REVERSE LOGISTICS OF E-WASTE IN DEVELOPING COUNTRIES: CHALLENGES AND PROSPECTS FOR THE BRAZILIAN MODEL

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Introduction

In recent years, e-waste reverse logistics (RL) has gained recognition both by academics and practitioners. Drivers for RL include the rapid growth of e-waste, the evolution of environmental legislation, and the increase in consumer pressure for social corporate responsibility (Lau, Wang, 2009, Janse, Schuur, Brito, 2009). This context has generated different models of RL in developed countries. In contrast, e-waste RL in developing counties is still in a preliminary stage. Initiatives in emerging economies like India, China and Brazil show that specific models must be adapted to local reality. The emerging model of RL in these countries is forced to cope with the lack of appropriate legislation and economic incentives, low public awareness, unbranded products and informal street waste pickers who are responsible for the increase in e-waste collection and processing with little regard to health, safety and environmental protection (Schluep et al., 2009, Manomaivibool, Vassanadumrongdee, 2011, Wang et al., 2012).

The Brazilian National Solid Waste Policy (BNSWP), signed into law in 2010, represents an innovative approach among developing countries in order to implement RL for e-waste. Under this approach, producers, importers and retail companies are co-responsible for developing and implementing a RL model, independent from the public waste management system. The Brazilian law is also the first regulation worldwide to recognize the importance of waste picker organizations in the recycling chain and to require the integration of these workers into the RL system (Demajorovic; Migliano, 2013). The success of this model is essential to Brazil because of the rapid increase in electronics consumption like computers and cell phones and the amount of e-waste being discarded. A study on e-waste generation volumes in 11 selected developing countries

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presented by Schluep et al. (2009) revealed that Brazil generates 96.8 metric tons/year of computer waste, surpassed only by China with 300 tons.

Although risks related to Waste Electric and Electronic Equipment (WEEE) appear as more challenging in developing countries, most of the published studies on RL were done in developed countries (Lau, Wang, 2009). But it is precisely in emerging countries, with lower social control, where the computer market is growing more rapidly, making their correct end-of-lifecycle collection and disposal essential to mitigate potentially negative social-environmental impacts. In this context some important issues are raised about the perspectives for reverse logistics implementation in Brazil, based on the model presented by the legislation. Are computer and cell phone supply chains in Brazil ready to fully implement the Brazilian RL model and to integrate waste pickers into that? Aiming to contribute to this debate, this research has as its main objective to discuss challenges and opportunities for the implementation of the RL Brazilian model for computers and cell phones. To reach this objective, we have the following related objectives: to present an overview of the reverse logistics international models in developed and developing countries and compare, based on the principles of BNSWP, the proposals for the implementation of the Brazilian model. As methodological tools, we conduct in-depth interviews with the main stakeholders involved in the developing of the RL sectorial agreement of e-waste.

Reverse logistics in developed and developing countries

RL is the process of planning, implementing, and controlling the efficient, cost effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin, for the purpose of recapturing value or proper disposal (Rogers, Tibben-Lembke, 1998). Several factors account for the greater interest in RL programs by managers and academics from the 1990´s on, especially: the evolution of environmental legislation (Jayaraman, Luo, 2007); consumer pressure and benefits to corporate image (Janse, Schuur, Brito, 2009, Lau and Wang, 2009). Also, competitive pressures and technological advances foster, on the one hand, product obsolescence and shortened lifecycles; on the other hand, the development of new materials that enable more reusing and recycling has helped inserting RL into management practices. Janse, Schuur and Brito (2009) research with 5 large electronics manufacturers has shown that 3 of them already had a division for RL management.

Also, several barriers to implementing RL are identified in different researches. Producers often postpone investments in LR due the costs related to the necessary infrastructure to collect end-of-lifecycle waste and to recycle or reuse this material. (Jayaraman, Luo, 2007, Stock, Mulki, 2009). Corporate lack of interest in RL is explained also because of the complexity in coordinating different supply chain players, such as wholesalers, retailers, consumers, collecting and recycling organizations (Rogers, Tibben-Lembke, 1998, Lau, Wang, 2009). Gaps in legislation can also impact negatively this process of coordination. European Directive, for instance, requires a share responsibility model to implement a system of collection and treatment of WEEE. But, while producers are

responsible for WEEE treatment, collection is not clearly defined (Rotter, Chancerel, Schill, 2011). Therefore, retailers may agree accepting retuned WEEE but refuse to pay the cost of transportation to producers or municipal collection sites. In some countries, other problems have also been detected, especially tax structures and the lack of financial incentives to expand the activity (Schluep et al., 2009). In this scenario, several models for RL management have been devised in developed countries and, more recently, in developing ones.

