and responsibilities mandated to PROs has actually increased dramatically. The first mission document published in 2005 contained 15 pages compared to 47 in the last one, published in 2014 (Vernier, 2018). Specifications have been added concerning the need to further investigate recycling treatments (plastics, flame retardants, rare earth elements, etc.), to develop new collection channels, to become more involved in the social economy, and so on.

In addition to eco-modulation, other important elements of the French system help to promote innovation and eco-design. One element that emerged from our interviews with actors of EPR

systems in Europe is the obligation for French PROs to use 1% of their turnover to fund research (Prod8). This mandatory financial support is an interesting way to stimulate innovation. Another element is that the responsibility of French e-waste PROs is not limited to financial aspects: having full operational responsibility from the collection to final treatment of hazardous waste encourages them to influence processing choices and support innovative valuation solutions. Finally, French PROs are created and administered exclusively by producers. It is nonetheless the collective governance within the accreditation commission that manages the various EPR systems (packaging, WEEE, end-of-life vehicles, etc.) in which all stakeholders are represented, including PROs. The accreditation commission discusses the specifications to be applied to PROs. Proposals for revision may be submitted by all stakeholders, including producers themselves. It is stated that "the [French] collective governance is seen as a critical element of success, and all stakeholders consider that the dialogue created and sustained through the scheme per se has a tremendous influence on its overall performance" (OECD, 2016, 249-256).

The French EPR scheme moves forward due to the participation of PROs in producing common rules. Eco-design thinking needs collective governance to support projects, getting them off the ground and ensuring their sustainability over time, in particular to define reporting rules, audit protocols, performance criteria, etc.

5. Conclusion

Despite broad enthusiasm about the potential of fee differentiation as an incitive to improve product and packaging design (Bio by Deloitte 2014, OECD 2016, Eunomia 2020): “It is difficult to determine the extent to which fee modulation to date has contributed to stimulating changes to product or packaging design” (Eunomia 2020). “Data is lacking to assess impacts of EPR schemes” (Watkins et al. 2017). Our analysis of the French case in the WEEE sector is a

contribution to filling this gap. However, it does not reveal quantitative direct effects but rather suggests that eco-modulation may have relevant indirect effects when it is combined with other instruments in a bundle as part of an adaptive EPR policy. Contributions, findings and recommendations are resumed in Table 4.

Table 4: Contributions, findings and recommendations.

Contributions	Findings	Recommendations
A comprehensive analysis of the French EPR system and eco-modulation scheme.	Main highlights: the EPR governance, the accreditation process, the role of PROs, the legal specifications, the bonus/malus system.	Precaution in the development of the mechanism in other waste sectors and on a European scale. Further work is needed: - A quantitative evaluation of the effectiveness of eco-modulation is necessary. - To be compared with other policy measures.
Insights on eco-modulation implementation.	No immediate direct effects of the eco-modulation mechanism. Main highlights: long term consideration, implementation steps, role of PROs, consultation process and careful integration with other instruments within a coherent and adaptive policy. Success factors: social acceptance, consultation process.	
What are the indirect effects produced by the collective strategy implemented in France?	Indirect effects observed: collective learning, development of tools and knowledge, role of PROs in linking individual and collective responsibility.	

Practically, the research gives insights on how to implement eco-modulation as part of an adaptive EPR policy framework. Eco-modulation implementation should be considered over the long term, as its legitimacy for stakeholders requires progressivity and revisability to adapt to complex and innovative products. Bonus and malus rates cannot be set at a maximum level from the outset. The actors should be given time to adapt. Once the measure is accepted and legitimized, public authorities have a greater opportunity to strengthen it. PROs play a key role in the implementation, support and evolution of the system. The observation of these framework conditions means that eco-modulation may only have a significant direct effect in the long term, as design cycles for producer and consumer behaviors do not change immediately in response to external incentives. How replicable is the measure in other countries? As we have shown, implementing such an instrument requires intense dialog with stakeholders to encourage its acceptability, a collective organization to organize its monitoring and deployment, as well as careful adaptation with other instruments within a coherent and adaptive policy. But most importantly, nothing indicates that the reactions of players in France to eco-modulation will be the same for other waste streams and in other countries with different EPR systems and economic cultures. This is why we invite further empirical studies considering both the long term and indirect effects.

More generally, this study echoes a recent analytical opening by Atasu that revisits the assumption that collective systems generate less incentive for eco-design (Atasu, 2019). In fact, rather than direct effects of eco-modulation, the collective organization of the French model has favored the emergence of indirect effects which are: collective learning, mainly through the criteria decision phase and during the audits conducted by PROs ; development of tools and knowledge driven by PROs such as the REECYC'LAB tool to evaluate products' recyclability ; and finally the role of PROs in linking individual and collective responsibility. These indirect

effects should facilitate, in a second stage, the dissemination of individual actions. Our analysis emphasizes the idea that eco-design is not based solely on the initiatives of individual firms but requires collective support that can be provided by PROs. In other words, there is a complementarity between individual and collective forms of action.

The performance of the French model depends on the ability of private actors to build a collective waste management framework that goes beyond individual responsibility mechanisms. This framework is based on a shared objective: to reduce pollution and recover waste. The French case provides an overview of how private actors can be involved through collective responsibility in the establishment and development of a waste prevention and management network and in the constant quest for better performance. It also highlights how an innovative collective organization can contribute to the transition towards a market of eco-designed products and services.

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*Declaration of Interest Statement

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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