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The long and winding road to resource efficiency – An interdisciplinary perspective on extended producer responsibility

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ABSTRACT

Extended producer responsibility is advocated for its capacity to spur resource efficiency through green innovation and closing loops downstream of consumption. Its rationale is the extension of the polluter-pays principle to the post-consumption phase. This paper analyze the underlying mechanisms that are supposed to work under the EPR approach, and proposes an alternative view. The main purpose of EPR is seen as the creation of the bases for legitimizing the involvement if industry taking over the task of diverting waste from landfill. Its success rests on the superior managerial capacity of industry and the need to organize post-consumption markets that transcend the local scale and have access to the economies of scale and scope. The emphasis on producers does not add anything special, but may reinforce the bases for legitimizing the implicit delegation of power to industry. Primary and above all, we have witnessed in the last 20 years a gigantic effort of market design, and this is the main demonstration of EPR's success.

The diffusion of extended producer responsibility (EPR)

Extended producer responsibility (EPR) has become a cornerstone of solid waste management (SWM) policies throughout the world. The EU has embraced it for a large number of materials, from used lubricants to batteries, from packaging to electronic waste (European Commission, 2010a). The Organization for Economic Cooperation and Development (Oecd) strongly recommends EPR for its effectiveness in achieving otherwise unconceivable recycling targets and promoting efficient secondary markets (Oecd, 2001, 2006).

The EPR principle has been initially proposed in the frame of management sciences and industrial ecology, as a way to improve resource efficiency. It rests on the assumption that patterns of waste generation result from the way the production and distribution are managed and organized; EPR implements the idea of "closed loops", promoting a re-design of value chains so as to encompass reverse logistics (Lindhqvist, 2000). EPR is seen as a practical way to introduce "green supply chain management" and to extend it to the post-consumption phases (Srivastava, 2007; Gupta et al., 2011). EPR enlarges the focus from end-of-pipe management of waste to resource efficiency, with a substantial boost to waste prevention and recycling. Green innovation is also expected, as EPR promises to provide incentives to recycling-oriented research and technological development (RTD) and design for the environment (Tojo, 2004).

Something suchlike has actually taken place: in 20 years recycling levels have grown exponentially, the dream of a "zero landfill" world is already reality in many countries. But to what extent is EPR the real cause? And if it is, what are precisely the underlying mechanisms? Insinuating that EPR effectiveness is more often postulated than demonstrated would perhaps be deemed as blunt neoclassical negationism – although influential economists, such as R. Porter, still express skeptical views (Porter, 2005). Yet nobody would seriously affirm that the question is answered once forever. Nor does the existing empirical evidence serve too much in order to formulate predictions and derive systematic lessons.

The present paper aims at moving some steps in this direction, mostly from an economic viewpoint, but grafting as much as possible further contributes and insights from contiguous disciplines: institutional economics, economic analysis of law and management sciences. We argue that policies inspired by EPR have been indeed successful, but probably for different purposes and for different reasons than initially believed.

We start from a taxonomy of market failures that hamper resource efficiency and sustainable consumption ("Resource efficiency and market failures"). A definition and a temptative classification of EPR are then provided ("Inside the black box of EPR").

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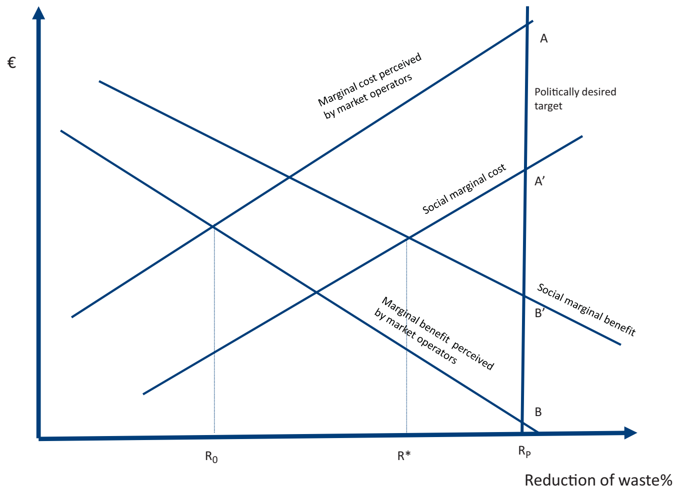

Fig. 1. Socially optimal rate of waste reduction and market failures.

"Theoretical arguments revisited", examines how EPR (and alternative EPR arrangements) tackle market failures, and attempts some generalizations.

Resource efficiency and market failures

If markets were able to transmit price signals without frictions, EPR would be unnecessary: a waste collection charge incorporating externalities (e.g. a landfill tax, a tax on raw materials) would generate equivalent results without distortions (Kinnaman, 2009). Therefore, a theoretical justification of EPR should start from a recognition of market imperfections, and then discuss the capability of instruments of tackling with them (Walls, 2003). In other words, EPR is a typical second-best policy approach, whose essence lies in the attempt to correct market imperfections through the deliberate introduction of some distortions to its functioning (Walls, 2006).

In a standard cost–benefit analysis, efforts for reducing the volumes of waste addressed to final disposal should be undertaken until their marginal cost is equal to the social marginal cost (Fig. 1). The marginal cost is supposed to have an increasing slope because of diminishing returns of these efforts. Preventing waste implies the sacrifice of utility associated to consumption, once the most obviously wasteful habits have been abandoned. Waste disposal could be reduced through recycling: but again achieving higher source separation levels for recyclables entails more complex and costly separate collection services (e.g. kerbside vs. drop-off); the quality of materials collected worsens, imposing more costly sorting processes downstream, higher discard rates etc.

Social benefits arise fundamentally from the market value of recycled materials and the saved costs (waste disposal, energy, virgin materials etc.). A third category of benefits may be added, namely the "warm-glow" utility arising from the pleasure of behaving ethically and for the good of the community (Kinnaman, 2009). We can suppose that the social benefit decreases at the margin with an increasing rate of recycling: in other words, the additional social benefit generated by an additional increase of recycling rate becomes lower, even if still positive. First, because the market value of recovered materials declines, since the average quality worsens, thence an additional recycling effort will reward a lower net additional economic value. Second, the more waste is recycled, the lower pressure is put on disposal sites (and hence their average price can diminish, or at least remain constant). Third, behavioral studies show that warm-glow benefits, too, are likely to decline beyond a certain threshold, once most people feel they have provided a fair commitment to the common good (Andreoni, 1990). Thence the positive feelings associated to improving recycling, say, from 10% to 20% are probably higher than from 70% to 80%.

