Rationalizing the Choice of the Extended Producers' Responsibility Scheme for Promoting the Recycling of Waste Lead-Acid Batteries in China

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Abstract

Environmental policy instruments can be generally applied to overcome problems of externalities through the consideration of environmental value in the decisions of private polluters. Scholars recognize the absence of a single policy instrument that fits all scenarios. Potential tradeoffs and actual feasibilities should be assessed reasonably, and choosing among various instruments is a key challenge for policy makers. The evolution of environmental policies can be generally divided into three stages, namely, regulatory instruments, market-based instruments, and persuade instruments. Extended Producers' Responsibility (EPR) is an environmental policy approach and generates many persuade instruments, including green product design, information disclosure and corporate recycle fund, etc. The EPR has played an essential role in EU's environmental policy making, and also diffused into other countries, especially in the field of waste recycling. This research conducts a case study by comparing the waste lead–acid battery recycling in the EU and China. Empirical findings indicate a leapfrog development with deficiency in market-based instruments and with promotion on persuade instruments of EPR in China, which is rationalized by a proposed optimized theoretical framework of externality and actual feasibilities in China. This research enriches the theoretical discussion on environmental management and inspires the policy design of related waste management issues.

Keywords

Environmental policy instrument, extended producers' responsibility, China, lead–acid battery,

1 Introduction

Extended producer responsibility (EPR) is an important strategy in the field of waste management. Based on a persuade approach, it forms many environmental policy instruments, which aim to overcome problems of externalities through integrating environmental value into the decisions of polluters. The EPR strategy was initially introduced by Professor Thomas Lindhqvist in 1990 and have been widespread implemented in developed countries. In China, where the waste in its expansion growth, the EPR scheme was officially formulated in 2016 and is currently in its pilot stage[1]. How to conduct the policy experiment and implement the EPR scheme in China, is a key question for facilitating the sustainable development of circular economy. However, before researching on the mechanism of local policy experiment for EPR, it is necessary to rationalize the choice of EPR, instead of other policy instruments, which will provide enlightenments for the on-going policy experiments and also contributes to the research of collaborative governance and theoretical discussion of environmental management.

Lead is a metallic element that is vital to industrial development and environmental protection. Its wide-ranging properties make it a versatile material in industrial manufacturing, especially in the consumption pattern of lead–acid batteries (LABs) (e.g., Brenda et al. 2015). Unlike other application forms, such as gasoline additives and paint pigments, which have been partially phased out, lead cannot be cost effectively replaced with other materials in batteries currently (Andreas 2013). The number of LABs has increased along with the economic growth of China, which is home to the largest LAB industry with an output of 205 million KVAh in 2013, representing over 30% of the global LAB outputs (Liu 2013; Guo 2013). Used LABs (ULABs) are important components of waste electrical and electronic equipment (WEEE).

[1] The Notice on the Policy Experiment of Extended Producers' Responsibility for Electric and Electronic Products (No. 2016-99, State Council of China).

ULABs serve as the main resource of secondary lead and contribute to more than 85% of the total amount of secondary lead worldwide (Ellis and Mirza 2010). In many developing countries, including China, where current gaps in environmental regulation, high demand for second-hand goods and the social norm of selling waste encourage the growth of a strong informal recycling sector, posing tremendous pollution risk to the environment. The improper management of ULABs results in tremendous environmental pollution and causes serious public concern. Especially in China, ULABs cause 95% of the total lead emissions and poses toxicity potential to 90% of the Chinese population (Agudelo 2011; Tian et al. 2014). The proper management and sustainable utilization of ULABs is a typical case of environmental policy making and a key challenge for the development of a circular economy.

The rest of the paper is organized as follows. A theoretical analysis framework is clarified in Section 2. A comparative study between EU and China is shown in Section 3, illustrating the differentiated policies and practices of LAB industries. The results and analyses are presented in Section 4. Finally, related policy implications on WEEE management and discussion on future research are provided in Section 5.

2 Theoretical Framework

The differences between private and social benefits cause problems relating to classic market failure, that is, externalities, a theoretical base of environmental problems. Considerable literature shows that environmental policy instruments can be applied to overcome externalities mainly through the consideration of environmental value in the decisions of polluters (Millennium Ecosystem Assessment 2008; Heal 2000). The right mix of environmental policy instruments as the main approach can avoid pollution and ensure environmental quality (Tietenberg 1998). However, potential tradeoffs need to be assessed reasonably when choosing environmental policy instruments by considering the correlation of private and social benefits and examining the characteristics of polluters and the actual feasibilities of various policy options (Jack et al. 2001).

In general, the evolution of environmental policies in developed countries can be divided into three stages: regulatory instruments, market-based instruments, and persuade instruments (Tietenberg 1998; Zhu and Zhang 2012). Much literature suggests that the three stages occur in sequence, with the latter stages only coming into use when the former ones exist. For example, the emission trading system, as a market-based instrument, depends on the establishment of a monitoring and auditing system, as regulatory instruments, which helps measure the amount of emissions of polluters (Shin 2013).

Regulatory policy instruments represent a traditional approach to environmental protection that has been widely used for years. For example, setting and enforcing emission standards are essential to avoid environmental pollution and provide incentives for enterprises to achieve cleaner production (Tietenberg 1998). Especially in authoritarian states, the central government sets the overall environmental goals, makes performance requirements for local authorities, and employs regulatory measures that ensure effective performance. However, the implementation process involves obstacles and challenges, including poor compliance of enterprises owing to the lack of monitoring capability and weak enforcement of local governments influenced by multiple stakeholders' involvement and institutional defects (Zhang 2013).

Market-based policy instruments, such as pollution charges, penalties, taxes, subsidies, deposit–refund, and carbon trading systems, are common ways to internalize externality value into the cost of private polluters (Zhang 2011). Compared with regulatory instruments, market-based instruments are more flexible (Engel et al. 2008). However, the optimal achievement of market-based policy instruments, such as the Pigouvian tax on disposal, heavily depends on fully functioning markets. The literature of environmental economics also emphasizes that market-based instruments, which face weak market supervision, high transaction costs, and information asymmetry, may become invalid in developing countries (Palmer et al. 1997).

