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Getting rid of electrical and electronic equipment. Disposal decision and service life in the light of institutional economics

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Abstract: Within the product life cycle, the user's decision regarding disposal (i.e. getting rid of the product) at the end of the utilization phase plays an important role in terms of the service life of a device of electrical and electronic equipment (EEE). This article first examines from an economic perspective whether and how consumers dispose of EEE. The costs of ownership, the utility of ownership, and disposal costs are identified as the key determinants for this decision. It is the costs of ownership that is the actual cause of the will to dispose, and it is the latter two determinants that prevent the user from disposing of them. While the size of the utility of ownership is already frequently analyzed in the discourse on repair, the perspective of disposal costs seems to receive little attention. Therefore, the article continues to investigate the extent to which the determinant of disposal costs can be put to use for regulation towards a circular economy. To this end, three disposal paths (circular, official-final, illegal), the regulatory objectives associated with them (prevention, safe disposal) and the types of hurdles associated with the respective disposal path (pecuniary, transaction costs, spatial, sanctional) are considered. The result is a complex situation for regulation, not least because of a path of illegal disposal that is not easy to control, which makes it difficult to simply apply economic pricing instruments. Instead, the concept of 'hurdle management' is introduced, which offers a perspective for future regulatory efforts with regard to disposal costs.

Introduction

The sector of electrical and electronic equipment (EEE) faces major circular economy challenges. One key measure is to extend the service life of EEE so that fewer new equipment needs to be produced. Therefore, within the product life cycle, the user's decision regarding disposal (i.e. getting rid of the product) at the end of the utilization phase plays an important role. One reason for this is that this decision directly determines the circularity of the device to a large extent. Another reason is that the conditions of this decision certainly have an influence on the user's earlier decisions in the usage phase. Effectively, the disposal decision has a lot to do with the duration of a product's service life.

This article first examines from an economic perspective whether and how consumers dispose of EEE. It also examines the extent to which the determinant of disposal costs can be put to use for regulation towards a circular economy.

An economic conceptualization of disposal

The starting point for an economic analysis of disposal is the realization that ownership is not free – even if we were given the product as a gift. There are costs of ownership (C_{own}), simply because a physical thing takes up space. There is also the potential cost of tidying up and cleaning around something, as well es costs of care and maintenance. The amount of cost depends very much on the specific device. But it is certain that for physical items these costs are always positive. And this is the ultimate reason for the desire to get rid of something (Lersner 1981, 2).

Applying a rational choice approach, an interest in owning products in the first place lies in the fact that the consumer considers the utility of ownership to be greater than the costs of ownership ($U_{own} > C_{own}$). After a while, the utility of ownership may decline due to various obsolescence reasons (Mellal 2020), so that

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the ratio reverses ($U_{own} < C_{own}$). There is, in other words, a negative net value for the owner (Birn 1992, 419; Shevchenko/Danko 2023, 234).
However, the decision on disposal depends on one more category: the disposal costs (C_{dis}). This is because at least you have to bring the now unwanted EEE somewhere, which takes some effort. So, not only the ownership but also the disposal is costly to the user.
Against this background, the consumer opts for the disposal if (see also Figure 1):

$$(U_{own} + C_{dis}) < C_{own}$$

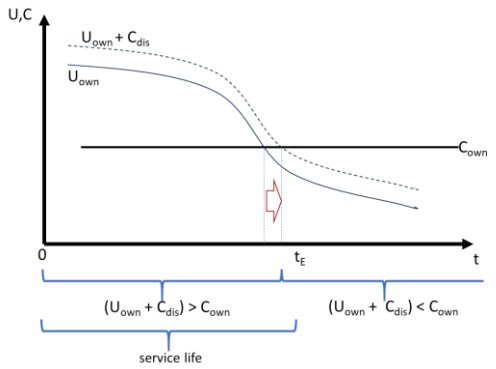

Figure 1. The user's disposal decision based on time dimension.

Consequently, while the cost of ownership (C_{own}) favors disposal, both the utility of ownership (U_{own}) and the disposal costs (C_{dis}) counteract disposal and extend the service life of the respective device. In this context, the discourse on repair and repairability addresses the strengthening of the utility of ownership (e.g. Reimann 2024). On the other hand, from an environmental economics perspective, increasing disposal costs (to the level of the social costs of disposal, see Pigou 1920) is also a useful regulatory starting point for extending service lives of EEE. Furthermore, the perspective is worthwhile insofar as demand on repair markets is weak. This goes as far as the increasingly relevant phenomenon of preferential obsolescence, where the devices still work, the user merely loses interest and consequently repair does not address the problem of a short service life at all (Packard 1960, 58; Kummer et al. 2022, 541). However, the idea of addressing the disposal costs is quite challenging due to the fact that there is more than just one disposal path.