A socially optimum recycling rate corresponds therefore to the point where the marginal benefit equals the marginal cost (R^*): beyond that level, an additional effort for increasing the recycling rate would imply higher costs than benefits. Governments, however, may choose $R_P > R^*$: this is equal to considering recycling as a "merit good", perhaps because some further values are believed to be associated with it, that go beyond individual utility and cannot be captured by monetary evaluation of benefits (Martinez-Alier et al., 1998).

The market equilibrium is actually determined by costs and benefits perceived by operators. These may diverge from the social cost and benefit curves for many reasons (Walls, 2003; Oecd, 2006). The overall result is an inefficient equilibrium (R_0 instead than R^*).

A first category of market imperfections regards the benefits associated to resource efficiency. In order to account for the full social cost of SWM, all externalities should have been evaluated and internalized, either with the requirement of technical standards for pollution control or via environmental taxes. The market price should also incorporate the "user cost", namely the economic value of future use of scarce non-renewable resources (Pearce, 2005, Fullerton and Wu, 1998).

This might not necessarily happen, for many reasons. The time horizon of policymakers may not fully consider long-term implications of dissipative use of resources and thence adopt a discount rate that undervalues future benefits (Massarutto, 2007). For example, SWM service prices may be regulated with a short-term horizon in order to minimize the impact on households or to prevent monopoly rents. Landfill owners may adopt predatory pricing strategies, to discourage alternative solutions, which require sunk investments and cannot deliver immediate results.

Yet probably the most important obstacle is the "unfair competition" of illegal disposal (D'Amato et al., 2011). Effective internalization implies that waste producers are charged according to the waste they produce (pay-as-you-throw and similar schemes). Even neglecting the high transactions costs for implementing such schemes, opportunities for playing against the rule are wide, and range from do-it-yourself "moonlight dumping" to organized crime.

Furthermore, interstate trade of materials should be considered. This is obviously a positive thing, as far as it allows to satisfy the growing demand for raw materials in developing economies (Ley et al., 2002); it also creates opportunities for "masked dumping", facilitated by asymmetric regulations and looser enforcement in the "waste havens" (Kellenberg, 2010, 2012). Materials that are theoretically aimed for recycling, if not actually recycled, will return back as waste to be disposed of in other countries or regions, thence bypassing regulations (Massarutto and Antonioli, 2012).

In the second place, recycling markets may be imperfect (Oecd, 2006; Arcadis and Eunomia, 2008). Resource efficiency requires efforts from many subjects. Consumers should separate waste and make responsible choices. Effective and accessible separate collection facilities should be in place. Convenient sorting and treatment capacity should be deployed downstream. Recycling markets should actually absorb sorted materials. Industry should ensure that products are easy to recycle. The retail sector should not encourage too much packaging.

All initiatives should be coordinated and integrated. An efficient collection requires an interplay between operators (who have to provide convenient and accessible systems) and users (who are supposed to effectively participate). Transport and logistics have to be optimized. Facilities have to be located and sized accordingly, technological choices should be coherent etc. This arises a classic collective action problem, particularly in the early phases when the "reverse logistic" system is not developed. Individual initiative alone, though commendable, may achieve local results, but can hardly deliver at the macro level, and could be thwarted by other players' inaction or lack of cooperation. Technological choices are highly complementary.

Actual costs might differ from efficient costs because SWM operations are focused on unsorted waste collection and disposal and follow administrative boundaries, without efficiency concerns. Separate collection and preparation for recycling may require different scales in order to be managed efficiently. Furthermore, recycling opportunities may take place in sectors that are quite distant, either in geographical or industrial terms. Identifying potential users may be difficult, especially if technologies are not consolidated, the value chain is long and requires many intermediate steps, and so on.

Users' requirements may not necessarily match those of producers. The latter typically wish to ensure a stable flow of the greatest possible quantity, while the former are more selective. Recycling might involve specific investments in order to reciprocally adapt the processes, generating a classic hold-up situation.

Moreover, quality of recycled materials is often difficult to assess ex-ante. This arises a typical "market for lemons", namely a situation that takes place when better-than-average quality products are excluded from the market because nobody is willing to pay more than an average price, taking into account the risk of buying low quality. In sufficiently developed markets, product standardization may spontaneously arise and tackle the problem. Something suchlike actually takes place for some materials (such as metals), but more often the market is too thin, with a little number of operators and a limited number of transactions, requiring specific arrangements (Massarutto and Romagnoli, 2006).

Transactions costs may also arise from price instability and risk of unavailability of a market for sorted materials. An investigation over the market price of recycled materials reveals that since the end of the 80s these have experienced high volatility (Oecd, 2006; Eurostat, 2013). The reasons of fluctuations are manifold. Prices of secondary materials depend strictly on those of the substitutes, which are affected by macroeconomic trends as well as by geopolitics, speculative bubbles and market power of dominant companies. Market structure and industrial bottlenecks along the value chain have an important influence as well, especially where markets are primarily local in nature (i.e. demolition waste), or when there are significant economies of density (i.e. wastepaper) (Oecd, 2006).

Market power also matters. Calcott and Walls (2005) show for example that manufacturers are incentivated to improve recyclability only if they can steadily benefit for the higher margin generated; yet recyclers may well appropriate the most part of it.

High price fluctuations increase the market risk associated to recycling. SWM operators and municipalities are constrained by public service obligations to find a solution: the society would bear intolerable costs if waste could not be regularly collected. As a result, utilities are highly risk-averse. Recyclers may then adopt an opportunistic behavior, exploiting their vulnerability.

Finally, the role of innovation should be considered. Fig. 1 illustrates market failures in a static environment, in which relevant parameters are fixed. That is, manufacturing processes, choice of materials, packaging strategies and so on are given; quantity and quality of waste generated is an exogenous variable, waste collection and treatment technology is given, recycling opportunities are determined by demand for recycled products.

These are reasonable assumptions only in the short term; in the medium and long term technologies could change (firms learn how to reduce the material content, to use less packaging, to design products that are easier to disassemble and to sort; consumers may learn how to avoid generating waste; recycling markets can be improved because more effective reuse opportunities are discovered, and so on. In fact, waste today is rather different from 30 years ago, precisely because manufacturing, distribution and consumption are different; what it will become in the next 30 years also depends on today's choices.