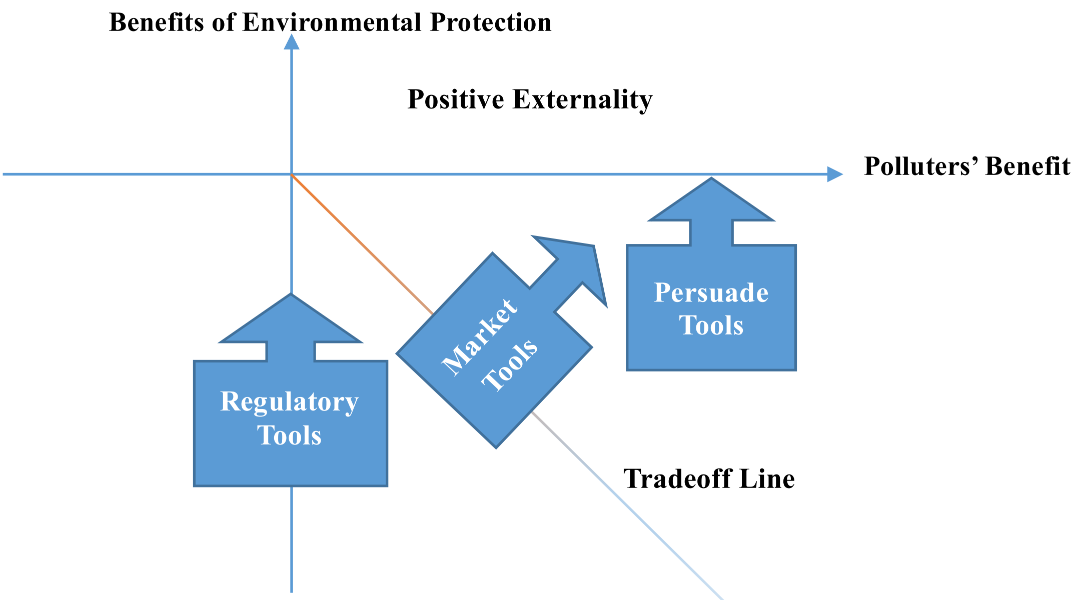
In recent decades, persuade instruments have become widely applied, indicating the start of the third wave of environmental management following regulatory and market-based instruments (Engel et al. 2008). Persuade instruments always act in the form of voluntary agreements with enterprises or information disclosure arousing public participation, which can simultaneously reduce compliance, transactions, and other costs. For example, eco-labeling is a creative form of environmental policy instrument that provides consumers with information about environmentally friendly products, expelling their market-oriented choices. From the angle of enterprises being persuaded to fulfil their corporate social responsibility and extend their voluntary efforts, persuade instruments create continuous incentives for polluters to improve their environmental performance. These instruments are also effectively applied in developing countries, where regulatory infrastructures and capacities are insufficiently developed or subjected to corruption (Tietenberg 1998; Zhang 2008).

EPR is a typical persuade policy approach and has been widely spread since 1990s. It forms many instruments, including green product design, information disclosure and corporate recycle fund, etc. Instead of regulatory instruments, the EPR mainly promote voluntary efforts. Moreover, compared to market-based instruments, the extended responsibilities of polluters overstep the function scope of market itself, and integrate more actors and various incentives.

Scholars recognize the absence of a single policy instrument that fits all scenarios (e.g., Jack et al. 2001). Potential tradeoffs and actual feasibilities should be assessed reasonably by environmental policy makers. Analysis can be conducted from two perspectives: internal factors, which are the properties of environmental problems; and external factors, which denote the context of implementing policy instruments for solving environmental problems.

First, with regard to internal factors, the properties of environmental problems should be clearly identified. Jack (2001) analyzed these problems in two dimensions: (1) the benefits of providing ecosystem services, that is, the benefits that the public derives from environmental protection via the application of policy instruments (Daily 1997); and (2) the benefits generated from polluting production without considering externality costs. Original externality analysis mainly focuses on yet constrains the negative externalities of environmental pollution. On the basis of the existing analytical framework, this research expands the analysis in detail by considering the tradeoff between the benefits generated from pollution and the benefits of mitigating negative externalities. Figure 1 presents this specific analytical framework, which indicates that different tradeoff scenarios suit different sets of policy instruments. When offsetting the benefits of environmental protection, the overall benefits accrue mainly to the polluters. Persuade instruments are thus likely to function well. However, when the activities of mitigating pollution mainly benefit others and cause overall loss, such as climate stabilization, the market failure of externalities may result in polluters' rejection of providing improvement and disobedience to environmental protection. This condition results in the only effective application of regulatory instruments. Market-based instruments can generate satisfactory effects on intermediary areas through the transfer of incentive schemes. However, this framework is only a simplified analytical pattern showing the relative effective functions of different types of policy instruments. Various environmental problems generally require a mix of environmental policy instruments, factors of marginal benefits, characteristics of polluters. These requirements call for the design of complex environmental policy instruments to provide appropriate incentives.

Figure 1 Tradeoff Diagram for Different Environmental Policy Instruments



Source: the Authors.

Second, with regard to external factors, the context of implementing policy instruments to solve environmental problems is worth examining. From the classical perspective of environmental economic analysis, contextual factors cause market failures. Furthermore, contextual factors may influence the choice of policy instruments for environmental management. For example, significant market heterogeneity equates to the increased potential to apply incentive-based instruments, including market-based and persuade instruments, rather than regulatory instruments, such as traditional inflexible command-and-control approaches. Transaction costs, which are heavily incurred in negotiating contracts, conducting scientific baseline studies, and enhancing monitoring systems (Jack et al. 2001), pose a challenge to classical environmental economic analysis. Especially when the market is separated by many small stakeholders, classic regulatory and market-based instruments may be ineffective due to their high transaction costs, including implementation, monitoring, and enforcement costs. The same challenges explain the difficulty in dealing with non-point-source emissions instead of solving the environmental problems of identifiable sources (Kerr et al. 2005). As for many countries in transition, the drastic changes in industrial output and pollution benefits hinder the setting and updating of pollution levies, subsidy standards, or fixed caps for tradable permits, resulting in the potential failure of market-based instruments in short-term governance (U.S. EPA 2004). Especially in authoritarian states such as China, where the market is unsound and inadequate, the political context, its associated incentives for the executors of policy instruments, and other socioeconomic context also dramatically affect the design of policy instruments (Oates 2003). These conditions may be reflected by cases in which local officers prefer short-term regulatory measures for the promotion of incentives and the allocation of permits creates a barrier to market entry to protect local firms, as elaborated in the following section.

