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Managing e-waste in China: the formal and informal sectors

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Abstract:

E-waste has grown exponentially around the world and is estimated to be growing at 3–5 % per annum. China faces a rapidly increasing amount of e-waste, both, from domestic generation and illegal imports. This paper examines the management of e-waste by formal and informal sectors in china, by means of descriptive and analytic approaches. The main results involve that China is the world's largest producer and importer of electrical and electronic devices, likewise China is the largest e-waste market. Furthermore, over 60% of E-waste produced in China is recycled informally. However, about 40% of e-waste was focused on the formal system. Finally, the major challenge for china in e-waste management is how to provide incentives for formal recyclers to reduce informal recycling activities.

Keywords: managing, e-waste, formal, informal sector, China.

JEL Classification Codes: E23, E26, Q5, Q53, Q59.

Introduction :

In 2022, approximately 59.4 million metric tons (Mt) of e-waste was generated or 7.8 kg per capita. It is estimated that the volume of e-waste will exceed 74 Mt by 2030. At the global level, the quantity of this waste is thus increasing in an alarming way, by nearly 2 Mt per year or 9 kg per capita. In 2019, the vast majority of e-waste generated (82.6%) was not collected in a formal system or managed in an environmentally sound manner. In general, these waste streams are not recorded in a consistent or systematic way.

China produced more than 200 million tons of waste annually, twice as much as in 1990 (STATISTA, 2020), as well, 60% of waste comes from electrical and electronic appliances. Since 2000, China has adopted a series of measures regarding electrical and electronic waste, including import bans, a policy to restrict the use of hazardous materials in manufacturing, and an accreditation system for recycling companies. Moreover, in 2010, China generated in excess of 2.3 million tons of E-waste, ranking second in the world following the USA with an annual E-wastes production of 3 million (Ying , Qinghua , Joseph , Yong , & Yongguang , 2013).

In addition, this quantity is multiplied by 5 in 2019, while china produces over 10 million tons of E-waste and this is expected to increase significantly. And so, China exceeds the United States to become the first producer of E-waste. Although authorities making many efforts for their management, in particular, they develop sorting and recycling, their treatment landfill or incineration is often expensive, polluting, and does not develop sufficiently the matter. As a consequence, the circular economy system is a sustainable development concept that reduces unsustainable material production and consumption.

The environmental outlook including the managing of e-waste in China is more worrying, while the economic development is characterized by high production and consumption of electronic and electrical products. As a consequence, the policy of modernization and economic growth admitted by the Chinese authorities integrates the

environmental aspect as one of the major components. So, our analysis will address the following question: how China manages e-waste (WEEE)?

Study hypothesis: In order to answer the research problem, the following hypothesis was formulated:

- ☞ The formal sector in china manages E-waste.
- ☞ The informal sector in china manages E-waste.

The objectives and importance of the study :

Today, most of the world's industry is based on the linear economy (extraction of raw materials, production, use, and waste). Despite, the earth's resources are limited, they are no longer infinite, and the manner of producing and consuming is no longer sustainable. The circular system is an alternative to solve party of this problem and reduce waste. Moreover, the flow of electrical and electronic waste equipment (WEEE) has become a serious problem. Its efficient recycling has great importance to China. In this paper, we attempt to present the experience of China in the recycling of E-waste.

Study Methodology :

This paper examines the management of e-waste by formal and informal sectors in china, by means of descriptive and analytic approaches.

1. **E-waste flow worldwide:**

In general, although E-waste recycling is increasing in developed both developing countries, the relative share of E-waste recycled remains stable due to the growing volume of waste to be recycled, which is itself linked to the very strong increase in the consumption of electrical and electronic equipment. At the same time, a large proportion of E-waste is exported, often illegally, from developed to developing countries.

Moreover, the main categories of waste electrical and electronic equipment (WEEE) will not differ from those in other countries and include items such as home appliances (televisions, refrigerators, washing machines, and air conditioners), personal mobile devices (PCs), business electronics, and industrial equipment. (Jianxin , Bin, & Cheng , WEEE flow and mitigating measures in China, 2008).

However, since 2014, the volume of e-waste generated globally has been steadily rising. In 2019, approximately 54 million metric tons, that's the amount of e-waste that was generated. Growing by nearly 2 million metric tons per year over the past five years, it is estimated that the amount of e-waste generated will exceed 74 million metric tons in 2030; the amount of e-waste generated globally poses a recycling headache and a threat to the environment and health.