Main characteristics of RL models in developed and developing countries

Switzerland was the first country to implement an organized system to collect and recycle WEEE, which has been active since 1995 (Sinha-Khetriwal, Kraeuchi, Schwaninger, 2005). This system was preceded by two volunteer initiatives by electrical-electronics manufacturers, who created two Producer Responsibility Organizations (PRO). In 1990, *S.EN.S* (Swiss Foundation for Waste Management) was created as not-for-profit organization for waste solutions on behalf of manufacturers, importers and retailers (Hischier, Wäger, Gauglhofer, 2005).The SWICO Recycling Guarantee was created in 1993 by the Swiss Association for Information, Communication and Organization Technology (SWICO) outlining the prerequisites for recycling companies to process SWICO material (Hischier, Wäger, Gauglhofer, 2005). However, the legislation itself on WEEE collection and recycling became effective only in 1998 (Sinha-Khetriwal, Kraeuchib, Schwaningerc, 2005).

PRO are managed by committees of manufacturer representatives, who are responsible for decisions such as the definition of the Advanced Recycling Fee (ARF) to finance the system and evaluate recycling contracts (Khetriwal, Kraeuchi, Widmer, 2009). According to Sinha-Khetriwal, Kraeuchi and Schwaninger (2005), 68,000 tons of WEEE were collected in Switzerland in 2003, around 9 kg/person, 125 percent above the 4 kg/person minimum demanded by Europe´s WEEE Guidelines. The waste collection system was successful due to the efficient waste flow management by SWICO and S.EN.S (Sinha-Khetriwal, Kraeuchi, Schwaninger, 2005). Khetriwal, Kraeuchi and Widmer (2009) stress the importance of the partnership between PRO and the Swiss Federal Office for the Environment, both initially and during the whole process; they have collaborated in implementing collection and recycling networks, and also in writing the law. Another essential element, in the authors' opinion, was basing the waste management system on Extended Producer Responsibility, with clearly-defined roles for all stakeholders involved – government, manufacturers, retailers, wholesalers and consumers. Because of PRO (financed by the Advanced Recycling Fee - ARF), responsibility for operating the system still rests with manufacturers, but co-responsibility of the other chain players is clearly defined by the law, which assigns their role in making sure that WEEE is returned to collection centers. The government has the role of monitoring the system and licensing activities, as in the case of recycling companies.

Another successful example in LR for WEEE is Sweden, which became the global leader in WEEE collection thanks to a 2001 agreement between EEE manufacturers and

local authorities. A cooperation system was established in which the Swedish producers' organization, represented by El-Krestsen, would be responsible for all disassembling, decontamination, recycling and environmentally sound disposal costs. All 290 Swedish municipalities would become responsible for the WEEE collecting system (SEPA, 2009). Swedish citizens return to recycling a little over 16 kg per capita of WEEE annually, to the over 1,000 drop-off centers around the country (Elretur, [2010?]). WEEE collection has greatly evolved since 2002, growing from 4kg per capita/year to over 16kg in 2008.

In 2008, a manufacturer organization launched the Swedish Association of Recycling Electronic Products (EÅF). Members' stores are used as drop-off centers. EÅF has made a financial compensation agreement with El-Krestsen, by which its members pay the same WEEE recycling fees as El-Krestsen members, in cities where they do not have drop-off centers (SEPA, 2009). The example of Sweden points to the importance of partnerships with local governments and with retailers, as well as between the WEEE recycling systems managed by distinct manufacturer groups. In the case of El-Krestsen, the partnership permits recycling by EÅF members at the same cost in places without drop-off centers, leveraging the spread and reach of both organizations around the country.

In developing countries some experiences are also underway. Project StEP, launched by UNO, is one of the most important and its goal is to minimize WEEE problems by creating global recycling standards through the assessment of the best existing alternatives. A development due to project StEP was the creation of a consortium joining two multinational EEE manufacturers, an EEE reconditioning company, a European precious metals refinery, several research institutes and a mixed metal waste recycling company, to create the ideal WEEE large scale recycling model in China. This initiative was reported by Wang et al. (2012), in their analysis of the environmental and economic benefits of implementing the Best of 2 Worlds (Bo2W) philosophy in developing countries. Their study compared the results to a low-scale Indian model implemented by the Swiss WEEE Program through EMPA, involving the informal sector in Bangalore in partnership with local recyclers.