3 Case Study in the Lead–Acid Battery Recycling Industry

The lead recycling industry has contributed enormously to the reduction in environmental pollution and resources (Raghupathy and Chaturvedi 2013). Since the 1960s, the global production of lead has continuously grown, rising from 2.5 million tons per year in 1960 to 11 million tons in 2014 primarily because of the increase in demand for lead batteries. As a result of the industrial transfer from developed countries to China, in 2014, China alone produced nearly 5 million tons of lead, which represent over half of the total amount produced worldwide and are significantly greater than the total amount produced by the next nine largest lead-producing countries. Comparatively, the industrial use of lead in Europe dates back to hundreds of years. Lead has been mined and processed throughout Europe, and Europe with its many years of industrialization was left with a historical legacy of land contamination and dozens of past pollution incidents. The European lead production, 75% of which mainly involves recycled materials, has remained steady and continuously decreased since the 1980s, dropping to no more than 2 million tons in 2014. European lead operations have been heavily regulated for many years, showing an overall unanimous pattern in the EU and variations among member states. Significant pollution incidents involving the lead industry in recent years have not been reported. Developing countries, including China, can gain rich experience from the EU.

The LAB industries in the EU and China differ greatly, thereby causing the need for different environmental instruments. First, the LAB industry in China mainly produces batteries for electric bicycles, whereas the LAB industry in the EU focuses on the supply chain of the automobile industry. According to statistics, approximately 95% of electric bicycles in China are powered by LABs (Jamerson and Benjamin 2007). Second, in China, current gaps in environmental regulations, the high demand for second-hand goods, and the considerable market value of exhausted batteries encourage the growth of a strong informal recycling sector, which poses tremendous pollution risk to the environment. According to an uncompleted statistic, 3,000 LAB manufacturing enterprises operated in China in 2003, with countless other small retailers and recycling workshops. Most of these businesses are located in the provinces of Zhejiang, Hebei, Guangdong, Fujian, Jiangsu. (Chen 2009), all of which feature high-density populations. These small manufacturing and recycling workshops are generally equipped with outdated technologies and lack pollution prevention facilities, thereby generating serious environmental risks (Lu et al. 2014). Third, instead of compulsory recycling requirements, such as the WEEE directives of the EU, the collection of LABs in China is mainly driven by the economic interest of private peddlers and expanded recycling plants (Zhou et al. 2007; Sun et al. 2015). Electric bicycle users in China can generally exchange their exhausted batteries for one-fourth of the original price (roughly 100 RMB in 2008), which is an attractive offer in many Chinese cities (Cherry et al. 2009). In 2014, approximately 60% of LABs were collected by small illegal peddlers, and 41% were finally processed via informal recycling plants in China (Gao et al. 2012). However, referring to the overall substance flow of lead in China, researchers investigating the LAB industry in the country found that 16.2% is lost during mining and concentrating, 7.2% is lost during primary smelting, 13.6% is lost during secondary smelting and recycling, and only 4.4% is lost during battery manufacturing within the entire battery-used lead substance flow (Mao et al. 2008; Cherry 2009). In the EU, used lead-based automotive batteries are typically returned to the point of sale or to recycling businesses and metal dealerships. In all cases, they are then sent to collection points, where they are collected by specialized companies that transport and deliver the batteries to secondary smelting plants operating under strict environmental regulations. LABs are an excellent example of end-of-life recycling, with more than 93% of LAB being available for recycling.

The legislation in the EU and China specifies covers permitting, monitoring, inspection, and enforcement requirements for industrial manufacture and recycling operations. To examine the different practices and analyze the reasons for the differentiated policy choices in the EU and China, we thoroughly review the management framework and sort out the environmental policy instruments in both regions. On the basis of the theoretical framework mentioned, this work classifies the portfolio of policy instruments into three types:

(1) Regulatory instruments, which are also called “command-and-control” approaches, mainly include product or process bans, technology mandates, and pollution or emission licenses.

(2) Market-based instruments, which are always based on incentives with market or corporate value, mainly include emission fees, auctions, pollution tax, subsidies to

emission reductions, and tradable permits.

(3) Persuade instruments, which function in voluntary agreements and represent the new trend in environmental management, mainly include information disclosure, corporate social responsibility, collective action initiative, and industry self-regulation standards such as the ISO 14000 certificate.

Table 1 The List of Policy Tools for LAB Management between EU and China

Policy Tools	**Detailed Measures**	**EU**	**China**
Regulatory tools	Plan, Directives	Seventh Environmental Action Programme (7EAP)[2]; Local initiatives[3], such as the Dutch National Environmental Policy Plan, based on the 7EAP	National Five-year Plans, especially the 12th and 13th ones[4]; Local initiatives and plans by sectors, such as the Secondary Non-ferrous Metal Industry Promotion Plan, based on the National Five-year Plans
	Industrial Policy	Waste Framework Directive (2008/98/EC)[5]	Notice on Standardizing Lead and Zinc Industry Investment and Guiding Opinions for Promoting Structural Adjustment (2006)[6]; National Circular Economy Pilot[7] and Urban Mining Demonstration Work[8]

2 The 7EAP sets a long-term vision for non-toxic EU and appeal to better integration of environmental concerns into policy making in other areas.

3 The 7EAP includes the objective for an improvement in the implementation, enforcement of environmental law at all administrative levels and guarantee a level playing field in different countries across EU.

4 The 12th five-year plan (launched in the year 2011) was treated as a milestone for the management on lead plants in China, considering environmental protection was for the first time given high priority in country planning, with 14 provinces were marked as the heavy metal key-managed regions (Xi et al. 2014).

5 The Waste Framework Directive (2008/98/EC) sets out measures to protect the environment and human health by mitigating negative impacts of the generation of waste and also by promoting recycling.

6 According to the notice, limits the total annual production capacity is limited to 4 million tons. This aims to promote the consumption of recycled resources to 30% of the total and the development secondary-lead industries (Chen 2009). Based on this, the government has conducted two waves of inspections and closed down outdated production capacities, with most of the secondary-lead plants shut down or consolidated from 2011 to 2012. For instance, in 2011, 77 out of 100 secondary-lead plants were prohibited to continue their production (Xi et al. 2014).