Table 1. Global E-waste Generated by year (million metric tons)

Year	2014	2015	2016	2017	2018	2019	2020
Amount of E-waste	44,4	46,4	48,2	50	51,8	53,6	55,5

Source: Researcher Elaboration using statistics of (STATISTA, 2021)

According to the results presented in table 1, Global e-waste generation is growing annually by 3 to 4%, this exponential growth of e-waste is explained by the higher consumption rates of electrical and electronic equipment (EEE) (increasing by 3% annually), shorter product lifecycles, and limited repair options (WEE, 2020).

Therefore, the global quantity of E-waste in 2019 is mainly comprised of Small equipment (17.4 Mt), Large equipment (13.1 Mt), and Temperature exchange equipment (10.8 Mt). Screens and monitors, Small IT and telecommunication equipment, and Lamps represent a smaller share of the e-waste generated in 2019: 6.7 Mt, 4.7 Mt, and 0.9 Mt, respectively. Since 2014, the E-waste categories that have been increasing the most (in terms of the total weight of E-waste generated) are the Temperature exchange equipment (with an annual average of 7%), Large equipment (+5%), and Lamps and Small equipment (+4%). whereas, only 17.4% of the global e-waste generated in 2019 was reported as collected and recycled by the official WEEE management system (Stefan, 2021).

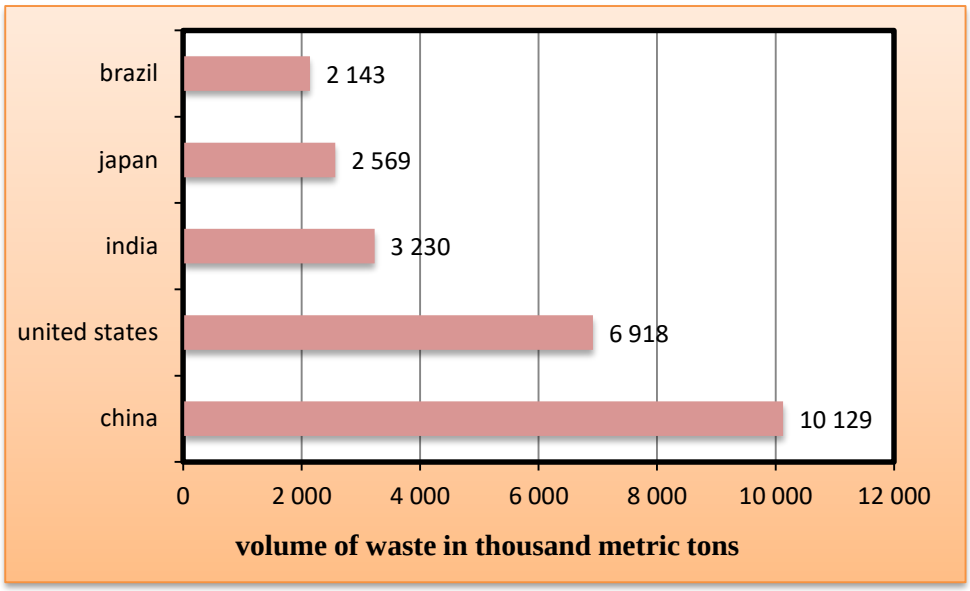
2. E-waste flow in china:

In recent decades there has been a significant increase in the volume of waste of electronic equipment in homes, offices and industries in China. Historically, in the late 2005s, there were a total of 503 recyclers who imported and recycled 9.55 million metric

tons of mixed metals, cables, motors, and other pre-processed products (Jianxin & Bin , WEEE flow and mitigating measures in China, 2008).

Electrical and electronic waste is generated by both the public and private sectors as well as by individuals. A total of 10 million metric tons of electrical and electronic waste was generated by China in 2019. As a consequence, E-waste, being one of the largest sources of heavy metals and organic pollutants in municipal waste and the fastest growing waste stream, has become a serious problem in China and other Asian developing nations (Bertram, Graedel, Rechberger, & Spatar, 2002). The figure below presents the most important countries based on generation flows of E-waste.

Fig .1. Leading countries based on the generation of electronic waste worldwide in 2019 (In 1000 metric tons)



Source: Researcher Elaboration using statistics of STATISTA 2021

By analyzing data for each country in 2019 reported in Figure 2, the results imply that countries such as China and India face a rapidly increasing amount of e-waste, both, from domestic generation and illegal imports. At the same time, these material flows from waste imports offer business opportunities, as well as satisfy the demand for cheap second-hand electrical and electronic equipment (Widmera, Heidi , Deepali , Max , & Heinz , 2005). Moreover, the world's largest producer of E-waste was China, with about 10 million metric tons in 2019, followed by the United States (6.9 million tons) and India (3.2 million tons). However, if we look at the volume concerning the

population, the Chinese are far from being the world leaders with 7.2 kilos generated per capita, which is finally the world average (Vanessa , Cornelis , & Ruediger , 2020).

