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# *Reverse Flow of E-Waste Trade Between Developed and Developing Countries in the Global Value Chain*

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***Abstract.*** Due to rapid technological progress, electronic products are being renewed and substituted with rapid pace, which led to the growth of electronic waste. This is gradually disrupting the customary trend of electronic waste trading. This paper discusses the new feature, e-waste reverse flow of the South to North, as a case study of Ghana in the global value chain (GVC). The result indicates that such flows are economically motivated by international demands and weight-pricing; technologically motivated by the restrictiveness of developing countries to low-end dismantling and reliance on advanced processing technologies; and institutionally enabled by inequalities that occur under the influence of different regulations like the Basel Convention. The research exposes power imbalances between the Global North and South via reconfiguration of the world value chains which relegates the developing nations to low-value chains. This has a dual impact on sustainable development: on the one hand it enhances resource circulation and international cooperation, on the other it might contribute to increasing environmental injustice, health risks and inequity in the value chain. The work proposes that reverse flows should be incorporated into a more inclusive global circle of economic governance structure by transfer of technology, coordination of policies and upgrading of value chains in order to facilitate shared prosperity and sustainable development.

***Keywords:*** E-waste, Reverse Flow, Global Value Chain, Sustainable Development, Ghana

## 1. Introduction

Due to the persistent increasing transformation of electronic devices in consumption and replacement, the electronic waste trade (E-waste trade) hasfounditself in the internet-based global development agenda. A historical trend in the e-waste trade across the globe has beenNorth-Southflow with developed nations selling obsolete and discarded electronic and electrical waste to developing countries. This paradigm is commonly described in the theoretical categories of the so-called Pollution Haven Hypothesis, which is motivated by the favourable factors of less disposal costs, comparatively loose environmental policies and low cost of labour skills in underdeveloped nations [1]. Recent years, however, have seen emerging evidence on this fact engineering that cross-border flows of e-waste are not one-sided. Another trend which is increasing and is referred to as South-North reverse flows of e-waste, is where some e-waste after preliminary dismantling or sorting finds its way back to the developing countries in the form of secondary resources. Such a

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reversed direction of tradenot only defies traditional knowledge but also poses new theoretical and practical questions on how world resources flow, environmental justice, and the development patterns of sustainable development.

This research seeks to conduct systematic research to investigate the causes, mechanisms and effects of this reverse flowonsustainable development in the world. It is concerned with two fundamental questions: First, what are the economic, technological, and institutional factors that are prompting the reverse circulation of e-waste south to north? Second, but most importantly is how this flow affects global development in a sustainable manner- especially by remaking global value chains? To answer these questions, the global value chain theory would be used as the main analytic tool in this paper. It narrows down on governance forms, market pathways and distribution of pricing authority in global production and recycling efforts in order to explore the place and role of the developing nations in the global e-waste recycling system.

In a methodological way, this paper uses Agbogbloshie e-waste treatment and processing area in Ghana, West Africa, as a case study. The research makes use of data regarding customs codes of electronic waste in relation to United Nations Commodity Trade Statistics Database (UN Comtrade) under several different categories such as scrap aluminum, copper, iron, metal-containing residues, and used batteries. This paper aims to help unveil the compositional nature of the electronic waste exports of Ghana through the descriptive statistics, data visualization (through R), and the literature analysis. Based on this premise, it breaks down the economic motivations, technological factors in the industries, and the policy control factors behind these exports.

The study has great practical value as it helps to better comprehend the changes in the international trends of electronic waste trade and the effects they have on the developing nations. Italso theoretical worth. This research will augment and reflect on the conventional international trade theories and environmental theories and incorporate some reverse flows into the analytical framework of global value chains, which will offer a theoretical foundation of designing a fairer and more sustainable global circular economy governance system.