After one and a half years, Wang et al. (2012) demonstrate that the large scale recycling system implemented in China, despite the amount of technical knowledge generated, was not efficient. One of the main challenges they faced was a lack of sufficient WEEE, at reasonable prices, to sustain the daily operation of the plant. Due to the absence of electronic waste treatment laws in the country, the informal sector dominated waste collection and negotiations. The project to treat such materials in an environmentally sound way became economically unfeasible for the consortium, losing in competitiveness to the informal sector. Wang et al. (2012) argue that implementing a Bo2W recycling infrastructure in large scale in China can only be successful when adequate laws are in effect.

In India, the pilot project showed more promising results; so far, two waste lots have been shipped to the European recycling plant. A small scale approach, similar to the model analyzed in China, was used to implement the Bo2W model. In pre-processing and manual disassembling phase, local informal labor was employed, with incentives to produce ideal lots to be shipped to the European recycling plant. Wang et al. (2012) have identified an important financial barrier in the gap between waste shipment and

post-processing payment by the European plant, since the informal sector works based on daily payments for production. This model is supported by the size and costs of the informal recycling sector, saves thousands of jobs and guarantees minimal wages for workers. Wang et al. (2012) suggest, as a solution for cash flow issues in the informal sector, a partnership between large local or international recycling organizations, who could act as middlemen between the informal sector and the plant, financing the cash flow. The authors stress another important factor: the need to implement safer processes, both to the environment and to workers' health. Even so, the authors claim it is preferable to use manual disassembling in developing countries, with lower operational costs and higher yield of recovered materials, as opposed to the high energy consumption, investment costs and lower recovery yields of mechanical sorting technology.

Despite some advancements, many challenges remain to a large scale implementation of RL in developing countries, such as: collection volumes insufficient to sustain the operation financially; technological gaps; and illegal exports of WEEE. Taxation issues are also identified as barriers to companies joining the programs (Schluep et al., 2009), as well as the resistance by self-employed waste pickers and informal sector companies to supplying WEEE to organized, well-equipped recycling centers. Finally, low awareness of WEEE potential risks to health and the environment is another barrier to implementing LR systems (Jang, 2010), which favours disassembling and recycling processes without safety equipment and environmental controls (Lundgren, 2012).

In Brazil, great progress has been recently made with the passing of Law 12.305/2010 establishing the BNSWP (Guarnieri, 2011). This has addressed the absence of national legislation focusing on adequate management of solid waste and RL.

Brazilian National Solid Waste Policy

The BNSWP defines guidelines for integrated management of solid waste. It also demands the implementation of RL systems by manufacturers, importers, wholesalers and retailers of toxic and technological products, guaranteeing that, after consumption, these products are either returned to the supply chain or disposed in environmentally sound ways (Brasil, 2010).

Several authors stress the innovative character of Law nº 12.305/2010, in special the Shared Lifecycle Responsibility, RL, Industry Agreements and the promotion of the eco-efficiency concept. The law gives directions on how production processes may generate less waste, on how to recycle, reuse and recondition waste, and how to include waste pickers as service suppliers in RL chains (Guarnieri, 2011, Yoshida, 2012, Demajorovic, Migliano, 2013).

In the specific case of electrical-electronic equipment, article 33 in the BNSWP established that EEE and their components, including computers, must be returned after end-of-life to their point of origin through RL, independently from public sanitation services and urban waste disposal. The law also established that RL systems should be defined by sectorial agreements, defined as contracts between the government and manufacturers, importers, wholesalers and retailers, aiming to implement shared product lifecycle responsibility (Brasil, 2010).

The law also innovates by recognizing waste pickers organizations as fundamental players in the recycling chain, and it stimulates their inclusion into initiatives to expand waste collection and sorting. Ribeiro et al. (2009) remind that in Brazil most of the recycled waste is returned thanks to waste pickers, who great social vulnerability is an essential source of profitability for the local recycling chain. In Brazil, around 1 million waste pickers daily supply the recycling reverse chain. Importantly, the new legislation claims that they should be included into RL processes through cooperatives and not as self-employed. The idea is that, through partnerships with large companies in the RL chain, waste pickers are able to get higher profitability and more dignified working conditions (Souza, Paula, Souza-Pinto, 2012). But building such partnerships still faces a series of challenges, such as: because they lack professionalized management processes and business legal structure, cooperatives often cannot issue an invoice for their services and are thus disqualified as suppliers to the recycling industry; little priority is given to management training among cooperative members, who value practical knowledge; and corporations or recycling companies know very little about cooperatives reality, generating misunderstanding and conflicts (Mota, 2012, Demajorovic, Migliano, 2013).

Research Method

The study was done using a qualitative, exploratory research. The complexity of RL for WEEE, with its several stakeholders often with conflicting interests, justifies the choice of a qualitative research approach. According to Godoi and Balsini (2010), qualitative studies help in understanding the agents involved, not in terms of regularity, but as to the motivations behind their actions.