Table 2. Estimate of obsolete WEEE in China (million metric tons)

Year	PCs	TVs	Refrigerators	Washing machines	Air conditioners
2003	4.48	33.51	9.76	7.56	0.65
2004	7.31	28.81	9.75	9.50	1.43
2005	9.81	32.32	13.57	15.22	1.62
2006	10.73	40.88	11.12	8.00	2.81
2007	12.68	44.49	11.38	10.83	3.23
2008	15.13	44.60	10.79	10.98	4.01
2009	15.57	48.43	12.32	13.40	4.76
2010	19.57	55.73	11.87	12.61	5.50

Source: (Jianxin Yang & all, 2008), p 1591.

As shown in Table 2, the numbers of obsolete appliances (PCs, TV sets, refrigerators, washing machines, and air conditioners) in 2003 were 4.48, 33.5, 9.76, 7.56, and 0.65 million units, respectively. Eight years later, the annual number of obsolete units of PCs and home appliances will enhance through both growing sales numbers and the decreasing medium lifetime of these items.

3. Previous study:

(Yu, Eric , Meiting , & Chaofeng, 2010) This paper reviews the existing framework for e-waste management in China including regulatory policies and pilot projects. The Chinese government has been active in creating a legislative and institutional framework to realize e-waste recycling. Pilot projects have been established with the intent to test new formal systems to replace informal recycling. These projects have usually failed to collect sufficient e-waste, mainly because informal recyclers pay consumers for their e-waste and pilot projects do not.

(Dutta & Sudha , 2021) The objective of this paper was to evaluate the status of formal and informal e-waste recycling facilities in India. It is estimated that 95% of e-

waste recycling in India is done by the informal sector at the cost of their health and the environment. Very little data and no descriptions of recycling processes in the formal sector in India were available in the literature.

(Sengupta, I.M.S.K.I , Kai , & Meng , 2022) In this paper the results prove that the formal e-waste recycling percentage in India is very low (less than 10%). The existing formal recyclers in India process approximately one-third of the total e-waste generated in the country, though they face e-waste supply chain constraints due to informal e-waste collectors.

4. Managing E-waste in China:

4.1. Informal recycling of E-waste in China

Initially, Chinese waste electrical and electronic equipment (WEEE) sources were made up of both domestic generation and imports. The flow of Waste electrical and electronic equipment (WEEE) imports is shared into legal and illegal imports. The legal sector is headed and monitored by China Customs and State Environmental Protection Administration (SEPA). Furthermore, most of the waste from domestic sources comes from post-consumer electronics. In contrast, only small amounts come from industrial processes.

As a result, China, which has become the world's largest producer, consumer, and exporter of electrical and electronic (EE) products, is facing great challenges in regulating its growing E-waste due to domestic production and illegal imports from overseas (Wanhua , 2008). Therefore, the majority of E-waste recycled is processed by the informal sector in China.

Thus, China's informal recycling sector is driven by huge profits, the majority of domestic E-waste, as well as imported E-waste are processed in China's informal recycling sectors. In addition, the estimation results prove that 1.5 to 3.3 million tons of E-waste was exported to China via various illegal ways each year and the percentage of E-waste from overseas had increased to 70%. Historically, in the late 2007s, there are more than 700,000 people employed in the E-waste industry, 98% of which were in the

informal recycling sector, while, only about two percent of which were employed by formal companies (Jinglei , Meiting , & Eric , 2006).

In addition, over 60% of E-waste produced in China is recycled informally. Further, the recycling rate of WEEE is 34%, 43%, and 62% in 2012, 2013, and 2014 respectively (Wang, Kuehr, Ahlquist, & Li, 2013). A recent study about the E-waste recycling site conducted by (Shengen , Yunji , Bo , De'an , Chein-chi , & Alex , 2015) proves that the leading one in China even in the world is located in Guiyu, while, Guangdong province processes about 20 million tons of E-waste waste per year. (Eva , 2017).

Overall, the side effects and influence of the informal sector in E-waste management have proven their limits. Firstly, informal recycling has been criticized for its serious environmental and biological consequences. Secondly, studies in Guiyu, and Taizhou, two celebrated informal E-waste recycling areas in China, have revealed high concentrations of heavy metals and persistent organic pollutants. (Xinwen , Mark , & Markus , E-waste collection channels and household recycling behaviors in Taizhou of China, 2014). Usually, these sites have hundreds of individual workshops involved in the WEEE recycling business.

Finally, China is not the only country in which the informal recycling sector is growing and flourishing. Many regions around the world, including Bangalore, Chennai, Delhi, and New Delhi in India, Lagos in Nigeria, and Karachi in Pakistan, are also experiencing a massive increase in informal E-waste recycling activities. Furthermore, E-waste recycling and processing facilities require a high investment budget, especially those fitted with technologically advanced equipment and processes (Hicksa, Dietmara, & Eugster, 2005).