This vision is reinforced by the intuition that many barriers that limit the recycling potential today depend on poor coordination of efforts and non conscious choices made at some stage of the production process. These choices could have been made differently, if only designers and managers would have taken certain effects into account, if standards were harmonized and so on. A "technological externality" occurs in this case. Redesigning the supply chain management can bring significant improvements without prejudicing quality, reliability, performance or energy efficiency, provided that a paradigm shift is triggered (Srivastava, 2007). Education, ideology, feeling of belonging to the community (social capital) also play a fundamental role (Van den Bergh, 2008; Osti, 2006). Behavioral studies reveal that the willingness of households to engage in separate collection is high, but requires to win the inertia of deep-seated habits and therefore implies a social learning process toward a recycling-oriented culture.

The effect of innovation and social learning could be that of shifting the marginal cost to the right and the marginal benefit upwards, or lower the slope of both.

The multiplicity of market failures arises the necessity to develop a more complex policy design. When policy targets shift from media-specific pollution to product life-cycle optimization, however, no single instrument, not even an optimal tax that accounts for all externalities (what economists define as a "pigouvian tax"), can deliver optimal results. Using complementary instruments is particularly important, when the policy has to address multiple market failures and transactions costs are relevant (Walls and Palmer, 2001; Lehman, 2012). Policy design has to provide effective structures of penalties and rewards (Palmer and Walls, 2002; Walls, 2003). Moreover, multiple instruments designed in order to deliver partial targets could interact in an unexpected way and provide ambiguous or pervert signals; coherence is thus essential (Matsueda and Nagase, 2012).

Inside the black box of EPR

Alternative EPR designs

Many have noted that EPR is not an *instrument*, but rather an over-arching *policy principle*, that could be enacted with many combinations of instruments (Walls, 2003; Lifset et al., 2013; Oecd, 2004a). Lindhqvist (2000) proposes a classification based on different forms of responsibility that are attached to the producer. The first degree (*liability*) concerns compensation in case certain negative effects actually arise from product disposal. *Economic responsibility* concerns the burden of the cost of post-consumer handling. *Physical responsibility* implies the duty to take actions directly in order to achieve policy targets. *Informative responsibility* entails the obligation to make available all the information that is required for dismantling, separating and recovering materials. Finally, *ownership* resumes together all forms.

Each form can imply different degrees of intensity and sharing patterns among different categories of producers or involve other players, such as public authorities and NGOs. Liabilities may be assigned to each individual player, or imply various forms of collective schemes, e.g. on the base of specific products (e.g. fluorescent lamps, PET packages), category of products (e.g. any kind of lamps, any kind of plastic packages), or macro-categories (e.g. electric and electronic appliances, all packages). Inevitably, the breadth of the chosen category also influences the kind of incentives that the scheme offers and the kind of externalities that it is supposed to tackle.

A second classification may be based on policy instruments. The EPR concept is consistent with a full range of instruments, but provides itself little guidance about which ones might be appropriate under particular conditions and for particular products. Economics is aimed to improve policy design from an efficiency viewpoint (Palmer and Walls, 1999; Walls, 2003; Kinnaman, 2009).

The classic distinction between command and control (C&C) and market-based instruments can be further expanded (Walls, 2006). Among the former category we can list take-back mandates, technical standards, mandatory recycling quotas. Market instruments include advance disposal fees, product or material taxes, deposit-refunds, tradable recycling credits, subsidies to green innovation and RTD. Political scientists would perhaps add to this list the "third stream" of instruments that bypass the classic "state vs. market" antinomy, and would emphasize the neo-corporative nature and the role of voluntary agreements and cooperation (Dente, 1995). Enforcement patterns are also important: if incompliance to C&C regulations is sanctioned with economic penalties, the incentive effect is equivalent to market-based instruments.

Furthermore, EPR schemes may differ according to the target they are aimed to achieve (Walls, 2003). For example, they can be focused on end-of-life, or widened to include environmental impacts throughout the product life-cycle. They may be intended to deal with waste volumes, the toxic constituents of waste, the method of waste disposal, or a combination of these things. They might be expressed in terms of volumes of recycling or of waste prevention and green design. They could be intended at the national scale, leaving more freedom to choose where to concentrate efforts; or at a regional or local scale.

Intermediate solutions are also possible: for example, responsibility may be placed on individual players, allowing them to delegate to an authorized third party, which could pool together the targets assigned to all associates. As a consequence, EPR often leads to the creation of producer responsibility organizations (PRO); a further important classification concerns the degree of competition and freedom of choice, either with respect to membership to the PRO or to the ownership of materials.

Membership could be compulsory for all producers belonging to a certain category; they could be instead free to choose among competing PROs. Waste producers could be obliged to use the facilities of the PRO, or left free to choose alternative solutions (e.g. direct sale to recyclers). Conversely, one or more PROs may be charged with public service obligations (e.g. operate as a last-resort umbrella) or decide upon convenience.

The perimeter of action of PROs may also vary. For example, it may include secondary and tertiary packaging (from industry and retail sector). Or it can be exposed to cream-skimming, for example because other operators are free to enter the market and operate only in the most profitable segments. It could be burdened with more or less specific public service obligations (e.g. achieving targets on a national or a regional basis; for each material/category or altogether, dealing with orphan waste or not).

Finally, EPR systems entail different patterns of cost allocation between taxpayers, SWM service users and consumers. The packaging sector provides an excellent example (Cahill et al., 2011). In the German case the PRO bears the *full cost* of recycling, including separate collection. This result has been generated by the take-back requirement: in order to avoid uncontrolled restitution of used package to sellers, the retail sector has created a dual collection system, whose cost is entirely paid by the green dot.

Other countries adopt a cost-sharing mechanism, where industry pays only the *differential cost*. Waste producers are charged the full cost of SWM also for the part that is separately collected; producers pay only the (eventual) positive difference that is required in order to make recycling a convenient option.

The Italian PRO, Conai, finances approx. 20–25% of total recovery costs, with the remaining 75–80% resting on the SWM bill (Massarutto, 2010). In Portugal the sharing patterns are the opposite: the PRO covers 77% of total financial costs of recycling (Ferreira et al., 2012). On the opposite extreme, in Denmark and in the Netherlands the full cost of is paid in the SWM bill; the convenience for municipalities to engage in separate collection is boosted by landfill bans and very high landfill taxation, reaching 105 €/t in the NL (EEA, 2005b). Industry is not charged any fee for separate collection and recycling.