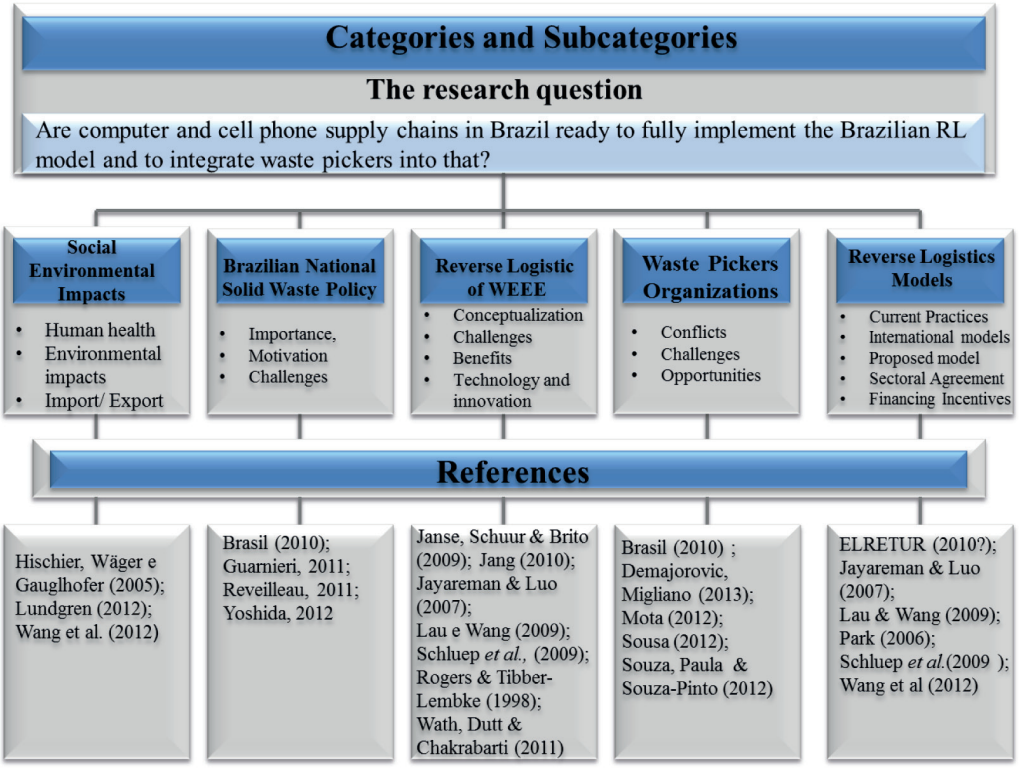
Methodological procedures included 21 in-depth interviews with multiple stakeholders including government, manufacturers, retailers, recycling companies, waste picker organizations and academics. The sectors and their representatives were chosen based on the literature review and information collected by the researchers' participation in forums and seminars on BNSWP and in debates focusing on e-waste. Futhermore, the snow-ball technique helped to identify new sources of information to the non-probabilistic sampling method chosen (Godoi, Mattos, 2010). Five computer and cell phone manufacturers, 3 WEEE recycling companies; 2 syndicates; 2 retailers, 2 waste picker cooperatives; 2 BNSWP specialists; 2 academics; 1 federal government representative; 1 state government representative; and 2 municipal government representatives were selected. The theoretical saturation criteria or redundancy, defined by Glaser e Strauss (1967) shows that the chosen sample was sufficient to guarantee a broad analysis of the research subject.

To ensure internal validity, particularly the reliability of the results, some procedures were adopted: triangulation of data through different sources of information, including interviews, documental analysis and observation in loco in cooperatives and recycling suppliers. The recorded interviews were transcribed and later submitted for interviewees approval (Creswell, 2010).

In addition to the above procedures, the reliability was also ensured by means of a protocol which established the objective, the research question, the theoretical structure,

the procedures for data collection, the collection instrument and the form of analysis and processing of data (Yin, 2010). The main elements of the Protocol and the following categories and subcategories identified in the literature review are shown below in figure 1

Figure 1. Categories and subcategories



Source: Authors

For Eisenhardt (1989), the analysis process is the essential element of qualitative research. The results were treated through content analysis. According to Bardin (2011) content analysis is a set of techniques that uses systematic procedures in order to guarantee an objective description of data content. Data collected during the interviews were organized and analyzed using the NVIVO software, which analyzes unstructured material in Word and PDF documents, videos, photos and audio files. The software was useful to organize the content of the interviews by the analytical categories. This tool also helped to identify agreements, contrasts and disagreements among respondents on the Brazilian LR model. The most important findings from this process presented in the next topic.

