Global business and emerging economies: towards a new perspective on the effects of e-waste

Dr. Joseph Amankwah-Amoah*

Associate Professor of Management

Bristol University

School of Economics, Finance and Management

8 Woodland Road

Clifton, Bristol, BS8 1TN

England, UK

E-mail: Joseph.amankwah-amoah@bristol.ac.uk

TEL: +44 (0) 117 3317936

*Corresponding author

ABSTRACT

Although there has been a growing body of research on the detrimental effects of electronic waste (e-waste) in emerging economies, this fails to capture a complete picture of the subject. The purpose of this paper is to address this deficit in our understanding by developing a unified perspective of the effects of e-waste. The paper advances three main perspectives (i.e. the positive, detrimental and the unified perspectives) of the effects of e-waste in emerging economies. These perspectives unify the existing scattered streams of research on the subject to offer more robust explanations of the effects of e-waste in developing countries. Through an illustrative case of an emerging economy, the paper demonstrates that contrary to the perceived view that e-waste from advanced economies to developing countries is detrimental; some sectors such as the second-hand market, aftermarket and repair industry have flourished. The paper outlines a range of strategies for countries that can be adopted to develop and enhance environmental sustainability.

Keywords: Electronic waste; e-waste; global business; externalities; Africa.

1 Introduction

Since the turn of the twenty-first century, waste electrical and electronic equipment (WEEE) or electronic waste (e-waste) has become a much more of pressing issue facing governments, technology companies and wider society (Baldé, Wang, Kuehr and Huisman, 2015a; Atasu and van Wassenhove, 2012). The past three decades have also witnessed unprecedented growth of e-waste as more products are produced and consumed by the rising global population (United Nations Environment Programme (UNEP), 2011). The current growth rate of 8% annually is expected to increase and poses major challenges to such countries (The Economist, 2014a). E-waste is one of the fastest-growing problems facing developing countries and the weight of e-waste worldwide is expected to increase (Chi, Streicher-Porte, Wang and Reuter, 2011).

In 2014, around 41.8 million metric tonnes (Mt) of e-waste was generated globally and is projected to surge to 50Mt by 2018 (Baldé et al., 2015b). In an increasingly changing global environment characterised by rapid technology innovation, electrical and electronic equipment such as laptops, mobile phones and computers are being superseded at a much faster pace and thereby rendering old versions obsolete (Baldé et al., 2015a, 2015b; Kiddee et al., 2013). As more consumers upgrade their products to the latest version, the old ones are rendered outmoded (Kiddee et al., 2013; Widmer et al., 2005). In the case of computers, the average lifespan has shrunk from 4.5 years in 1992 to around 2 years in 2005 (Widmer et al., 2005). The growth of e-waste has also garnered a growing stream of research which has enhanced our understanding greatly (e.g. Orlins and Guan, 2015; Robinson, 2009).

Notwithstanding these past accomplishments by researchers, their analyses suffer from a number of deficiencies. First of all, much of the existing research on emerging economies has focused on

mainly the negative effects stemming from developed nations (e.g. Asante et al., 2012; Kiddee, Naidu and Wong, 2013; Perkins, Brune Drisse, Nxele and Sly, 2014). In addition, much of the existing literature has developed in insolation. Given the one-sidedness of the existing streams of research, there is a need for a comprehensive overview of the literature to enrich our understanding of the effects of e-waste in emerging economies. Such analysis would also help to put the subject on a much stronger footing.

This paper represents an effort to address this gap in our understanding by reviewing the literature on the effects of e-waste in emerging economies. The paper then illustrates the theoretical analysis using insights from a developing economy. We focus on emerging economies, in general, and Ghana, in particular, to illustrate the effects. Our focus was driven by a number of factors. First, Ghana is one of the most stable democracies in Africa with thriving industries and technology development (Amankwah-Amoah & Debrah, 2010; Amoyaw-Osei et al., 2011). Second, the Agbogbloshie Market in the country has been dubbed "the world's largest e-waste dump site" (The Guardian, 2011) and "Africa's computer graveyard", and takes around 192,000 tonnes of e-waste a year (Asante et al., 2012; Vidal, 2014). Therefore, this setting provides a promising example to inform the analysis.

The paper makes two main contributions to information technology, strategy, operations management and waste management research. First, although some studies have examined the effects of e-waste (e.g. Xu et al., 2012), they have largely focused on the negative externalities of e-waste and thereby overlook any potential positive externalities. The paper develops and advances three main perspectives (i.e. positive, detrimental and the unified perspectives) on the effects of e-waste in emerging economies. These unify the existing theoretical explanations on

the subject. Second, much of the existing analyses have focused on the impact of the wider economy and thereby ignoring the industry-specific implications. The study fills this void in our understanding by using insights from the second-hand market and electronic repair industry to demonstrate how e-waste has helped to foster innovation and industrial development.