Arguably, saved disposal costs explain the difference (much higher in Italy and particularly in the North, where separate collections are concentrated; and lower in Portugal; while in the UK the relatively lower gate fees are complemented by high and growing landfill taxation.

Some facts about EPR

EPR promised to induce manufacturers to incorporate waste considerations in their strategies, and therefore to foster green design and waste prevention. This argument was in fact the strongest one in support of EPR at the beginning (Lindhqvist, 2000). In the second place, it was expected to facilitate recycling, by "closing the loop" downstream of consumption and creating a reverse logistic system. Third, it would improve overall efficiency. After two decades, a balance can be drawn.

The impact of EPR on green design and product innovation has been much lower than expected (Walls, 2006). Even considering that concepts such as "recyclability" are slippery and very difficult to measure, especially on an aggregate base, most of the applied research so far provides scant evidence of a decisive shift in this direction. Moreover, since empirical studies are mostly based on anecdotal evidence, industry-wide generalizations are not authorized.

Some anecdotal evidence is reported about individual companies initiatives, particularly concerning vehicles (Hanisch, 2000). In the packaging field, some prevention has occurred due to reductions in material use and product/packaging downsizing (Walls, 2006). Yet the field where an effect on green design was most expected, that of engineered products such as electronic equipment, improvements have been insignificant (Yu et al., 2008).

It is also quite well documented that innovation efforts have been more frequently directed to sorting and recycling techniques rather than to product design (Walls, 2006). This is particularly evident in the case of plastics or composite materials.

Among the few studies conducted with a macro perspective, Nicolli and Mazzanti (2011) use panel data on patents to show that the peak of technological innovation can be placed in the decade preceding the advent of EPR was adopted. EPR might have restrained the trend to stagnation, but apparently did not prompt a new wave of radical innovations.

Concerning the second aspect (i.e. facilitating recycling) success is indubitable. The advent of EPR is always correlated with booming increases of separate collection and recycling. The case of exhausted oils is paradigmatic. Until the late 80s, most of it was dumped in an uncontrolled way. In a few years nearly 100% could be retired from the market and routed to recycling (Oecd, 2004a). A similar tale can be told about batteries and end-of-life vehicles (Zoboli et al., 1999) and packaging waste (EEA, 2013; Cahill et al., 2011).

Non-EPR countries, and above all the US, recycle much less. However, at least two notable exceptions (Netherlands and Denmark) suggest that the poor performance in the US results from a lower emphasis of SWM policies on recycling, rather than failure to adopt EPR.

The third issue (cost-effectiveness) is more controversial. Most of the comparative assessment work has still to be done. In general terms, a comparison should consider all costs, while the only easily available information is that on financing needs of PROs (EEA, 2005a).

In the case of used oil, evidence suggests that overall costs have been negligible. In Italy, the financial need of the PRO, which is supposed to cover all collection and reprocessing costs (70 €/t) corresponds to approx. 0.5% of the market price of lubricants. Favot and Marini (2013) analyze the impact of electronic waste regulation on the market price through a panel investigation on EU countries where the recycling system had achieved different degrees of maturity. Price increase due to mandatory targets has been rather small, though not negligible (+2.19%).

Empirical evidence is less conclusive about packaging waste (Cahill et al., 2011). If comparisons are limited to financial needs of PROs, systems based on take-back requirements, such as Germany and Austria, seemingly show much higher costs than those adopting market-based approaches. Acciari (2008) uses data from the EU umbrella organization for packaging waste, Pro-Europe, to calculate an unweighted average of participation fees paid to the respective national PRO by the six most relevant materials contained in packaging waste (Fig. 2). The figure also reports for some countries the fee charged to plastic waste.

However, such a comparison is misleading, since it fails to consider that patterns of cost sharing between packaging PRO and public services. As we argued above, these vary substantially across nations. If we adjust the figures in Fig. 2 taking into account also the share of the total cost that rests on the SWM budget, most differences disappear. The full cost per ton collected/recovered is 260/369 €/t in Portugal (Ferreira et al., 2012), 200–250 € in Italy (Massarutto, 2010) and 207/225 €/t in Austria (EEA, 2005a).

It also needs to be remarked that a significant cost reduction took place over time. For example, the cost of recycling plastic waste in Germany dropped by 77% from 1997 to 2009; a further drop is expected to drive the full cost in 2013 to be only 5% of the 1997 value (DSD, 2013).

What is the underlying principle of EPR?

The Oecd (2001), inscribes EPR in the broader category of the polluter-pays principle (PPP), stating that it "extends" the concept of polluter to product themselves. Being the PPP so widely accepted, EPR's legitimization comes straightforward.

This definition is however more problematic than it seems, since it is not obvious who the polluter actually is. After all, ". . . environmental impacts of disposal are caused by the consumer's decision to consume, not the producer's decision to produce" (Sachs, 2006).

Following the PPP approach, responsibility should be shared along the entire supply chain (Lenzen et al., 2007). In this line, emphasis should be driven away from producers, and regard instead the product itself, as the "product stewardship" movement suggests (Palmer and Walls, 2002).

Moreover, identification of producers as polluters can occur only on an individual basis. This arises formidable implementation problems, that can be practically avoided only if "polluters" can share their liability with others; yet once the link between the individual polluter and the damage is lost, the essence of the PPP is also lost (Sachs, 2006).

An alternative viewpoint can be offered by a "law and economics" perspective, which developed a coherent theoretical framework for analyzing the issue of liability allocation (Faure, 2009). Its essence lies in the intuition that externalities have a "public good" dimension, in the sense that they result from the combined interplay of otherwise harmless actions. In such cases, the allocation of liability should not be based on "fault", but rather search for the "cheapest cost avoider" (CCA), namely the subject that can more effectively provide a remedy, or the "best briber" (who can more effectively transmit the stimulus of the policy to the most appropriate stages).

EPR institutes could thence be understood as principles of liability that, according to circumstances, may lead to strict responsibility (in case a specific subject can be identified as the CCA), or more frequently to joint and/or several responsibility (in case a collective effort is more suited).

Collective compliance schemes that usually populate the EPR scene, in this light, may be seen as "insurance mechanisms", aimed at pooling all costs on behalf to the community of operators along the supply chain. The legitimization of EPR should be sought thence more in the pragmatic demonstration of the superior capabilities of EPR-based institutions than to the demonstration of faults.