## 2. Literature review

According to different theoretical insights, most researchers assume that the trend followed with the flow of electronic waste isfromdeveloped countries to the developing countries. Waste disposal costs are a key factor that should be of particular concern in waste disposal, and the trade will be more inclined to the direction that has lower disposal costs. Moreover, the people living in industrialized nations are normally experiencing the “not in my backyard” response in the event of establishing new disposal plants [2]. In addition, the cheaper disposal plants of developing countries are available and environmental norms and regulations are weaker or not observed significantly. Due to lower cost of labor in the developing countries the taxes tend to be avoided, and the export to the developing countries (legally or otherwise) becomes cost-effective [3].

Nonetheless, other researchers have indicated that the electronic waste exported by the rich developed nations to the poor developing nations may not be as large as the intra-regional exportation of e-waste by these developing nations. The reality of the matter is that such a trade is mostly between non-Annex VII regions and Annex VII regions. This orientation goes against the direction expected of the Convention(1989) through the assumption of national vulnerability [4]. Empirical studies also show that most trade flows of any electronic waste are dominated by factors that are related to the capital intensity of production as well as the other input factors as opposed to differences in the costs of pollution in states. This is a kind of dynamic that gives the high-income

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countries comparative advantage in such trade. This means that the current discourse on global electronic wastes needs to be revisited.

Although the conventional pattern of North to South flow of electronic waste has been well studied, current studies oppose this concept. It demonstrates that a reverse flowalso occur, i.e. the transfer of waste to Annex VII countries out of non-Annex VII countries. A systematic insight into the reverse e-waste flow is, however, yet to be developed.

There is lack of systematic typology of the phenomenon itself. The causal forces, which are economical, technological, and institutional, do not have a theoretical base.Its multifaceted implications on the global sustainable development are practically assessed, with regard to Global South countries.

Existing research has yet to systematically analyze the driving mechanisms and impacts of reverse flows of electronic waste. Ghana, as a core nation for electronic waste processing in West Africa, offers an ideal case study for this issue due to the representativeness of its Agbogbloshie processing zone and the comprehensive data support from the United Nations trade database. The following analysis will examine Ghana's export data and industrial practices from three dimensions: economic, technological, and institutional.

## 3. Ghana case study

This study analyzes Ghana as a case due to the presence of one of the world's largest informal e-waste recycling sites in Agbogbloshie, Accra. Also, the relatively complete UN Commodity Trade Database records for Ghana from 2010 to 2023, which provides feasibility for research. The graphics mainly consist of four categories of electronic waste: external packaging (aluminum, copper, iron), ash (slag/ash/residues), printed circuit boards, and batteries. Descriptive statistics calculate each category's percentage of total exports; stacked bar charts using R program illustrate annual trend distributions; logarithmic scales prevent misleading effects from extreme data points.

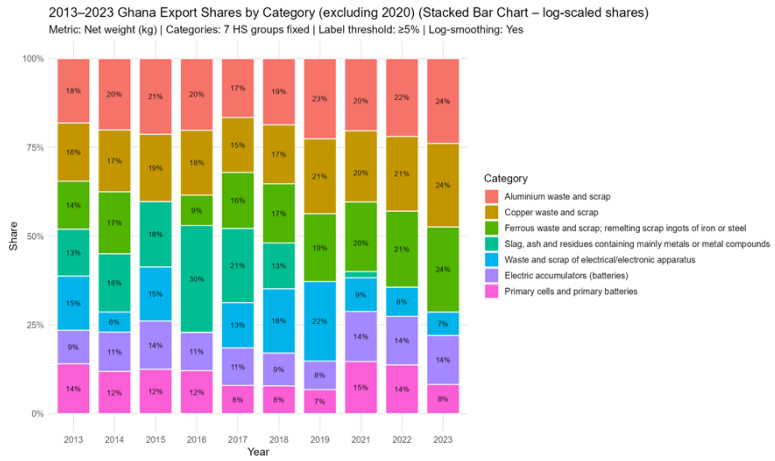


Figure 1. 2013-2023 Ghana export shares by category

This examination indicates a number of different phenomena in exports (Figure 1). To begin with, the amount of recovered waste incinerated as a result of smelting of the residues is always less compared to the quantity of non-incinerated recovered waste, which is mostly composed of externally mechanically dismantled materials. Less than 30 percent of exports are made up of slag, ash, and residues that are mostly made up of metals or metal compounds. Second, non-incinerated exports which are dismantled in a mechanical way contain an exceptionally large percentage of