7 The National Development and Reform Commission (NDRC) of China, together with six other ministries launched two main batches of national circular economy pilot projects from 2005 to 2007, promoting development of large-scale enterprises with advanced technologies (Xi et al. 2014).

8 The NDRC launched the Urban Mining Demonstration Work for Waste Metal Recycling since 2010. Up to now, there are 39 enterprises out of four batches approved, with four LAB recycling pilot bases (Xi et al. 2014).

	Hazardous Waste Inventory	Waste Framework Directive (Directive 2008/98/EC)[9]; Classification, Labelling and Packaging Regulation (Regulation EC 1272/2008)[10]; European Waste List / European Waste Code (EWC) (2000/532/EC)[11]	Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste (1995)[12]; National Inventory of Hazardous Waste (1998, 2008, 2016)
	Bans	Restriction on Hazardous Substances (RoHS) (2002/95/EC; 2011/11/EU)[13]; Waste Electrical and Electronic Equipment (WEEE) (2002/96/EC; 2012/19/EU)[14]	Announcement for Strengthening Environmental Management on Waste Electrical and Electronic Equipment (2003)[15]
	Permits / Licenses	Regulation on the Evaluation, Authorization of Chemicals (REACH)[16]; Industrial Emission Directive (IED)[17]; Waste Framework	Announcement for Strengthening Environmental Management on Waste Electrical and Electronic Equipment (2003)[21]; Regulation on the Collection and Treatment of Waste Electric and

9 Waste Framework Directive (the Directive 2008/98/EC) establishes the European Waste List and defines hazardous waste. It especially forms a basis of two main hazardous waste control systems in EU, including the control on movements within a Member State and the control between Member States or to outside EU.

10 For each hazardous substance or different types of substances, the Classification, Labelling and Packaging Regulation (the EC 1272/2008) inventory gives a specific hazard class and category code, with clear statement to assist classifying the waste.

11 The EU Commission has established a harmonized list of wastes according to the European Waste Code (EWC) (2000/532/EC). This provides a European wide list for identifying a particular waste and is standard in each Member State. ULAB are typically classed under EWC 16 06 01* Lead batteries (the * classifies the waste as hazardous) in EU.

12 As stipulated by the law, LAB was listed as hazardous waste and is requested to be treated separately. The law set specific lead concentration for industrial slag, stating that if higher than 5 mg/L, then be classified as hazardous waste (Xi et al. 2014).

13 The Restriction on Hazardous Substances (RoHS) (2002/95/EC; 2011/11/EU) restricts the use of hazardous substances in electrical and electronic equipment. RoHS (2002/95/EC) lists the restricted substances and the maximum concentrations tolerated (lead is 0.1% concentration), and guide enactment of the domestic laws of Member States.

14 The Waste Electrical and Electronic Equipment (WEEE) (2002/96/EC; 2012/19/EU) promotes the environmental sound management, collection and recycling of WEEE. According to WEEE, waste industrial batteries, automotive batteries and accumulators are strictly prohibited from being disposed of by either incineration or landfilling. It also sets an overall collection target of 45% average weight of products, including LAB, placed on the market was set rising to 65% in 2019.

15 In 2003, the Ministry of Environmental Protection of China issued this special requirement for secondary lead companies (Xi et al. 2014). However, the management on industry's market access conditions was gradually abandoned in past years.

16 Under the Regulation on the Evaluation, Authorization of Chemicals (REACH), use of lead and lead compounds in battery manufacturing is requested to be registered, and has recently been included in the 7th priority list for substance's recommended for authorization in EU. If this recommendation is accepted by the European Commission, battery manufacturers would have to apply for authorization to continue using the substances in future and would need to provide evidence to the European Chemical Agency (ECHA) that risks to human health and the environment are properly controlled to reduce any risks. Moreover, under REACH, the EU Commission also has the power to restrict use (e.g. ban of use) of any chemical that is found to represent an EU wide risk to human health or the environment. Such a restriction has been currently applied to the use of lead in jewelry and consumer products that could be mouthed by small children.

17 Under the Industrial Emission Directive (IED), LAB manufacture must obtain a permit to operate. These are obtained from relevant competent authorities in the EU Member State where the enterprises reside.

21 This has stipulated a license permit management for LAB industry since 2003.

		Directive[18]; Local Administrative Orders[19]; Criminal Sanctions Directive (2008/99/EC)[20]	Electronic Equipment (2011)[22]; Local Administrative Measures [23]
	Technology Mandates	Industrial Emissions Directive[24]; Best Available Techniques Reference Document (BREF Notes)[25]	Technical Policy on the Pollution Prevention and Control for Spent Batteries (2003)[26]; Guidance on the Cleaner Production of Lead Acid Batteries Recycling Industry (2009); Treatment Technical Guidance on Waste Lead-acid Batteries Pollution Control (2010); Technical Guidance on the Collection, Storage and Transportation of Hazardous Waste (2013)
	Performance Standards	Industrial Emissions Directive (IED) (Directive 2010/75/EU, replacing	Prevention of Environmental Pollution Caused by Solid Waste (2004)[28];

[18] Under the Waste Framework Directive, waste collectors, carriers and transporters of LAB are required to be registered by authorities. It aims to ensure that waste producers can only transfer waste to someone who is registered. Each regulator is expected to keep a public register of carriers so producers can undertake checks (usually on-line) to ensure they are using a registered carrier/transporter. Waste collection and transporters have to keep records to demonstrate compliance with the legislation when inspected by the authorities. Moreover, under the Directive, there are exemptions from registration for companies producing/handling small quantities of ULAB (e.g. <10t), with written confirmation from the authorities. This exemption covers battery distributors who handle scrap batteries on behalf of their customers and garages replacing a car battery. Though with exemption from a registration, they need also to minimize the risk to human health and the environment.

[19] Administrative orders can be imposed requiring permits to be complied with. These include serving notices of non-compliance on operators requiring them to comply with the permit conditions or informing them by letter of the need to comply. These usually require the operator to make a correction within a set time period and failure to do so could result in court action and/or fine. Withdrawal of a permit can be undertaken in serious cases to avoid/reduce severe effects on the public.