Theoretical arguments revisited

EPR and recycling costs

Are there structural reasons to predict a superior efficiency of separate collection and recycling, when managed under an EPR scheme? The reverse-logistics of the take-back system is characterized by economies of scale (Mayers, 2007). EPR may thence allow more efficient operations, simply because it is not constrained to the territorial base in which SWM services are usually organized.

An effective recycling implies a larger and possibly global scale of operation, since the demand for recycled materials will concentrate where manufacturing is located. Managing large quantities allows a more effective planning of transport and logistics. Access to the national media – which arguably enhances the effectiveness of communication – is easier for large organizations operating at the national level. Similarly, cooperation with large NGOs is facilitated. Economies of scale also characterize R&D activities oriented to improve the range of materials reusability.

Collection systems imply mostly fixed costs (Massarutto et al., 2011). Therefore, the average cost depends on household's response and implies a risk that is more effectively managed on a larger scale. A national PRO may concentrate efforts where the response of households is more collaborative, and use less intensive techniques in other places. An indirect proof of economies of scale lies in the fact that whenever SWM industry consolidates its operations at a supra-local scale, it tends to bypass PROs or to internalize preparation for recycling (Massarutto and Antonioli, 2012).

However, these theoretical advantages depend on EPR design. Palmer and Walls (1999) underline the advantages of collective system vs. individual take-back, precisely because the latter imply a chaotic logistics and substantial transport costs.

Economies of scope are also likely to take place. For example, they arise when the same operator manages all collection schemes in a given area. Porter (2005) suspects for this reason that dual systems imply an inefficient duplication of costs. Wagner (2012), in turn, sets up a framework for confronting integrated systems (under the responsibility of a single authority) and competing "dual" systems. Convenience arises from a multi-dimensional set of variables, and cannot be presumed.

Anyway, PROs may well contract out their operations to the same entities that run waste collection facilities, in order to achieve the same economies. Arguably, this is more effectively done by a single organization than by many individual subjects. It is interesting to note, for example, that in the UK packaging system competing PROs tend to develop exclusive contracts with municipalities (Massarutto and Antonioli, 2012).

Economies of scope could also arise from the integration of similar or complementary materials collected from different sources.

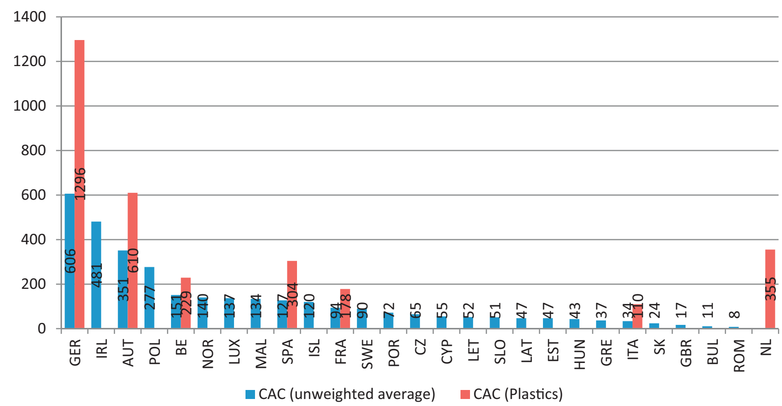

Fig. 2. Average contribution charged by packaging PROs to associates in Europe (€/t).
Source: Aadapted from Acciari (2008) and ACV (2013).

This feature is a key for understanding the success of EPR schemes for particular flows (used oils, batteries, tyres), but a similar conjecture can be made for plastics and more generally all the materials whose recycling implies complex value chains.

Moreover, industry – and especially oligopolistic industry – can more effectively agree on product specifications and common standards, and find the way to share phases that are more conveniently operated collectively. This argument suggests that individual responsibility systems work well in concentrated industries.

Separate collection schemes of a large number of municipalities has to be coordinated with treatment phases that prepare materials for recycling. PROs can do this in a more effective and flexible way, while regional plans are rigid and lack a business-oriented mentality.

Furthermore, a dual system may overcome the trade-off that SWM operators face when they have to choose whether to develop own disposal capacity or to rely on recycling markets, which are more insecure (Massarutto, 2007). Given their obligation to provide a solution anyway, they might prefer the former strategy, especially when waste trading among areas is obstructed by normative barriers such as the self-sufficiency principle.

SWM operators could be motivated with appropriate design of the rewarding system, particularly if their contract includes incentives to recycle and/or does not allow the full shift of the disposal cost onto customers (Oecd, 2004b); yet this requires delegation to third parties, and creates enforcement problems since actual results may not depend solely on the commitment of collectors.

An organization which is explicitly and solely devoted to recycling with appropriate incentives can concentrate more effectively on maximizing results. Since EPR absorb at least a significant part of costs, it provides stronger motivations for municipalities (since higher separate collection rates also mean lower SWM costs and related charges).

EPR and internalization of costs

EPR can also effectively address some of the reasons that hamper full internalization of costs. The first concerns illegal disposal. A number of theoretical studies argue that if illegal dumping is an available option, the optimal instruments should combine the internalization of environmental cost in the SWM fee and a direct incentive to respect the rule – be it a certain target of recycling or whatever (Walls, 2003; Choe and Fraser, 1999; Shinkuma, 2003).

EPR is consistent with the use of instruments that internalize the cost without providing incentives to play out of the rules, such as advance disposal fees and product taxes. Since the cost of SWM has already been paid with the product price, they will have no reason to dump, leaving apart the trouble of separating waste. Moreover, it can also include direct incentives to take-back, such as deposit-refund schemes.

Shifting part of responsibilities and related costs on subjects that are easier to control – such as collective PROs – may strengthen the incentive to comply. It is much easier for the government to verify whether the target has been respected at the macro level than to monitor the individual behavior of millions of waste holders.

Moreover industry, and especially big business, is organized in multinational enterprises. The control over globalized supply chains allows to track materials more effectively than governments and international agencies, particularly when the number of intermediate steps is great and the geographical scale grows

Of course, this is not to be expected as an automatic outcome; it should be instead explicitly incorporated in the EPR design (Buclet, 2002). This is particularly important for e-waste, given the high degree of globalization of material flows.

Another general advantage of EPR concerns the capacity to collect and allocate the financial resources needed for implementing an effective recycling system. Rather than the marginal incentive to waste prevention EPR's effectiveness could be sought precisely in the capacity to gather financial resources for fuelling the system in a more viable and consensual way.