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aluminum, copper, scrap iron. Third, a small percentage of exports are made up of functional internal parts like printed circuit boards and batteries. There are two major findings of these observations. Firstly, the fact that the smelting residues are always less than 30 percent shows that the e-waste exports of Ghana are an indication of a recycling system using dismantling as a major form of recycling utilized. Second, the leading position of aluminum, copper and iron scrap export (constituting around 55 to 72 percent) suggests the low-end, dismantling-oriented industry of extracting external resources that are easy to recover. The low rate of use of printed circuit boards and batteries implies a low system of internal component recovery and restricted technical attributes.

This paper examines and describes this phenomenon on the economic, technical, and institutional front.

### 3.1. Economic factors

To begin with, price signals in the market and profit motives. The exports of electronic waste in Ghana are mostly metal scrap including aluminum, copper, and iron (55–72% of total exports). The advantages of these materials are evident in agreement of prices and trading network in foreign markets. The recycling industry of Ghana has a weight-based pricing regime and real-time mobile payment settlements on transactions, thus improving the efficiency of transactions and capital liquidity. The large-scale manufacturing of automotive products and electronic products such as computers in the developed countries drives the demand of the high purity-grade metal raw materials; this creates perpetual market pressure, which makes Ghana an important hub in providing secondary raw materials. This dynamic is further boosted by the availability of major secondary raw materials, developed markets as well as the networks of buyers [5].

Second, informal economy and low-cost structures. The processing of e-waste has been stipulated by a labor-based and in the dismantling model in Ghana where informal workers are employed at low costs to dismantle parts of the device [6]. This model minimizes the initial investments in recycling which permits Ghana to sustain a comparative advantage in low value-added parts on the world value chain. It, in turn, is one of the primary sources of exporting primary recycled materials to Northern countries [7].

### 3.2. Technological factors

In Ghana and the West African region in general, most e-waste companies are based on simple, cheap labor-intensive dismantling methods-manual disassembling and open air burning. Although this may be useful in extracting the large percentage volumes/weight of metals (i.e., iron castings and copper wires), this is incredibly ineffective in extracting rare and precious metals, including gold and palladium found in parts like printed circuit boards [8]. This is because of the lack of sophisticated mechanical sorting, pyrometallurgical or hydrometallurgical technologies and equipment, which means that the recovery of these high-value materials is extremely low, or non-existent.

This technologicallack isdirectly from the region’s industrial makeup, which is dominated by small and medium-sized workshops which the scholar called “Informal sector andlacksthe capital and capacity for large-scale, high-tech investments [9]. This has created a vicious cycle of low-value recovery being brought about by technological backwardness; hence, restricting capital accumulation and hindered technological upgrading. Besides, local industrial structure can be described by the refining without dismantling fragmentation. In situations where precious-metal-enriched intermediates are first removedfrome-waste, Ghana does not have the industrial capacity to

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carry out subsequent high-purity refining and purification stages in-country [10]. Therefore, such potentially lucrative value chain intermediary items must be shipped to the developed countries with consolidated industrial networks and sophisticated technologies i.e. Europe, China and Middle East so that they could be further refined [11]. This dynamic has entrenched the recycling industry of Ghana at the bottom of the global precious metal value chain such that it is only able to gain of the raw material level at the highest ratio.

Therefore, thesignificantcauses are technological dependency and subordination status in the value chain in Ghana. In the GVC, Ghana is in the disassembly without refining part. Its technological constraints deny its possibility of rising up the value chain and this compels the use of technological systems of Northern countries to recycle at high value-added-recycle hence the creation of a technology-dependent reverse flow.