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Research results

To answer the main research question, i.e., the barriers and perspectives in implementing RL for e-waste, we present the understanding of the multiple sources of information, considering the category analysis identified in the literature review.

The first group of questions focused on the interviewees perception of the main impacts of e-waste on human health and the environment. All information sources do not recognize the productive process of EEE as a fundamental source of risk to human health and the environment. Issues such as toxic substances used in the manufacture of EEE and new product development strategy that favor the miniaturization of electronics devices were not identified by respondents as a significant risk associated with the production process and also as barriers to expansion of the reuse of WEEE. The risks have been recognized only in the process of post discharge and are related to its handling by cooperatives. No respondent believes that Brazil will receive WEEE imported illegally, as well as becoming an illegal exporter of this residue.

> ACA-01 – "we have visited some cooperatives. They are breaking the monitors with hammers and leaving them abandoned. They are not aware of the lead hazard and poisoning.
>
> IND-05 – "we don't see disposal of computers in the middle of the street. Those images of computers thrown on the street certainly don't match the Brazilian reality. ."

The second block of questions deepened the perception of the respondents on the importance attributed to BNSWP. As positive aspects, all interviewees agree that BNSWP represent a fundamental regulatory framework to advance the RL initiatives for WEEE. In addition, its importance is linked to the Brazilian market´s dynamism and its exponential growth of EEE consumption and e-waste generation

> GOV-03 - "The BNSWP has given the necessary instruments to implement the LR. Formerly we had CONAMA resolutions demanding the return of post-consumer waste, but not specific instruments for the LR. Now we have a legal framework that makes mandatory the implementation of LR, such as sectorial agreement or the term of commitment.
>
> ACA-01 – The motivation, I think is clear! Brazilians are consuming more computers and electronics. Brazil today has around 1.33 phones per person. The number of phones sold per year is increasing by around 18% to 20%. Furthermore, the time that consumers change their old cellphone for new ones has decreased to.about 7 to 9 months, according to data from ANATEL. So more and more waste is being generated" "

Despite the positive aspects of the new legislation, conflicts and challenges emerged more frequently in the discourse of the interviewees. This may be partially explained by the industry´s position before the law was passed.The strong industry resistance to accept post-consumption responsibility had resulted in the 21-year period needed for the law's approval (Guarnieri, 2011, Reveilleau, 2011, Yoshida, 2012). A key point for companies was the issue of costs related to implement RL. This finding confirms several other research projects in different countries that support the fact that financial costs is the main reason why the EEE industry still resists the adoption of RL programs (Lau, Wang, 2009, Stock, Mulki, 2009). Cost involved in the initiatives lead to other problems like the conflicts of interests between members of the reverse logistic chain. The private sector accuses the government of not having clearly defined the roles in the reverse chain and complains about the lack of incentive policies for its implementation. On the other hand, the government accuses the private sector of inflating challenges in order to postpone implementation. Industry players themselves accuse each other of unwillingness to bear the transportation costs involved in RL. It seems that these conflicts have been amplified in the Brazilian case, although they have also appeared in other international models, because of the absence of previously defined roles, as was the case with the Swedish and Swiss models discussed above (Sinha-Khetriwal, Kraeuchi, Schwaninger, 2005, Hischier, Wäger, Gauglhofer, 2005). Also, share responsibility, it is something quite new in Brazilian reality (Yoshida, 2012). Therefore, members of the reverse supply-chain of WEEE need to learn how to cooperate and work together to fulfill the Brazilian law requirements.

> IND-05 – "retailer doesn't seem to be very interested in talking because they don't want to pay for the primary logistics. What is the primary logistics? The consumer would deliver the equipment to any retailer, then it would have to transport the equipment to a cargo distribution center and then the industry would collect in those centers, as we do not have capacity to collect in each store. Our initial agreement was to establishes the number of points where the industry will pick up WEEE, and retailers would be responsible for storing this load for us to go and get it

> COM-02 – "Responsibility for storing post-consumer products will fall always on large retailers units like supermarkets, because they have big areas available. But this affects competitiveness because storing WEEE brings costs. Moreover, big retailers will be responsible for receiving the biggest share of the total amount of e-waste collected, while most of the sales are made by smaller business.