According to (Hicks, R, & M, 2005) and (Jiinglei, Eric, Meiting, & Chaofeng, 2010) (Xinwen , Martin , Mark , & Markus , 2011) the main reasons leading the exponential growth of the informal E-waste recycling sector in china include: (i) the non-compliance of consumers to return and pay for the disposal of their old electrical and electronic equipment; (ii) high and unregulated levels of importation of E-waste for

use as second-hand devices, together with substantial economic benefits from unregulated recycling activities; (iii) lack of awareness among consumers, collectors, and recyclers of the potential hazards of improper E-waste handling; (iv) absence of recycling infrastructure or appropriate management of E-waste; (v) lack of financial resources to invest in improved E-waste recycling infrastructure and training; (vi) absence of effective take-back programs for obsolete and end-of-life EEE; (vii) high demand for materials (due to large and growing manufacturing sector) lack of interest in E-waste management by multinational IT companies and lack of incentive to become involved; and, (viii) high demand for used electronics, high demand for used parts (due to the domestic electronics industry).

4.2. Formal recycling of E-waste in China:

The three major legal sources of E-waste in China are households, offices (businesses, institutions, and government), and the original equipment manufacturers. It is widely recognized that China is the most important producer of electrical and electronic equipment waste in the world. While the reported 35 million tons of E-waste imported from developed countries toward China each year places it as the most importer of E-waste around the world.

According to current Chinese laws and regulations, most E-waste is forbidden to be imported. Furthermore, 2.4 million tons of E-waste comprising computers, printers, refrigerators, TVs, and mobile phones were put on the market in China. According to government statistics, 25 million TVs, 5.4 million refrigerators, 10 million washing machines, 1 million air conditioners, 12 million computers, 6 million printers, and 40 million mobile phones were thrown out in 2009 (Ongondo, Williams , & Cherrett, 2011).

For China, the recycling of waste of Electrical and Electronic Equipment (WEEE) by the formal sector represents a big challenge. In recent years, the development of the E-waste formal recycling system has achieved remarkable progress. In 2008, less than 20% of E-waste was collected by specialized companies in Beijing, among which only about 10% were disassembled for the recovery of materials (Wang et al., 2011).

However, in 2011, there were around 336 million home appliances (televisions, refrigerators, washing machines, air conditioners, and computers) put on the domestic Chinese market. Most of the 61.3 million home appliances are collected and treated by the formal sector. Furthermore, 130 E-waste recycling enterprises are registered on the E-waste Dismantling Enterprise List (Feng , Ruediger , Daniel , & Jinhui , 2013). Therefore, about 40% of WEEE was focused on the formal system.

Some companies also launched a series of reclamation campaigns for e-waste in China. Together with China Mobile and Motorola, Nokia launched a take-back program 'Green Box' program to collect obsolete mobile phones and accessories in December 2005. Only in 2009, they all collected almost 20 tons of E-waste, but Nokia reported that only 1% of phones have been recycled in China. The majority of them are stored in people's homes or sold to individual recyclers. (Lin & Yangsheng , 2012). Other international corporations like Dell, HP, Lenovo, Sony, Siemens, Motorola, and Nokia engaged in all kinds of e-waste collection schemes. Usually, they paid a little money to consumers for their old computers or PCs. For instance, Dell paid 1 RMB per 1kg computer. As a result, Dell collected about 55 thousand kg from 2006 to 2008. (Jinglei , Eric, Meiting , & Chaofeng , 2010).

CONCLUSION :

The exponential growth in the consumption of electrical and electronic products has resulted in a massive amount of e-waste. China has become one of the largest countries in the production, consumption and generation of e-waste.

This article has shown that e-waste recycling is largely driven by the informal system. The main results involve that China is the world's largest producer and importer of electrical and electronic devices, likewise China is the largest e-waste market. Furthermore, over 60% of E-waste produced in China is recycled informally. However, about 40% of WEEE was focused on the formal system. Even though, China has been among the top importers of E-waste and one particular region, Guiyu province, is known worldwide as the reprocessing site for E-waste from developed countries.

Finally, it has to be pointed out that; China produces about 10 million tons of e-waste per annum, making China the highest e-waste producer in the world, followed by the United States, which produces 6 million tons. These wastes are added to the imported wastes making the situation more and more difficult. Since 2014, the volume of this waste has jumped by 22%, and e-waste Forum experts estimate that by 2030, it will exceed 70 million tons. So, the major challenge for china in e-waste management is how to provide incentives for formal recyclers to reduce informal recycling activities.

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