Three competing disposal paths

To keep it simple, three disposal paths can be distinguished, that are available to the user.

1) The *circular* disposal path: The owner might sell the device or just give it away on second-hand markets for another person to use (Frahm et al. 2025). As a result, the service life of the device is extended. Apart from the continued use of the device, this appears the most 'sustainable' option.
2) The *official-final* disposal path: The owner wishes to dispose of the appliance without another use being anticipated and she uses the official channels provided for this purpose. The conditions for this path are laid down in particular in the European WEEE Framework Directive (Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment) and the corresponding national implementing legislation. A key requirement is that EEE should be disposed of separately from normal household waste (recital 14 and article 5 WEEE). This means that old devices can be treated properly during the after-use phase (Nuss et al. 2016, 38; Elmer et al. 2005, 2).
3) The *illegal* disposal path: To be more precise, it is a socially (including environmentally) harmful disposal that is reasonably made illegal by regulation. There are several forms of this category, namely the disposal by landfill, the unseparated disposal in the household waste, and the sale of appliances for dismantling with unfavorable environmental consequences. Which form of waste disposal is suitable depends, among other things, on the size of the device. Small devices fit into a household waste garbage can while large devices do not. In any case, an "improper disposal" (Kummer 2022, 542) on this disposal path is associated with ecological risks, especially in the case of electrical appliances.
From the user's point of view, these three disposal paths are each associated with different disposal costs. In the light of the rational choice assumption, the user will compare the costs C_{dis}^{circ}, C_{dis}^{off}, and, C_{dis}^{ill} and opt for the cheapest path (Bunde/Zimmermann 1988, 182; Birn 1992, 419). And based on the cheapest path the owner will not only decide *how* to dispose of it, but also *whether* to dispose of it. For in the light of the three disposal paths, the more precise version of the aforementioned condition about the 'whether' of disposal is:

$$(U_{own} + Min[C_{dis}^{circ}, C_{dis}^{off}, C_{dis}^{ill}]) < C_{own}\ .$$

To make it clear: The user's decision as to whether or not to dispose of the item is based solely on the disposal path with the lowest

disposal costs. This poses quite the challenge for regulation.

The institutional challenge of three competing disposal paths

The existence of three disposal paths poses a particular challenge for the institutional framework for EEE. Especially without the third, i.e. illegal disposal path, the problem of short useful lives could be solved relatively easily. One could apply the findings of neoclassical environmental economics and demand (higher) disposal fees from the user when handing over the waste on the official-final path (Pigou 1920). In this way, the environmental policy goal of prevention (recital 3 WEEE Directive) could be well addressed. The objective of prevention simply aims at reducing the amount of e-waste (Kloepfer 2001, 42; Lersner 2005, 11), it leads to longer service lives of products, it strengthens the circular strategies of slowing und closing (Shevchenko/Danko 2023, 225), and therefore plays a crucial role for the circular economy (of EEE). With this focus, the disposal costs of official-final disposal could simply be set high enough so that, if disposal takes place at all, the circular disposal path is increasingly chosen. In the area of waste policy and especially in connection with EEE, however, it is not possible to put a stop to the illegal disposal path without further ado. Therefore, regulation in connection with EEE waste is therefore rightly determined by a second objective in addition to prevention: the safe disposal of waste (recital 3 WEEE Directive). With regard to the three disposal paths, the objective of prevention attempts to strengthen non-disposal (further use) and circular disposal over official-final disposal. And the objective of safe disposal in turn attempts to strengthen official-final disposal over illegal disposal.

From an environmental perspective, the official-final disposal path appears ambivalent. While the circular disposal path (or continued use) clearly points in the direction of sustainability and the illegal disposal path is clearly harmful to the environment, this is not so easily possible to judge for official-final disposal. This is because this disposal path is relatively sustainable compared to the illegal one and relatively unsustainable compared to circular disposal or non-disposal. This means that the relationship between the two objectives prevention and safe disposal is also fraught with tension, as measures for controlling the incentives with regard to the official-final disposal path may be contradictory. In particular, while a disposal fee on the official-final disposal path should result in more prevention it can however lead to more illegal disposal and thus have a counterproductive effect with regard to the goal of safe disposal (Bunde/Zimmermann 1988, 182). Figure 2 illustrates this connection between the disposal paths, circular economy objectives and the sustainability perspective.