People have an asymmetric perception of what they spend, and are therefore more reluctant to accept an increase in the SWM fees than a correspondent increase in their shopping bill, since the price increase of market goods due to EPR would be quite small and difficult to appreciate. Of course, the same argument can also be reversed against EPR: the fact that it actually allows to hide the social cost of over-recycling may allow policymakers to set inefficient targets.

At the same time, if the allocation of cost is fair enough, market shares will not be seriously affected; industry will be willing to participate, provided that the internalization of recycling costs will be absorbed without traumatic effects on equilibrium. Market leaders may even tolerate some free riding from small premises.

If industry bears the cost of recycling, waste diverted from disposal entails a net saving for municipalities and SWM services. Municipalities are thus more incentivated to collaborate with PROs; even those who own disposal facilities may be induced to do so, provided that they can sell the excess capacity on the spot market, arguably at higher prices than the regulated price they are obliged to charge to their captive clients (Massarutto, 2007).

Furthermore, the issue of long-run financial stability of EPR systems should also be considered. Forslind (2009) finds an interesting parallel between recycling and the pension sector: he interprets recycling as a costly care that products need after "retirement". Building on this intuition, he argues that EPR systems that are financed by explicit *ex ante* mechanisms, such as product charges or advanced disposal fees, provide the system with an insurance about the magnitude of economic resources that can be employed; in their absence, each manufacturer would be left with the uncertainty about how much they would spend. For this reason, like "funded" pension schemes, EPR allows superior results in terms of social welfare.

Transactions costs, missing markets and EPR

EPR can overcome transactions costs in many ways (Oecd, 2006). According to how they are designed, however, they might also generate further and more substantial transactions costs (Palmer and Walls, 1999; Sachs, 2006) and arise market power issues (Lehmann, 2004).

A rich case study literature illustrates that the most typical result associated with EPR is precisely the emergence of a more coordinated system and consolidation of the market (Walls, 2006; Oecd, 2004b, 2006). EPR offers the basis for a more structured market framework. Centralized transactions reduce the variety of cases, thus favoring technical standardization. Negotiating with many local authorities at the same time, PROs can coordinate and harmonize separate collection and sorting activities. They may also counterbalance the market power of recycling industry (Calcott and Walls, 2005).

Having an entrepreneurial approach focused on achieving the targets at the lower cost, PROs have the highest incentives to rake through the market in search of possible destinations, to promote direct investment in recycling capacity (Simões et al., 2013). Moreover, EPR favors efficient patterns of risk allocation. Municipalities are ensured the regular withdrawal of materials at a fixed price. Having the ownership of a critical mass of materials, PROs can negotiate more effectively its bulk marketing and be a more reliable and predictable counterpart for the recycling industry. Long term agreements with reciprocal securities (such as take-or-pay clauses) might be set up in order to guarantee fair terms of trade and market stability. Specific investments characterized by sunk costs are then encouraged. If the recycling industry is also directly or indirectly involved hold-up risks are further reduced. Economies of scale and scope are patent in the management of the kind of risks associated with similar contracts, since market price fluctuations can be more effectively pooled by large organizations on a long term basis, and if they can differentiate risks operating on more materials at the same time.

Empirical studies have not investigated these assumptions in detail; it is difficult thence either to assess whether such benefits have actually taken place or to appreciate how different EPR structures have performed. A general hypothesis, on which many theoretical studies agree, sustains that collective systems may be preferred with this respect (Walls, 2006); while competitive systems – and ultimately a free-market solution based on individual responsibility – would generate substantial transactions costs, that are justifiable only under certain circumstances, where market concentration is high and/or products involve very specific needs (Sachs, 2006).

Of course, this also raises concern about the market power acquired by the PROs themselves. Finding the right balance is difficult because it depends on the structure of each industry and possibly varies in time and space. Fleckinger and Glachant (2010) show that collective systems may arise collusive behavior by the adhering producers, especially if the market structure of the concerned good is oligopolistic; individual responsibility may foster a superior outcome in terms of social welfare. However, if the SWM industry is on its own characterized by market imperfections, the opposite is true: social welfare is maximized if producers can effectively ally.

This issue is a special case of a more general dilemma, namely that of finding the right balance between public service obligations and competition. The general interest may require nation-wide recycling targets, control over the destination of materials beyond the legal frontier of waste, dealing with orphan waste etc.

Independent recyclers operating on a voluntary basis have ever existed and will continue to exist, for all materials that owners wish to discard, but have a positive market value that an organized premise might exploit. Similarly, voluntary efforts of manufacturers directed at fostering product stewardship do exist and will continue to exist, provided that industry considers this a source of competitive advantage. However, voluntary efforts are likely to concentrate on segments where the economic benefit is positive. The problem of "orphan" waste and free riding remains open.

If the public interest imposes to extend efforts also to non-profitable market segments, some cross-subsidies or legal privileges are needed to ensure financial sustainability. Collective organizations may assume the "universal service obligation" of managing all waste that belongs to a certain category.

However, PROs created in order to achieve overall national targets and subsidized by participation fees may "cannibalize" the market where previously independent premises operated. This is typically the case of secondary and tertiary packaging or the most valuable e-waste. They could exploit the vulnerability of municipalities and SWM operators, forcing them to accept unfair terms of trade. They might serve the interests of few companies, for example by fostering cross-subsidies among materials or practicing unfair conditions to non-members.

The contrary might also occur. Municipalities themselves can free-ride, for example by "assimilating" certain commercial waste flows to urban waste, and forcing them to use the public service instead than private solutions. This also implies that the sorted waste flow, thanks to the more homogeneous quality of commercial waste, will be marketed at a higher price, for the benefit of the local SWM company.

Finally, market power issues could arise between PROs and individual companies on which obligations are initially imposed. Here, again, it is difficult to generalize; patterns of PROs organization depend on the more general patterns of industrial organization. In Germany, for example, until recently no one was legally bound to pay; however, the threaten to exclude from shelves products not showing the green dot provided a powerful incentive to buy it. The high concentration of the retail sector made this threaten credible, although small producers, with a local distribution, may eventually free-ride. The higher fragmentation of the Italian system suggested to rely instead on a legal monopoly. Conai, despite being a private body with self-governance and organizational autonomy, is charged with a legally binding obligation (complementing spontaneous initiative in order to achieve the target, signing a nation-wide framework contract with municipalities, present an annual waste prevention and recycling plan, etc.) and is financed by a mandatory fee (i.e. a tax) that each packaging producer or importer is obliged to pay.