[20] In the event that an offence/incident is serious or the use of civil sanctions has failed to resolve an issue, the authorities, including the police, can take action through the courts to prosecute an offender.

[22] Accordingly, LAB was classified as e-waste, applying a same requirement of collection and treatment.

[23] Associated administrative measures, such as power cut by China Electricity Supervise Office, were collaborately applied (Chen 2009).

[24] Under the Industrial Emissions Directive, authorities are required to set emission limits that do not exceed the levels associated with Best Available Techniques (BAT) under normal operating conditions.

[25] This Reference Document are developed by a Technical Working Group (TWG), which is composed of members with technical, economic, environmental or regulatory expertise. TWG experts are nominated through the Member States, Industry Associations and environmental NGOs. Under the IED, BAT emission limits are established based on what is achievable using the techniques available for a particular sector e.g. the lead industry is included under the Non-ferrous Metals Industry. BAT for each sector is determined through an information exchange process involving Member States, Regulators, industry and environmental organizations. This setting process is organized and run by the European IPPC Bureau based in Seville Spain.

[26] As stipulated by the policy, techniques of collection, sorting, transportation and regenerate waste batteries are clarified (Zeng et al. 2015). Based on that, between 2008 and 2009, MEP, with its research bodies, intensively promulgated a series of technological standards for manufacturing and recycling LAB.

[28] According to that, waste batteries are classified as hazardous waste and its related package, collection, storage, transportation and dispose operation are stipulated (Zeng et al. 2015).

		Directive 2008/1/EC; 96/61/EC, etc.)[27]; Other associated standards, such as the Air Quality Directive (2008/50/EC), Limit Values Directive for Lead in Ambient Air (1999/30/EC), and the Water Framework Directive (WFD, Directive 2000/60/EC), etc.	Emission Standards for Pollutants for Battery Industry (Draft, 2012)[29]; Lead & Zinc Industrial Pollutant Emission Standards (2013)[30]; Other minor standards, such as Emission Standard for Air Pollutions of industrial Kiln and Furnace (GB 9078-1996) and Pollution Control Standard for Hazardous Waste Incineration (GB18484-2001), etc.
	Tort Liability	Remedial Action; WEEE[31]	Deficiency
	Inspection and Monitoring	Transposition of the EU Directives (Directive 2006/66/EC)[32]; Industrial Emissions Directives (IED) (Directive 2010/75/EU)[33]; Pollutant Release and Transfer Register (PRTR) (Regulation EC No. 166/2006)[34]	Environmental Inspection Special Actions[35]
	Environmental	Environmental Impact Assessment (EIA)[36]	Deficiency

[27] This Directive introduces operation provisions, with an aim to avoid deterioration in the quality of soil (and groundwater). It is the main and effective EU instrument for regulating emissions from LAB and ULAB operations and other activities.

[29] This Standard sets the discharge limits for pollutants of LAB industry, both for existing and new plants (Zeng et al. 2015).

[30] This is treated as the first specific legislation for lead industry, with mandatory environmental standard and modified strict indices for pollutant emission (Xi et al. 2014).

[31] Under WEEE, besides the request of preventative plans and measures in place, if environmental damage has occurred, the operator is required to work with authorities to develop proposal for approval to undertake remedial works in the first instance. If the operator fails to undertake the remedial measures the authorities can undertake the works and recover the costs.

[32] This Directive (2006/66/EC) requests the transformation the transposition of its requirement into local legislations of each EU member states (Sun et al. 2015).

[33] Under the IED, member states are expected to establish the system of environmental inspections, including an inspection plan and programme, reporting scheme, information disclosure and non-routine emergency management, etc., in order to ensure the operator is complying with the permit. Moreover, member states are required to take measures to prohibit the waste being illegally dumped or disposed of and incorporate these measures and penalties into their legislation.

[34] The Pollutant Release and Transfer Register (PRTR) is an important tool for tracking industrial pollutants, which records releases of pollutants to soil, water and air. The permits often specify requirements for providing the authorities with monitoring data on a regular basis and also for reporting any breaches in the permit conditions. It also specify the data reporting frequency, format and related remedial action to be taken to prevent a recurrence of breaching the limit.

[35] Under the huge public pressure caused by the incidences of children lead poisoning, the MEP of China launched two waves of special environmental inspection actions between 2011 and 2013, by which most of the plants that didn't pass the requirements were banned (Xi et al. 2014).

[36] Since 1985, this Directive has stipulated the requirement for environmental impact assessments on the likely environmental effects of new projects. 7EAP also asks for a systematical assessment on the environmental, economic and social impacts of policy tools and requests the full implementation of related legislation on Environmental Impact Assessment to ensure better decision-making and policy design. For example, the screening procedure booklet (UK Environment Agency guidance).

	Impact Review		
	Crisis and Alert Management	Control of Major Accident Hazards involving Dangerous Substances (Seveso III Directive / Directive 2012/18/EU)[37]; Major Accident Prevention Policy (MAPP)[38]	Interpretations on Environmental Criminal Cases Applicable Law Issues (2013)
Market-based tools	Industry admittance	Baseline Reports & Site Closure[39]; Waste Treatment & Permitting[40]; Waste Batteries & Accumulators Directive (2006/66/EC) [41]	Access Criterion of Lead and Zinc Industry" (2007)[42]; Secondary Lead Industry Access Conditions (2012)
	Product Label	Classification, Labelling and Packaging of Substances and Mixtures (CLP, EC 1272/2008)[43]; Regulation on the Registration, Evaluation, Authorization and Restriction of Chemicals (REACH)[44]	Vacant
	Emissions Fees	Monetary Penalty Notice[45];	Regulatory Measures

37 Under the Seveso III Directive, there are stringent requirements on facilities where there are potential risks from hazardous substances in the event of a pollution incident of environmental contamination. For example, the catastrophic incident in the Italian town named Seveso in 1976, following which, the EU adopted legislation (Seveso I Directive) to prevent similar incidents arising. Lead and lead compounds related operations are now fall within the scope of Directive Seveso III.

38 Under the Seveso III Directive, the operator is required to have a written document setting out the major accident prevention policy (MAPP) and ensure it is implemented. The aim of the MAPP is to ensure satisfied protection of the environment and better human health proportionate to accident hazards. Where environmental damage has not occurred but there is an imminent threat the operator is required to inform the authorities and take preventative measures without delay. The authorities can themselves take action and then recover costs from the operator if where no action is taken. Documentation is required step by step during the process. For example, routine waste inspections in Germany (Hesse Federal State) follow a standard manual.