The third block focused specifically on the question of RL. Challenges also appears as more important than any benefits generated by the implementation of the new law. For example, accordingly to Janse, Schuur and Bashir (2009), one of the the main benefit due LR legislation requirement would be to generate innovations in the use of raw materials and materials that facilitate the process of reuse and recycling. In the interviews, 40%

of respondents addressed this aspect of the BNSWP as positive, but only 1 see this as feasible in the current scenario. The main problem is still cost sharing and responsibility. The issue with transportation costs is emblematic of how difficult it is to advance the RL Brazilian model in order to fulfill some of the major objectives of BNSWP. Jang (2010) defines this activity as central to render any RL initiative unfeasible. In Brazil, this issue is aggravated by the country´s continental dimensions and the inefficiency of transportation systems. Even though these country characteristics are very relevant, the crucial point seems to be how to share costs. For the government representatives, the law clearly defines manufacturers as accountable for WEEE, with the prerogative of sharing this responsibility with wholesalers and retailers. Yet, the research has also shown that there are conflicting views among manufacturers, wholesalers and retailers, who use gaps in the law to avoid a definitive distribution of the transportation costs involved.

> COM-02 – "In countries where RL is advancing, industry is clearly responsible for implementing the process, while other members of the supply chain are invited to participate. In Brazil, law defines share responsibility for the implementation of RL, but do not define the specific tasks of each member of the reverse supply-chain

> IND-01 –If the law says that the retail has to receive and deliver the material to industry, so it's expected form industry that they do so, but retails representative claim that the material is there and should be collect by the industry itself, so everyone can understand what's best for themselves, these was one of the big problems because law is not clear defining the roles of members in the reverse supply chain.

In order to finance the costs of the RL system for WEEE, the creation of a recycling fee is being discussed, to be charged at the moment of equipment purchase or return. Studies on the Swedish (SEPA, 2009, Elretur, [2010?]) and Swiss (Khetriwal, Kraeuchi, Widmer, 2009) experiences have shown that the fee was essential for their success. In the Brazilian case, the model has not yet been defined, as the industry wants the fee to be visible to consumers and tax-free. This aspect is linked to the problem of consumer consciousness observed in studies by Jang (2010), Wath, Dutt and Chakrabarti (2011), and Lundgren (2012). Interviewees affirm that Brazilian consumers' lack of consciousness results in improper disposal of WEEE and in resistance to pay the additional costs of a recycling fee. This is a different reality from Europe, where the percentage of correct disposal is higher than the one enforced by law, and consumers do not bother to pay the disposal fee because of high environmental consciousness (Khetriwal, Kraeuchi, Widmer, 2005).

The challenges related to transportation costs previously discussed are joined by gaps in the Brazilian law. There are 256 distinct state and city laws, with different or even contradictory demands, due to the absence of a national legislative standard for WEEE and RL, according to industry and commerce stakeholders.

Another challenge is the shortage of recyclers capable to meet all the legal requirements and certification demands in treating materials adequately, without risks to human

health or the environment, and respecting labor laws. On the other hand, a positive aspect of the Brazilian law was the significant increase in license demands by recycling companies in the state of São Paulo. Nevertheless, there is no perspective in the Brazilian scenario of recycling plants being established to extract computer board materials. The interviewees affirm that, besides the high construction and operation costs (Schluep et al., 2009; Wang et al., 2012), WEEE demand in Brazil is not sufficient to keep a recycling plant running - something around 15 percent of plant capacity according to industry, commerce and recycling sources.

The fourth group of questions focused on one of the most innovative aspects in the Brazilian law, that is, the inclusion of waste picker cooperatives (Mota, 2012, Yoshida, 2012). The study´s findings show the importance of investing efficiently in order to improve the cooperatives' management processes, which go beyond just supplying equipment. It is necessary to offer constant training and new technology, to educate managers and to respect regional differences, as argued by Souza, Paula and Souza-Pinto (2012). In this aspect, partnerships between large manufacturing or recycling companies and cooperatives may be interesting for both sides, offering higher profitability and dignity for waste pickers (Demajorovic, Migliano, 2013, Souza, Paula, Souza-Pinto, 2012). But the potential of the collaboration with cooperatives has only been recognized by government representatives, the academia and the cooperatives themselves. In fact, in19 out of the 21 interviews complicating factors related to working with the cooperatives were mentioned, despite the opportunities that this could offer to Brazilian reality, as supported by Demajorovic and Migliano (2013), Mota (2012) and Souza, Paula and Souza-Pinto, (2012).

> IND–02 – "I don't see waste pickers organizations included in the process of RL of WEEE. When choosing a managing organization, which needs a mandatory environmental permit to handle WEEE, waste pickers organizations will have to meet this standard. The most controversial aspect of the law is the inclusion of cooperatives in this process ".