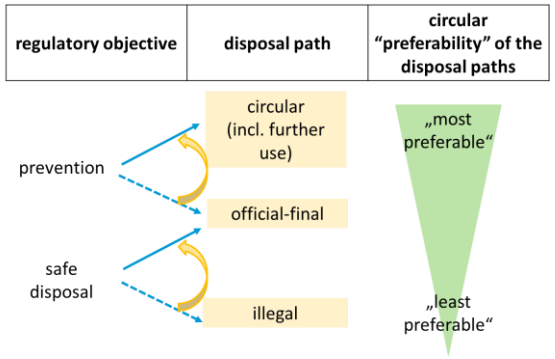

Figure 2. Two objectives and three disposal paths.

What is now advisable from a regulatory perspective in view of this rather complex situation? Regulatory intervention via disposal costs requires what one might call a differentiated 'hurdle management'. In order to approach this, a closer analysis of the disposal costs must be undertaken.

Disposal costs as the sum of various hurdles

An analysis of the disposal costs can be made by understanding them as a sum of various hurdles. The concept of hurdles is helpful, among other things, because it makes it clear that costs that have nothing to do with pecuniary costs play also quite an important a role (Gawel/Bretschneider 2017). With regard to disposal paths, the following types of hurdles may be relevant:

a) Pecuniary hurdle: Is there a pecuniary price (actual money) to pay for getting rid of the device? (Zimmermann et al. 2024, 11) Of all the hurdles considered, this is the only one that can also be negative, namely if you can make a profit from the device in the course of disposing. And that is the reason why: The device to be disposed of can be an economic good from the point of view of the market 'examining' this question, but it can also be waste. To a certain

extent, it oscillates between these two variants, so that waste, especially in the case of EEE, has a 'good-like character' (Bunde/Zimmermann 1988, 177). So, if it really is a good, then the owner can act as a supplier on the market and has the opportunity to generate revenue for it. And the pecuniary hurdle, i.e. the pecuniary costs of disposal, is negative. If, on the other hand, the market does not recognize any value in the appliance, then the owner willing to dispose of it is a demander. He demands the scarce goods of space and assimilation capacities for the appliance. In an ideal neoclassical world, he would then pay a fee for good reasons (ibid., 176). The pecuniary hurdle would then be positive.

b) Hurdle of process and transaction: This refers to the transaction costs, starting with gathering relevant information up to the entire settlement with the counterparty of the transaction.

c) Spatial hurdle: The appliance will have to be spatially moved in the course of disposal. This raises the question of the extent to which the disposer is burdened with the transportation (Best/Kneip 2011).

These hurdles b and c do refer to the dimension of convenience (Dixit/Vaish 2015; Wagner 2013; Yale/Venkatesh 1986) as well as to the dimension of time (Becker 1965).

d) Hurdles of expected sanction in case of illegality: In the case of illegal disposal (only), the expected value of the sanction level and the probability of detection plays a role as a hurdle (Becker 1968). As already indicated, the difficulty here lies in the fact that it is often challenging to control such socially harmful forms of disposal (Kloepfer 2001, 90).

Applying a rational choice perspective, the user will 'calculate' the sum of each disposal path and compare the 'relative prices', with the implications of the 'whether' and the 'how' of disposal mentioned above. Of course, this will vary a lot depending on the specific case. However, the general idea can be illustrated like in Table 1.

Table 1 illustrates once again how challenging a regulatory intervention in favor of useful lives with the help of disposal costs is. Let us assume that a user is considering getting rid of a small electrical appliance. What are the various hurdles on the different disposal paths?

		disposal path		
kind of hurdle		1) circular	2) official-final	3) illegal
a)	pecuniary	a1	a2	a3
b)	process and transaction	b1	b2	b3
c)	spatial	c1	c2	c3
d)	expected sanction	a priori "zero"	a priori "zero"	d3
Sum (overall C_{dis})		C_{dis}^{circ}	C_{dis}^{off}	C_{dis}^{ill}

Table 1. Disposal paths and their respective costs as a sum of respective hurdles.