39 Under the scheme, the competent authorities are required to be provided with a soil and groundwater baseline report before operations, using, producing or releasing hazardous substances, commence or before updating a permit.

40 It requires that all companies involved in the treatment and recycling of waste such as ULAB are required to have a permit from the competent authority.

41 The key objective of this Directive is to control the types of batteries being placed on the market and requiring their sound collection and recycling at their end-of-life stage (Sun et al. 2015). As this legislation is a EU wide Directive, member states need to develop country specific legislation based on their interpretation.

42 Based on this access criterion, nationwide cleanup actions had been conducted by the MEP of China and eight other ministries or departments since 2011.

43 It is now used as the basis for labelling of hazardous chemicals and mixtures and aligns EU legislation with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) to identify hazardous substances and inform worldwide users of the hazards. It stipulates that any WEEE placed on the market has to have a sign showing the WEEE cannot be placed in waste bin for disposal. The hazards are communicated by pictograms labels, data sheets and standard statements.

44 Under REACH and CLP, substances used in batteries are subject to classification. Lead metal has recently received a harmonized classification as Repro 1A and will soon be entered in Annex VI of CLP Regulations. It will then be considered as a Substance of Very High Concern (SVHC). Lead oxide used in the manufacture of lead based batteries is already classified as a type of lead compounds, under Annex VI, as a repro-toxic substance and is classed as a SVHC under REACH. Moreover, ULAB are classified as hazardous under EWC.

45 Endorsing the "polluter pays principle", EU sets discharge limits for the release of toxic substances to watercourses. The

		Civil Sanctions[46]	
	Taxes	Local Measures of different member states	Cancelled[47]
	Recycle Fund / Subsidies	WEEE Directive / Producer Collection Scheme[48]	Vacant[49]
	Deposit Refund System	Take Back Scheme[50]	Vacant[51]
	Environmental Liability Insurance	Wastes Shipment Regulation[52]	Vacant[53]
	Occupational Specific Requirement	EU Environmental, Health & Safety Policy[54]; Council Directive 98/24/EC[55]	Occupational Diseases Prevention and Control Act (2002)
Persuade tools	Information Disclosure	Arhus Convention[56];	Environmental Protection Law (2015)[59]

limits may not always be based on scientifically proven thresholds but represent the lowest emission levels considered to be generally achievable; Local authorities can issue fines to tackle environmental offences by serving a penalty notice on the offender, mainly in the form of fixed monetary penalty notice and variable monetary penalty notice.

46 A number of European countries use fines under the civil sanctions process to ensure compliance in the event of an environmental offence being identified.

47 The tax rebate of 13% and VAT exemption for the lead and LAB industries in China had been gradually cancelled since September 2006. In 2011, the tax rebate policy was abandoned. However, with a series of petitions afterwards, this policy was re-applied to only formal enterprises, with an aim to compete with small illegal enterprises (Xi et al. 2014). However, there is a clear trend that this policy has been re-abandoned in recent years.

48 Under the Directive, producers are responsible for the financing of the WEEE management. Producers are required to join a producer collection scheme (either household or non household WEEE) and pay to fund the scheme. The competent authority has a list of approved schemes that a producer can join.

49 The measure of subsidies is still in abeyance and under discussion in China since 2014. Several related ministries of China worked jointly to design the LAB recycling fund system since 2014. However, the imposed value and financing scheme are still uncertain (Tian et al. 2015). Comparatively, the national electronic waste fund / subsidy has been applied to other WEEEs for years since July 2012.

50 In details, for automotive batteries/accumulators from private, non-commercial vehicles, there is no charge or obligation to buy another battery if these are taken back. However, because of the commercial value of the lead, there is a discount if they bring their battery for replacement. Industrial battery and accumulator producers are expected to provide a take back scheme, although third parties may also collect them.

51 Comparatively, the trade-in allowance (Old for New Service) has been applied to other WEEEs for year 2009 to 2010.

52 Before the transportation of waste LAB, a financial guarantee must be in place in case of non-compliance and will include the cost of returning the waste to the originator. A contract has to be in place with the person receiving the waste and insurance for damage to third parties is also required. Each shipment has to be accompanied by movement forms signed by all actors.

53 Besides the vacancy of official insurance, the commercial insurance does not accept the cases of hazardous waste movement.

54 Based on the policy, the EU has been given shared responsibility with member states, under the Treaty of European Union, in helping them to address health and safety risks in workplace and ensure a same-level playing field.

55 The Directive sets the minimum requirements for the protecting workers from the negative effects of chemical agents in the workplace on their safety and health. Under the Directive, occupational exposure limits and biological limit values for lead have been established which must be transposed into member states' legislation. The Commission can then take the appropriate action such as reviewing EU limits and introducing stricter controls on the manufacture of LAB and the treatment of ULAB.

56 According to the Convention, member states are required to ensure that public have access to and participate in the process for granting/changing/updating permits. The competent authority is also required to make available to the public the basis of the decisions, results of consultations, details of the permit conditions, any derogations and the reasons for it. For instance, full inspection reports should be made available to the operator and be publically available within two months of the inspection.

59 The Law stipulates the general rules of environmental information disclosure, there is not yet specific policy for the information disclosure related to LAB in China.

		Public Access to Environmental Information (Directive 2003/4/EC)[57]; UNECE Protocol on Pollutant Release and Transfer Registers (PRTR, the Kiev Protocol, EC 166/2006)[58]	
	Third-party Certificate	Monitoring Certification Schemes[60]	Vacant
	Voluntary Agreements	Recycling Efficiencies of Waste Batteries and Accumulators Regulation (Regulation 493/2012/EC)[61]; Lead Industry Voluntary Initiatives[62]	LAB Advocacy Coalition[63]
	Public Awareness Raising and Public Initiative	Directive on Spent Batteries (Directive 91/157/EEC)[64]; 7EAP[65]; Access to Justice[66]	Techniques Mandates on Pollution Prevention of Hazardous Waste (2000)[67]

Source: the Authors.

57 Disclosure is the general rule and the public interest takes precedence. Member states are required to ensure that the authorities make environmental information available to any applicant in request without stating their interest (Edwards 2012). Under request, if the authorities fail to provide the information, the applicant can seek an administrative or judicial review.