> COO-01 – "Without proper empowerment and skills development, I do not see how waste pickers organizations could be effectively included in the implementation of the RL

The last group of questions dealt with the possible alternatives for the development of a RL model of WEEE in the Brazilian reality. Issues such as the creation of a recycling fee to sustain the entire system of LR, including collection, transportation and sound destination is a consensus among interviewees. In terms of the most adequate model for RL management in Brazil, interviewees seem to agree with Khetriwal, Kraeuchi and Widmer (2009) on the importance of PRO and defend implementing a model similar to the Swiss and Swedish ones. In Brazil, the Management Organization (MO) would be be responsible for the LR system, including distribution of the collection points, services hiring, such as transportation, consolidation points, recyclers suppliers and sound dispose of toxic substances contained in the WEEE in landfills. .

> IND-05 – In our model we will hire a MO who will perform the tasks required by law.such as collection and destination. Producers will share the costs operations according to the amount of WEEE generated by each manufacturer. We did not expect to create a company, but rather hire a company in the Brazilian market that has the ability to operate it.

> COM-02 – Commercial premises will receive WEEE. We will not be responsible for collect in the households or in the collection points spread through the city. The MO is responsible for picking up WEEE in the collection points. These collection points can be installed in commercial premises or other partners. The resources generated with the recycling fee will go directly to the MO that would be responsible for financing the entire process. We can have more than one MO. The model of Switzerland and France is very similar "

Government representatives suggest the collaborative participation of the municipalities in the collection of WEEE, leveraging existing infrastructure, provided they are paid by the industry to this end.

> GOV-01 – "The municipalities have a waste collection service and we think That the public sector could collect WEEE and be paid by industries for the service provided. This service could be a source of income for municipality and we are now discussing the necessary instruments to implement the alternative.

Some players defended the creation of pilot models to test their efficiency and to diagnose bottlenecks and obstacles that need to be corrected. However, government representatives claim that the Sectorial Agreement will be signed without all the hindrances solved, because the models discussed so far demand features not included in the new legislation. Central themes that emerge are the classification of WEEE, defining WEEE as a hazardous or not hazardous waste, since the presence of toxic material in some of its components, implies additional difficulties for storing and transporting end-used Computers. Also fundamental is an alternative taxation system that encourages the recycled process of WEEE without incurring on double taxation, avoiding the problems of the current legislation.

> COM-02 – At first the Ministry of Environment (MMA) will sign an agreement with us, with the embedded cost. The manufacturer will transfer the whole financial amount to the MO in order to cover all management expenses related to RL operations. Then we will open another line of negotiation with the Ministry of Finance to be financial compensated for contribution

Considering all discussion presented above, we present a synthesis of the main characteristics of the Brazilian model, as compared to other international experiences.

Table 1 – International Models and potential Brazilian model

	Switzerland	Sweden	China	India	Brazil
Government	Active	Participative	Not active	Not active	Active
ndustry	Total Management	Transportation/ Recycling	Ships WEEE		Total Management
Consumer	Pays ARF Returns	return			Pays embedded fee and returns
Informal S.			Excluded	Pre-Processing	No training
Model	EPR PRO	EPR Gov / PRO	Consortium StEP	Empa Program	SPC
Financing	TAR	Industry	Self Sustained	Self sustained with pre-paid to waste pickers .	Embedded fee to cover RL costs
Performance	9kg/p.c/year high consc.	16kg/p.c/year high consc.	Lacks Indicators	Lacks Indicators.	Lacks Indicators

Source: Authors
Note: SPC = Shared Producer Responsibility, EPR = Extended Producer Responsibility

The Brazilian government tends to become active in defining and creating fiscal, credit and financial incentives, but not in inspecting the Management Organization (MO); this is going to under the responsibility of the industry managing all RL for WEEE. The operating organization will be hired in the Brazilian market and the steps in the RL process may or may not be outsourced. Besides the MO, another organization will be created to audit all the companies in the reverse process, as well as the results obtained. Brazilian consumers should be responsible for returning cell phones or computers cost- and incentive-free at drop-off centers. An embedded fee to cover RL costs will be charged at product purchase, which the industry will transfer to the MG. After disposal of equipment at drop-off retail points, the MG will collect and transport it to a site, where it will be sorted by brand and pre-stored. After that, it will be transferred to trans-shipment centrals for de-characterization and recycling, decontamination and elimination of final rejects.