### 3.3. Institutional factors

To start with, the Basel Convention and Differentiated Regulation. Batteries, printed circuit boards and other components are classified as hazardous waste under the Basel Convention which places severe limitations on the transgression of electronic waste across borders. But the scrap metal, aluminum, copper, and iron is under the non-hazardous waste and therefore can be traded comparatively freely (Annex IX of the Basel Treaty B1010). This regulation difference gives Ghana a legal course to sell metal scrap to the developed states and at the same time restricts its chances of selling highly polluting parts [12].

Second, there is the driving force of the EU Waste Electrical and Electronic Equipment Directive and Circular Economy Policy. Directive on Waste Electrical and Electronic Equipment stipulates high targets that must be met by recycling by the EU thus pressuring its member states to find recycled metal raw materials in other parts of the world [13]. This generates institutional stability in the demand of Ghana to export metal scraps, which demonstrates how the policies of the Northern countries are dragging the resources of the Global South.

## 4. Effects of reverse flows on sustainable development of GVCs

The Ghana case is a clear indication of the asymmetries of power structure, and imbalances in thevalue distribution of global value chains (GVCs) in an appointed manner. Under this transnational e-waste recycling system, Ghana is strategically locked out of the high-value adding side of the chain: the developed countries, with their ability to command technical standards, market access and market pricing power, grab the high-value added phases of the design, deep processing and sales processes; the developing countries such as Ghana are relegated to the low-tech, pollution-inducing, and health-threatening work of primary dismantling and crude sorting [14]. This division of labor brings a lot of economic value to the upstream end of the chain. Ghana gets a mere processing fee but the massive environmental and social impact of heavy metal contamination of the soil, water through poisoning, and health injury to the worker.

Moreover, this lock-in makes direct contribution in lopsided exchange in commerce. The unrefined form of the raw materials of primary metals produced by developing countries (crushed iron, scrap aluminum and scrap copper) is exported at low prices whereas developed countries use sophisticated technologies to refine them into high purity of recycled metals or high value-added products and later sell it to other parts of the world at high prices [15]. Not only does this lead to the continuation of the decline in the terms of trade of the developing countries and the global inequalities in wealth, but it also has an extremely negative effect on the ability of the developing

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countries to upgrade their industries, accumulate technologies, and develop sustainably due to the involvement into the circular economy. The situation in Ghana indicates that unless it involves a focused transfer of technology, equity in terms of trade, and reforms in the international system, the reverse direction of today flows of electronic waste might not only sustain but also increase the existing inequalities within the global value chain [16].

As such, the backwash current of this electronic waste has a twofold effect on the sustainable development in the world. The positive impact of it is observed in the possibility to recycle resources and cooperate between the North and South. This flow enables converting the discarded electronic devices into resources, which offer a vital resource base to the development of a global shift to the circular economy and aid to minimize the reliance on virgin mineral resources [17]. More to the point, the systematic introduction of technology transfer and capacity building into trade structures, namely, so-called technological environmentally safe deep recycling of waste materials, pollution control institutions, and frontline processing nation such as Ghana administration expertise, promises to sever the existing one-dimensional pattern of the model of the resources transfer. That would result in a different kind of North-South collaboration that has to do with the exchange of technology and the ability to increase capacity, which will significantly contribute to the efficiency and fairness of closed systems of resources on a global scale.

Nevertheless, its considerable adverse effects cannot be neglected, which are exhibited mostly in the form of environmental inequity and deprivation of the sustainable development agenda. On the one hand, spatial displacement of pollution and health costs has been witnessed: there is clear local pollution of soil, water, and air in Ghana, which is a result of extensive processing techniques such as open-air burning and acid washing, subjecting the residents (mostly children), to apparent health hazards, such as respiratory illnesses and lead poisoning, which is directly counterproductive to the pursuit of sustainable development. Conversely, failure to govern can create systemic failures: Because regulatory differences exist between hazardous and non-hazardous waste under an international convention such as the Basel Convention (alongside a lack of enforcement capacity in some countries) this can result in systemic failures of the hazardous waste system to the ends that it is exploited by waste smuggling or creating pollution havens in areas with weaker enforcement capacity. This is not only generating environmental injustice but essentially causing an irrelevance and a lack of credibility of the global environmental governance system [18].