58 Based on this, EU has established an integrated pollutant release and transfer register (PRTR) system and laid down rules for it's functioning. So far, there has been a register of approximately 30000 EU industrial operations across and includes facilities outside, e.g. Norway and Iceland. This on-line electronic register provides details on ULAB and LAB facilities and other lead operations in Europe. However, information on collectors are not included unless they come within the IED Directive. Information is provided on the amount of lead and other substances released to the environment and covers facilities listed under the IED.

60 In EU, those undertaking and monitoring may be required to be certified. For example, in the UK, there is a Monitoring Certification Scheme (MCERTS) operated by the CSA Group, on behalf of the Environment Agency, and is an independent certification body. This approves and accredits the instruments, people and laboratories used to undertake the monitoring, sampling and analysis. For companies they must have arrangements in place to monitor independently assessed against the MCERTS Standard. In addition, the MCERTS inspector has to operate within an acceptable quality system such as ISO 9001.

61 For LABs and accumulators, a minimum recycling efficiency of 65% is expected to be achieved. EU has issued guidance on how this should be calculated, which is actually calculated to be at least 95%. Member states are required to design their own scheme and report every year on their recycling efficiencies to the Commission. These were either government approved schemes (e.g. Cobat - Italy and UFB - Austria) or free market operators (UK, Germany, France).

62 The ILA made efforts to support industry voluntary initiatives, including the industry's voluntary target to reduce worker blood leads (Voluntary Blood Lead Reduction Target), covering over 7,000 workers in the lead industry in Europe, North America and Australia.

63 The Battery Industry Association hasn't taken the same role in promoting industry voluntary actions as ILA. The new LAB Advocacy Coalition operated by MIIT of China and Chilwee Group is making efforts to take a leading role in China.

64 This Initiative was launched in Europe in the 1990s after the first directive on spent batteries (EC 91/157/EEC) was implemented in 1991 (Sun et al. 2015).

65 Based on the precautionary principle, there is a need in 7EAP to make the knowledge base more accessible to public citizens and also policy makers to ensure a sound understanding of the state of the environment to make policy design.

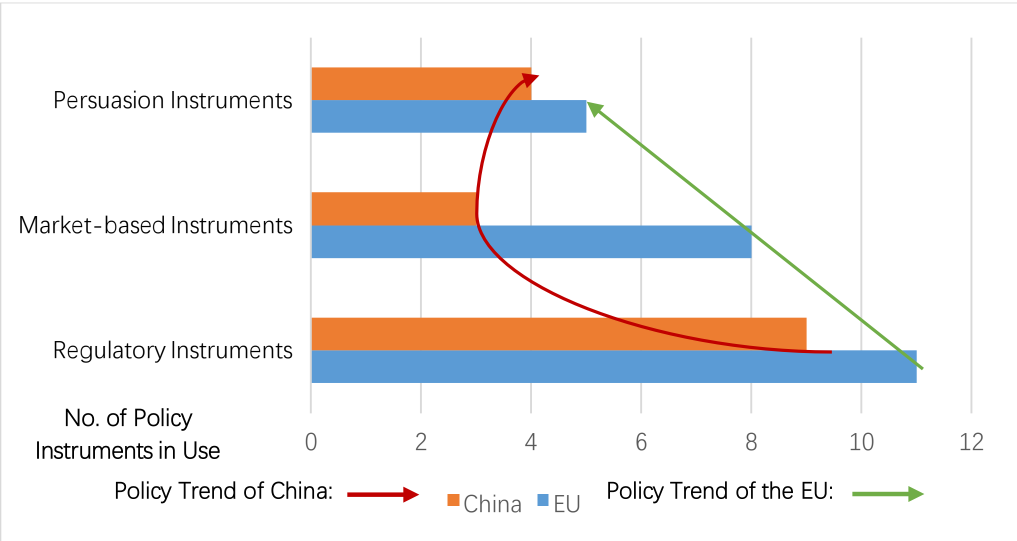
66 Under this Directive, member states are required to ensure public the access to legal system or another independent/impartial body for a legal review to challenge the decisions/act/omissions. However, the public (including NGOs) have to have a sufficient interest or there is an impairment of a right as determined by the local authorities.

67 It delivers the initiatives to encourage separate collection of ULAB from other municiple waste.

4 Results and Discussion

Through a comparative study on LAB recycling in the EU and China, this research tests the hypotheses by recognizing the different choices of policy instruments (Figure 2). This simplified statistical description of the difference between the EU and China shows that both regions deal with LAB issues on the basis of regulatory instruments. Although market-based measures and persuasion instruments have made progress in the EU, the theoretical assumption of the three progressive waves of environmental management indicates an inconsistency and a leapfrog development of environmental policy choice in China, with a lack of market-based instruments and a distinct promotion on persuade instruments, typically as the EPR scheme. The reason analysis is discussed below, providing the basis for potential future research.

Figure 2 Choices of Policy Instruments in the LAB Industries of China and the EU



Source: the Authors

Different environmental policy instruments are appropriate for different types of problems in diverse circumstances. The internal factors of environmental problems influence the choice of policy instruments. Policy makers are responsible for determining the condition under which a certain set of instruments is the appropriate choice. According to the extended externality theory deducted in this research, different types of policy instruments suit different situation. As has shown in Figure 1, persuade instruments can be effectively applied in the filed above the tradeoff line, meaning the benefits of polluters are affordable to cover the compensation or the pollution prevention cost. This rationalizes the choice of EPR for the environmental protection cases of LAB recycling and many other circular economy practices, where the pollution is technological avoidable and the reproduction is profitable. There only needs to set up exterior mechanisms to arouse the inner incentives of polluters, no matter from the perspective of social recognition, corporate image or sustainable development goals, etc.

Besides the internal factors of environmental problems, through a comparative study on LAB recycling in the EU and China, this research tests the hypotheses of the external factors by recognizing the contextual feasibility affects different choices of policy instruments (Figure 2). Extensive discussions have been made about the criteria for examining the implementation of policy instruments; examples include the efficiency criterion (e.g., Pearce 1997), the cost effectiveness criterion (e.g., Helfand et al. 2009), distributional equity, political process transparency (e.g., Revesz and Stavins 2005), and the economic properties of hybrid instruments. However, no single instrument fits all dimensions. Through a comparative case study between the EU and China, we found that the properties of LAB recycling in the EU and China differ in addition to the difference in general criteria. Such differences indicate that the distinctive Chinese characteristics and the context for implementing policy instruments significantly determine the choice of environmental policy instruments.