The extent to which these concerns are real is difficult to assess. Lehmann (2004) uses the background of new institutional economics to provide an in-depth analysis of the German DSD system from an antitrust viewpoint. He concludes that its allegedly anticompetitive institutional structure has an economic rationale face to the multiple market failures that it is supposed to tackle.

In Italy, too, a recurring complaint from the side of municipalities concerns the exploitation of their vulnerability by Conai; an indirect proof is the fact that the price paid for withdrawing materials from separate collection is among the lowest in Europe (ACV, 2013). A recent inquiry conducted by the Antitrust Authority on the Italian packaging PRO concludes that risks of market power abuses are concrete, but not verifiable; the mere fact that Conai enjoys some market power is not inefficient per se, since there is no counter-proof that the same results could have been achieved otherwise (AGCM, 2008). Yet the issue is not definitively settled.

It should be also emphasized that the need to allow privileges to PROs charged with public service duties also varies according to the degree of maturity of the industry. Many countries that initially adopted monopolistic EPR structures have later relaxed them allowing space for competition.

In Italy, the quota of Conai on the total recycling has been declining, in favor of independent systems and disintermediation. The consortium is legally bound to set up a national framework contract with municipalities, obliging Conai to accept all sorted waste fitting in the agreed standards and pay the agreed price. Municipalities and SWM companies, in turn, are not bound to accept, but are free to choose alternative solutions. The most active operators in the SWM industry have started to develop their own system or to internalize sorting and preparation for recovery, prior to marketing them directly (Massarutto, 2010). In France, similarly, the leading PRO holds a residual responsibility and is obliged to offer to all municipalities a baseline contract for the withdrawal of materials. In Germany, the DSD has been obliged to accept other competing schemes; yet the market is more strictly regulated, and competing PROs operate in practice as “resellers” of the same service, whose cost is actually shared, rather than offering completely alternative services.

A market-based version implies the existence of many competing schemes that obliged subjects may freely choose. This is for example the approach chosen by the UK, where each obliged subject has to provide the proof that a certain amount of packaging waste has been recovered, through the purchase of “packaging recovery notes” (PRN), that are legally recognized to recyclers on the basis of what they actually recycle. In practice, many competing PROs acquire the legal obligation from their clients; they can buy PRN from recyclers or, more often, organize a system that collects and recycles directly. These PROs have been created by the largest SWM companies and/or by recyclers themselves.

The relative merits of different systems are difficult to assess, even because the recycling market has clearly not found a stable equilibrium. The market price of PRN in the UK has experienced a sudden jump as the target deadline was approximating, as a result of an insufficient effort displayed; while national PROs established in other countries have significantly lowered participation fees after achieving the target.

The structure of the concerned industries has a determinant role. In the case of electronic waste, for example, the degree of concentration is higher and the geographical scale of transactions larger; this has favored the creation of own systems operated by the major market players.

Innovation, green supply chain management and EPR

Despite the high expectations about EPR with respect to green innovation and design for the environment (DfE), actual results achieved so far are quite disappointing, as argued in “Some facts about EPR”. Were those expectations misplaced or exaggerated? Or is it, once more, a matter of how EPR schemes have been designed? The latter hypothesis has been investigated in a number of applied studies. What emerges is a fundamental agreement around the likelihood of a trade-off between recycling-oriented and innovation-oriented schemes.

To start with, it should be acknowledged that designing a recycling-oriented scheme is quite straightforward, since the targets are much easier to specify and to verify. In turn, the very definition of DfE is fuzzy and ambiguous, results are difficult to assess and to predict, and do not depend solely on the commitment of industrial players (Walls, 2004). This is what economists define an agency problem: since the policymaker cannot precisely assess whether obliged subjects have complied and whether desired efforts have been actually put into place, it is more difficult to design norms and reward schemes.

Walls (2006) examines 15 instruments consistent with EPR and evaluates them with regard to the incentives provided toward 4 core dimension of resource efficiency – overall waste reduction, virgin material use, recycling and DfE. Instruments that are likely to perform optimally on all dimensions (such as individual take-back requirements) are unfortunately not feasible due to prohibitive transactions costs or alleged perverse incentives. On the other hand, instruments that are both feasible and likely to have an effect on recycling provide only weak and indirect incentives to DfE.

Similar results arise from Runkel (2003) for the specific case of product durability. His theoretical model compares the effects of different policy frames. Again take-back requirements provide a better performance (although all the instruments examined are predicted to have some positive effect).

Brouillat and Oltra (2012) conclude that recycling fees and mandatory recycling quotas, while maximizing the effort toward separate collection and recycling, are less effective in promoting upstream innovation and DfE, because of the “free-riding” effect that is typical of collective schemes (namely, each individual associate refrains from engaging in efforts, expecting others to do it first: but in this way too little effort would be provided on a collective basis, if any at all). A combined tax-subsidy scheme, with subsidies directly paid to industrial R&D targeted to environment-friendly innovation would offer the best result. Other C&C instruments (e.g. technical standards) can operate in the same direction, but in a less efficient way and with weaker incentives to innovation. Dubois (2012) shows that static recycling quotas will progressively weaken the incentives to innovate; he suggests to complement them with a tax on the non-recycled part. Sachs (2006) contends that the degree of “collectivization” of responsibility is a more decisive factor than instruments. In order to foster DfE, incentives should be individualized: each firm should receive precise signals about the impact of its own products, that also function as rewards for DfE efforts. This can be achieved with an extensive program of individual take-back, that could be implemented for instance through leasing schemes and sufficiently high deposit-refunds. In alternative, each firm could be charged a personalized membership fee to collective PROs, taking into account the specific features of its product. If such a signal is not in place, the benefit of innovation will be shared by all, generating a classic free-riding situation. However, since individual schemes are affected by substantial transactions costs, he concludes that the “holy grail” of DfE is actually not achievable by EPR.

This argument deserves to be better examined at the light of the economic theory of green innovation. Porter and van der Linde (1995) postulated a positive link between environmental regulation and competitiveness, provided that it is able to trigger an innovative response: innovation and learning by doing, whilst reducing the cost of actually implementing the policy, allow first movers to acquire a dominant position. Public policy can leverage on the factors that create competitive advantage in order to maximize the incentive.