Starting with the circular disposal path, the pecuniary hurdle may be 'zero' or 'less than zero'. Of course, this depends on the value or resale value of the appliance. What is certain, however, is that the hurdle of process and transaction is significantly positive. This is because it definitely takes time to find a buyer. The internet has greatly reduced the hurdle here, but the hurdle remains positive. In addition, there are the potential challenges of information asymmetry, such as the functional characteristics of the device (Frahm et al. 2025; Zimmermann et al. 2024, 8; Boyer et al. 2021). The spatial hurdle may vary and could also be a matter of negotiation between supply and demand. Overall, there are only no positive disposal costs for this path if revenues overcompensate the transaction costs. In all other cases, the user has positive disposal costs.

Next, we will look at the illegal disposal path, which quickly reveals the dilemma of regulatory control. From the user's perspective, the garbage can for household waste quickly comes into view for small devices. The pecuniary hurdle for such disposal is 'zero', as a regular fee for household waste is incurred anyway. Furthermore, the hurdle of process and transaction is zero, as I don't need a counterpart. In addition, the spatial hurdle is 'virtually zero', as at least you don't have to leave your own property. And finally, the hurdle of a possible sanction in the sense of an expected value is low, insofar as the probability of detection is low. All in all, the disposal costs

for this path are practically zero. This means that this disposal path dominates the circular disposal path in all cases in which the latter does not offer possible proceeds that more than compensate for the transaction costs. And the overall hurdle of 'zero' for the illegal disposal path puts the official-final disposal path under considerable pressure in light of the objective of safe disposal (Elmer et al. 2005, 2).

It is now easy to see that the waste regulation on EEE, in particular through the WEEE Directive, responds to this challenge for the official-final disposal path. For the pecuniary hurdle, the WEEE Directive stipulates that users can hand in their devices "at least free of charge" (recital 14 and article 5 paragraph 2a WEEE Directive; see also Elmer 2005, 1; Florian 2009, 42). This hurdle is therefore 'set to zero' in regulatory terms, whereby the national legislators are also given the option of setting a 'negative hurdle' here. With regard to the process and transaction hurdle, article 14 of the WEEE Directive, for example, stipulates that users must be "given the necessary information about: […] the return and collection systems available to them […]." And in practice, users do indeed feel "well informed" (Kummer 2022, 540f.). Finally, with regard to the spatial hurdle, the WEEE Directive stipulates that "[M]ember States shall ensure the availability and accessibility of the necessary collection facilities, taking into account, in particular, the population density […]" (article 5 paragraph 2a WEEE Directory, see also recital 14) The spatial hurdle is addressed in a plausible way. However, unlike the previous hurdles, the spatial hurdle cannot simply be set to 'zero' in regulatory terms. This is therefore the hurdle that is most likely to lead to positive disposal costs on the official-final disposal path.

This sketchy analysis makes it clear that the illegal disposal path is a challenge, even if regulation is already addressing it. And this is also the challenge for addressing the service lives via the disposal costs. And yet a more detailed analysis of the individual hurdles remains worthwhile in terms of the circular economy.

Conclusions for a circular economy regulation

The situation with the three disposal paths and the respective hurdles is challenging. How can we look at this in terms of the circular economy? First of all, it is helpful to keep a kind of 'ideal solution' in mind. And this 'ideal solution' is that, on the one hand, disposal fees address the avoidance goal and that, on the other hand, increased controls and sanctions make the socially harmful disposal path less attractive (Gawel 1995, 112).

However, the more practice-oriented work tends to consist of the hurdle management mentioned above, see also again Table 1. In conclusion, only a rough orientation with the help of four categories of hurdles is offered here.

- There are hurdles that simply *cannot be subject to regulation* (e.g. in many cases c3). There is simply no sensible regulatory option, let's say, to station the household waste garbage can further away from the house, just to increase the spatial hurdle here.
- There are hurdles that can be (and that are) *determined directly* from a regulatory perspective (a2, b2, c2, so the 'line' of official-final disposal). In this context, reward systems are occasionally discussed with a view to the official-final disposal route (Shevchenko et al. 2019).

In conclusion, however, the two remaining categories of hurdles should be emphasized here in particular, as they are not sufficiently recognized as such in the discourse:

- There are hurdles that depend on the *enforceability of sanctions* against illegal disposal (d3). It is worth finding out in which areas control options could be improved.

Finally, there are hurdles that can – at best, but still – be *influenced indirectly* by taking a closer look at the relevant markets (a1, b1, a3, b3), i.e. the circular second-hand market as well as the illegal market of socially harmful disposal

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