(1) The leapfrog development of policy choices related to LAB recycling management in China is mainly due to the federalism scheme of local environmental management in China. The

management of waste ULABs in the EU is essentially based on the EPR; hence, producers of batteries, including importers, shoulder the life cycle responsibility of collecting and recycling ULABs (Sun et al. 2015). Governments play a role in arranging collection facilities and raising public awareness. Under the model of fragmented authoritarianism (Lieberthal and Oksenberg 1988) for environmental management in China, local governments are responsible for dealing with the problems related to ULABs. The championship model of the economic competition among local governments contributes to the rapid development of the economy in China. However, this model also forms local protectionism, allowing the operation of polluting enterprises and informal actors. Moreover, the model is also embodied in the transportation of waste LABs into other regions for effective treatment. Influenced by the promotion incentive mechanism for local officers, particularly in cases of blood lead events, national inspections, or mass contingency, local authorities always prefer regulatory instruments, which can achieve short-term effects, and they have started employing persuade instruments in response to the appeals of the central government and the public. Given the failure of market instruments at the local level, the central government is not likely to establish a nationwide institution on the basis of the economic incentive approach, thereby leaving a huge vacancy in the policy instrument box.

(2) The deficiency of market-based instruments for the LAB industry in China is also due to the inadequate market, especially the lack of guarantee mechanisms for applying market-based instruments. For example, the absence of a monitoring system generates an enormous influence. Enterprises commonly evade governmental monitoring by discharging pollutants secretly at night or during the intervals between inspections. Compared with the EU, China shows a significant lack of a continuous emission monitoring system and data auditing scheme, such as PRTR. Such deficiency weakens the governmental capacity to employ market-based

instruments for the effective management of LAB recycling. Moreover, the informal actors forming the majority of the LAB recycling industry generate a significant threat to the market. According to an incomplete statistic, over 3,000 LAB enterprises were operating in China in 2003. After two waves of remediation, 300 plants remain in China, although the secondary lead plants have been restricted into a small scale (Chen 2009). Informal recyclers, mainly peddlers, and informal plants have continuously shouldered the majority of LAB recycling, thereby intensifying cutthroat market competiti on. Despite former attempts to employ market-based instruments to provide incentives for formal enterprises to compete and eliminate informal actors, such instruments remain suspended in deadlock partly because of the inadequate market.

(3) The properties of lead related industry, including the closed-loop substance flow of lead within limited industries and the significant negative effects of heavy metal pollution, lead to the need for different policy instruments in the LAB industry. Globally, 54% of lead production comes from secondary sources. This condition makes lead unusual among metals, as it is only one of the three metals (with Nb and Ru being the two other metals) to involve heavy production originating from secondary production instead of primary production. Compared with the EU, where LABs are mainly for automobiles with large sizes, high value, and low acid concentration, China runs LAB recycling mainly for electric bicycles and thus face tough challenges, considering the acid-rich characteristics of LABs and dispersed and informal operations. The considerable value of waste LABs results in the prosperity of informal lead recycling, which also leads to the inadequate market and lack of market-based instruments. Moreover, LAB-related industries have mainly transferred from developed countries to developing countries, especially China, where lead has been given the top priority for hazardous waste management. This condition leads to an essential difference in policy choices between the EU and China.

These findings may also set the theoretical basis for policy evaluation on the experimental policy, the Notice on the Policy Experiment of Extended Producers' Responsibility for Electric and Electronic Products (No. 2016-99, State Council of China). Ahead of all, the theoretical analysis rationalizes the choice of EPR in the specific context of China and especially for the management of LAB recycling. In details, the policy stipulates the implementation of environmental policy instruments of ecological product design, the usage of reproduced materials, the promotion of information disclosure, forming recycle association etc., which are all typical persuade instruments. Moreover, the policy specifies four pilot industries, including LAB, WEEE, automotive products and carton package, which are all profitable for recycling. However, it needs to keep the persuade mechanism and avoid falling back to regulatory approach during its implementation process. Related actors, especially the public citizens, need also be aroused to join the pilot and management, in order to provide strong incentive for enterprises and ensure the successful adoption of EPR in China

5 Conclusion

LAB recycling is a multi-billion-dollar business that currently only supplies half of the global annual demand. Future demand is expected to remain high, especially for energy storage applications (e.g., wind and solar power). Advanced LAB systems will have increasing use for the next generation of cars (e.g., stop–start applications). As experienced in the EU, the modified choice of policy instruments plays an essential role in the development of the LAB recycling industry and proper management of lead pollution in China. Environmental policy instruments are mainly applied to minimize the externalities of environmental problems. The differentiation of externalities and the various contexts for implementing policy instruments shape the choice of policy instruments. The core finding of this paper is a leapfrog choice of environmental policy instruments in the field of LAB recycling industry, with deficiency of market-based instruments and promotion of persuade instruments.

EPR is a typical persuade approach generating lots of environmental policy instruments, including green product design, information disclosure and corporate voluntary efforts on waste recycling. This study chooses waste LAB recycling as a typical case for investigating the selection of policy instruments. According to the theoretical analysis, different types of policy instruments suit and reflect different environmental problems. Two factors, namely, the characteristics of environmental problems and the context for implementing policy instruments, play essential roles in the decision-making process of policy makers. Through a comparative study on LAB recycling in the EU and China, this research tests the hypotheses by recognizing the differentiated choice of policy instruments, which mainly exhibit a leapfrog development for persuade instruments, such as EPR scheme, along with a deficiency of market-based instruments in China. Thereafter, the authors stipulate that the authoritarian administrative system and the incentive scheme of its accessorial local officers, the decentralization of authority in environmental management, the inadequate development of circular economy market and the properties of related industry lead to the differentiated choice of policy instruments for LAB recycling in the EU and China, rationalizing the choice of EPR in China. These results are expected to enlighten other empirical studies and comparative research among various industries in the future. The findings may also set the theoretical basis for evaluating the experimental EPR policy in China.

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