Empirical research has partially confirmed this intuition, and better qualified under which conditions it may be true (Blanco et al., 2009; Wagner, 2003). These are in fact consistent with the above findings, in the sense that regulations should be flexible and explicitly targeted to innovation at the firm level. The probability of a proactive approach to innovation is highest when the expected benefit for the innovator is higher. In general, market-based instruments provide higher incentives to innovation (Requate, 2005).

First movers can achieve a competitive advantage because they are able to intercept, prior than competitors, the willingness to pay of consumers for more ecological products; yet this might remain trapped in a market niche, or generate a virtuous circle, with more consumers attracted and more firms emulating the innovator.

Obviously, the latter scenario is the desirable one from the viewpoint of environmental policy, since appreciable results at the macro level can only stem from a rapid diffusion of innovations to the whole industry. The public policy, while creating a favorable context for pioneers should also seek to accelerate the phasing out of old processes and dictate the pace of substitution, for example with a progressive tightening of standards. The response of demand, that of public policy and the timing are fundamental (Iraldo et al., 2009).

Environmental policy, in turn, may foster another and more transversal kind of innovation, that is embedded in environmental services. Differently from product-specific innovation, this is driven by a demand arising from the industry as a whole, and is better stimulated when the patterns of demand evolution are more predictable. Here collective EPR could probably represent a more effective tool than individual schemes, especially in less concentrated sectors, for the same reasons discussed in "Transactions costs, missing markets and EPR".

As a matter of fact, the pre-1990 literature postulated the unfeasibility of recycling rates above 10–15%, given the very high cost of sorting the waste stream and the limited market value. The dramatic increase experienced by recycling and recovery in the last 20 years is clearly the fruit of a technological shift, which took place downstream much more than upstream. It is actually more the fruit of organizational than technical innovation. Technical innovation has been significant in the engineering of sorting plants and in the processes aimed at obtaining low-quality secondary products (e.g. unsorted plastics used as additives for building materials). The recycling of composite packages, such as tetrapak, relies on technical arrangements that took place in the post-consumption treatment phases, while little has been done in the product engineering stage.

The Italian case deserves some special investigation, since Italy retains the market leadership in Europe for recycling, being one of the few developed economies that is also a net importer of secondary materials. This industrial capacity builds on a long-lasting tradition. Despite the relatively mature level of its recycling industry, Italy experienced a formidable boom between 1995 and 2005 (Bianchi, 2008): the number of units increased to 2.460 (+47%), employed persons to 12.600 (+42%). Value added amounts to 779 million (+86%) and total turnover to 4.183 (+124%); this development is particularly impressive considering that during the same period the Italian manufacturing industry on aggregate has declined by 2%.

Many clues suggest that this phenomenon is strongly influenced by EPR. It is likely, therefore, that organizational and institutional innovation has allowed technological innovation to fully displace its theoretical potential. It is also possible that the kind of innovation that triggers recyclability is not necessarily embedded in equipment and patents, but requires instead conscious choices on materials and assembling of components. For example, recyclability of plastic packaging has largely benefited from the elimination of PVC – something that does not require patents.

Another neglected aspect concerns the systemic nature of innovation – especially radical innovation, which is supposed to foster a paradigm shift beyond the boundaries of the innovative firm result of a team effort, where it is difficult to recognize and adequately remunerate each individual contribution. In order to ensure that players holding key resources are actually engaged, they need to perceive that the expected payoff is worth their commitment.

The key concept is that of "innovation systems" (Weber and Hemmelskamp, 2005): patterns of technical development result from a network of interactions between innovative firms and a vast number of players – research institutions, education, vocational training, finance, suppliers of equipment and components, consultancies, and finally customers and policymakers. Trajectories of technical change depend therefore on how the supply chain is organized, and in particular on the delicate equilibrium between competitive forces and cooperation.

If applied research will confirm the relevance of these dimensions for resource efficiency, the consequent policy recommendations for EPR design could partially change, for example revaluating the role of collective systems: if adequately motivated, these may effectively catalyze the creation of collaborative networks, leaving individual companies more free to focus on their competitive advantage, while PROs become a "neutral space" where resources and knowledge can be shared, prototypes validated, experiments and sunk costs more effectively shared.

Concluding remarks

It is a tricky exercise to assess the merits of EPR as a policy principle, since it is not easy to separate the effect of targeting producers in general, and those of choosing a specific set of instruments. Most of the arguments discussed in "Theoretical arguments revisited" in fact do not imply a particular role precisely for the producer. More simply they rest on the fact that industry is stimulated to inject its superior organizational and managerial capacity into the recycling market. The fact that the capacity to spur green innovation has been lower than expected sounds as a further hint that individual producers have actually received so far only weak and indirect signals from EPR policies; green innovation upstream seems to be driven more by independent marketing strategies than by EPR.

In our view, most of the comments in the literature underrate the fact that what we have witnessed in the last 20 years has been, primarily and above all, a gigantic exercise of market creation – in the light of the experience, a very successful one. 20 years ago certain recycling targets were unconceivable simply because the downstream market was, at best, extremely thin and fundamentally local, if existing at all. What has facilitated the creation of recycling markets, in our view, is not the fact that producers are involved, but rather the creation of powerful entities that have taken over the task to organize and structure the recycling markets.

This circumstance should perhaps suggest to shift the focus of the analysis from producers to the PROs. The main merit of EPR has been that of creating the legitimacy base of the system and providing a widely accepted cost-sharing criterion; and perhaps also representing a credible threaten that triggered industrial response.

Some market distortions was probably inevitable in the start-up phase. The issue today is whether the market edifice is now complete enough to allow a gradual dismantling of scaffolds, or if they are still needed, perhaps with new and different tasks. Maturity has already brought corrections and gradual opening to competition. Further innovative arrangements and creative institutional developments have to be expected.

These will be hopefully able to spur also long-term results concerning waste prevention; without forgetting, however, that the baseline target of controlling waste flows is not yet fully achieved. In cases such as that of electronic waste – characterized by a substantial opaqueness the global value chain, with massive flows still disappearing in an uncontrolled way, it would be wiser to assign priority to "having one bird in the hand", namely, assuming control over the system (Huisman, 2013). Other waste streams still await the identification of appropriate schemes: from organic to demolition waste, from combustibles to toxic compounds, from food waste to orphan waste and rehabilitation sites.

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