It can be concluded that this pattern of flow is not only a possible path to sustainable management of world resources, but also a road to the worsening of inequality and environmental degradation. The way it will impact the sustainability of the world rests on whether global government can be able to utilize its strengths through curbing its weaknesses.

## 5. Conclusion

This paper employs the global value chain frameworkin order to use a systematic approach in analyzing the new phenomenon of South-North reverse flows of electronic waste using the Ghana case. Results also indicate that those flows are not by chance, but they are due to the combined and driving force of economic, technological, and institutional factors that occur in the global value chain. Economically, the demand of the international market, weight-based pricing systems are the most fundamental pull factors; Technologically, the developing countries are having to be chained on their low-end dismantling operations, which results in a structural dependency on the superior processing technologies of the developed nations. Laws, such as the Basel Convention that distinguishes between hazardous and non-hazardous waste on the international level, open the way

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to the legal opposite trades of very particular materials (e.g., aluminum, copper, and iron scrap). This circulation is the signature of significant redistribution of the global system of flow of resources.

What is more important is that this study explains the essential role of such a restructuring of value chain to sustainable global development. On the one hand, it enhances the flows of resources globally, which offers the material basis and prospective possibilities of North-South collaboration and the transition to a circular economy across the world. Alternatively, it strengthens and intensifies the existence of power imbalance and unequal allocation of values along the value chain. The developing nations are the ones who pay most when it comes to maintaining the environment and health yet they get paltry returns, they are stuck in the low-end lock in. Such cross-border movement of environmental prohibitions besides simply severely impairs the local sustainable growth objectives, it also questions the equity and effectiveness of global environmental managing.

Therefore, even though reverse flow of e-waste itself is a neutral transfer of materials, the way it develops depends wholly on the governance framework on which it is established. To turn it into the real trigger of sustainable global development people should go beyond the old-fashioned model with cost redistribution and the division of labor on low end. In order to direct this flow into a constructive force of facilitating equitable and sustainable decentralization in global circulation, the measures to be recommended in this study are as follows:

In the case of technology transfer, it is important to adopt phased and flexible approach based on the industrial reality of the developing nations where informal workshops are the major reality. In the short-term people should emphasize the promotion of inexpensive low-environmental-impact physical sorting and pre-processing technology (small mechanical crushing equipment with backup sorting by hand), as opposed to initiation of high-capital pyrometallurgical or hydrometallurgical technology. At the same time, through the support of the developed countries and organization of international organizations, open regional technical training and demonstration centers in strategic locations such as Ghana. Such centers are supposed to offer equipment, trainers, and support services to local practitioners to increase their capacity to process the environment and standards of occupational safety.

In the area of coordinating the policies and upgrading governance, there should be joint work completed to promote international rule reforms and home domestic policy incentives. In the international arena, amendments to such frameworks as the Basel Convention must be sought with the introduction of certain amendments to responsible reverse flows. This would involve importing countries of electronic waste resources to contribute to a section of the environmental governance and technical assisting costs and create funds of compensation. Out in the country, the first-mover nations such as Ghana ought to come up with strategic industrial support policies. The enterprises that have started using environmentally friendly processes and reducing safety to the necessary level should have tax breaks, equipment subsidies, or green credit, which means that they should be provided with tax breaks. Such forms of the economy will encourage the informal sector to shift its models to standard, low-pollution forms.

Finally, the process of e-waste should become a part of a new global system of managing the circle of the economy, which is based on equity, mutual benefits, and a complete sense of responsibility in all respects. It is only then that global dissemination of resources can progress in hand with equal development that would then bring about indeed sustainable world development.

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