Conclusion

This study has identified some of the main challenges and perspectives involving implementing RL in Brazil and compared models already implemented in other developed and developing countries. Below we

Even if most of the stakeholders interviewed seem to agree on the model to be implemented, its effective operationalization will face a series of barriers, including cultural, geographic and technological dimensions. Special emphasis should be given to the conflicts inside the chain itself and the low willingness of manufacturers, wholesalers and retailers to work cooperatively, mainly in terms of costs sharing. Also, the low consciousness of the population and the difficulties in adjusting taxation in the Brazilian law pose a threat to the model's financing. The possibility of a double taxation pointed out by interviewees represents a political cost, with little interest to the government. Also, the

possibility should be considered that an increase in costs of final products may stimulate consumers to purchase products in the gray market .

Brazil´s huge territory makes collecting waste even more difficult outside big urban areas, due to the logistics costs involved. We should keep in mind that the volume and value of product raw materials are essential to offer gains of scale and to ensure the financial feasibility of RL activities. In Brazil, the present technology only allows the recycling of components with lower aggregated value. Computer boards can only be sorted and packaged for reconditioning overseas, thus transferring to other countries the biggest share of the value generated with the activity.

Finally, the presented model poses a threat to one of the most innovative points in the Brazilian law, especially in the context of emerging countries: the inclusion of waste picker cooperatives in the process. RL programs in emerging countries may be innovative not only in terms of economic and environmental gains, but also in increasing income and social inclusion. Wang et al. (2012) research in China and India demonstrated that few results have been accomplished in this aspect, and Brazil seems to go in the same direction. The industry´s low willingness to work in partnership with cooperatives, with their management deficiencies and the lack of training to work with WEEE, are indications that the law will hardly be obeyed. Financial incentives, education and training for waste picker cooperatives seem paramount to help the law fulfill its social purposes.

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***Abstract*:** E-waste reverse logistics initiatives in important industrial economies like India, China and Brazil show that specific models of reverse logistics, adapted to local reality, are required in developing countries. This research objective is to discuss the main challenges and opportunities for the implementation of the reverse logistics Brazilian model for computers and cell phones. Methodological procedures included 21 in-depth interviews with multiple stakeholders including government, manufacturers, retailers, recycling companies, waste picker organizations and academics. Results show the importance of the new regulation to enhance the dialogue among the members of the electro electronic supply chain for the development of the Brazilian model of reverse logistics. However technological gaps in recycling e-waste within the country, its continental dimension, taxation challenges and conflicts between waste picker organizations and the industry are challenges for the Brazilian model success.

***Keywords*:** E-waste, reverse logistics, waste pickers, shared responsibility, recycling,

***Resumo*:** As iniciativas de programas de logística reversa de resíduos eletroeletrônicos em países como Índia, China e Brasil mostram que modelos específicos, adaptados à realidade local, são necessários em países em desenvolvimento. Esta pesquisa tem como objetivo discutir os principais desafios e oportunidades para a implementação de modelos de logística reversa de computadores e aparelhos celulares. Os procedimentos metodológicos incluem 21 entrevistas em profundidade com múltiplos *stakelholders* incluindo representantes do poder público, fabricantes, varejo, recicladores, cooperativas de catadores e acadêmicos. Resultados evidenciam a importância da nova legislação para ampliar o diálogo entre os membros da cadeia de eletroeletrônicos para o avanço do modelo brasileiro de logística

reversa. No entanto, barreiras tecnológicas para reciclagem de resíduos eletroeletrônicos no país, as dimensões continentais, entraves tributários e os conflitos entre organizações de catadores e indústrias ameaçam o sucesso do modelo brasileiro.

***Palavras-chave*:** Resíduos eletroeletrônicos, logística reversa, catadores, responsabilidade compartilhada, reciclagem.

***Resumen*:** Iniciativas de logística inversa de desechos eletrônicos en importantes economías como India, China y Brasil demuestram que se requieren modelos específicos de logística inversa, adaptados a la realidad local en los países en desarrollo. Este proyecto de investigacin tiene como principal objetivo discutir los desafíos y oportunidades para la implementación del modelo brasileño de logística inversa para computadoras y teléfonos celulares. Los procedimientos metodológicos incluyeron 21 entrevistas en profundidad con múltiples stakaholders como representantes gobenamentales, fabricantes, empresas recicladoras, minoristas, organizaciones coletoras de materiales reciclables. y académicos. Los resultados muestran la importancia de la nueva regulación para mejorar el diálogo entre los miembros de la cadena de suministro de electrónicos de forma a contribuir para el desarrollo del modelo brasileño de logística inversa. Sin embargo gaps tecnológicos para reaprovechamento de componentes eletroeletrónicos en Brasil, su dimensión continental, desafíos fiscales y conflictos entre organizaciones de coletores de materiales reciclables desafían la implementacion del moldelo brasileno.

***Palavras-clave*:** Resíduos eletro eletrônicos, logística inversa, cartoneros, responsabilidade compartida y reciclage