The rest of the analysis unfolds as follows. First, we develop a working definition of the subject and provide an overview of the literature on e-waste. This is then followed by a review and development of the three main perspectives on the subjects. The unified model of explanations for the evolution of e-waste is presented. The penultimate section identifies examples from an emerging economy to demonstrate the key arguments. The final section sets out a range of promising implications for governments, policymakers and other stakeholders.

2 What is e-waste?

Scholars have broadly defined the term "e-waste" to include a range of electronic and electrical devices such as refrigerators, televisions, microwaves, washing machines, computers, copiers, stereos, VCRs and fax machines considered obsolete and/or discarded by the user (Puckett et al., 2002; Step Initiative, 2014). Such products have often reached the end of their lifecycle. However, their lifespan can be extended as second-hand goods by other users in the same or another country. Such products can be reused, refurbished, utilised in other products or recycled. Some of the primary causes of e-waste include technological obsolescence, changes in technology infrastructure, innovations and changes in government policy (Deubzer, 2012).

One of the main contributory factors is the ever-shortening lifespans of electrical and electronic equipment (EEE) (Baldé et al., 2015b). Many products are becoming obsolete at a much faster

rate than ever before and thereby creating more e-waste. The preceding discussion outlined above have been summarised in Figure 2. The figure demonstrates how a product that has reached a final stage in one geographical context/market can be redeployed for same or new uses in another market.

Insert Figure 1 about here

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3 Electronic waste effects in emerging economies: towards a unified perspective

Three unique streams of research have evolved to inform and provide foundations for a better understanding of the effects of e-waste in emerging economies (see Figure 1). The first stream, the detrimental perspective or adverse effect, argues that e-waste from developed to developing countries can only have deleterious effects on the local economy, industries and the health of workers. A growing stream of research has uncovered effects such as encouraging child labour, water contamination and air pollution as outcomes of e-waste (Asante et al., 2012; Baldé et al., 2015b). Electronic waste, entailing flame retardants, arsenic, cadmium and polyvinyl chloride, poses a threat to human life and individuals handling the waste (United Nations, 2014).

A recent study also uncovered that, electronic appliances can entail up to 60 different elements which are harmful if not treated properly (Orlins and Guan, 2015). These can contaminate of local rivers and soil, which then hampers agricultural activities in many developing countries (Asante et al., 2012; Orlins and Guan, 2015).

One interesting line of research has indicated that informal and formal workers are often exposed to toxic substances due to weak regulatory and legal systems in many developing countries (see UNEP, 2015; Perkins et al., 2014; Chi et al., 2011). One of the factors that has exacerbated the

problems is that many of the workers in the developing world are often untrained in mitigating the harmful effects and are unprotected from them (Orlins and Guan, 2015). They also often do not possess the specialised and protected personal equipment required to recycle safely.

During the recycling, studies indicate that workers are often exposed to dioxins, brominated flame retardants and heavy metals which stay in the environment for a protracted period (Asante et al., 2012; Orlins and Guan, 2015). A study by Xu et al. (2012) uncovered that e-waste was linked to higher risk of stillbirth in a local area. Indeed, some scholars have gone as far as to suggest that "the transfer of used electronic devices to developing countries" should be forbidden (Kiddee et al., 2013, p. 1237). Although this particular narrative has garnered much theoretical and empirical support, it presents only a partial picture of the effects of e-waste. A recent study on Liberia by Strother, Williams and Schluep (2012) uncovered that the country lacks the necessary human capital and financial resources to develop and implement e-waste management programme capable of supporting law enforcement. Consequently, the country like many others in the developing world has struggled to contain inflow and processing of obsolete electrical and electronic equipment (Strother et al., 2012).

Insert Figure 2 about here

The second stream, the positive or beneficial perspective, contends that there are largely positive externalities stemming from e-waste for recipient developing nations. To illustrate this line of argument further, we turn to the theory of second-hand markets. This theory argues that used product in one market has the potential to generate positive externalities in another such as igniting growth and innovation (Fox, 1957; Scitovsky, 1994).

A growing body of research in this area suggests that used products in one market can be refined, regenerated and modified into productive new uses or product innovation (Oraiopoulos, Ferguson and Toktay, 2012; Amankwah-Amoah, 2015). Scitovsky (1994, p. 37) puts it this way: second-hand markets for consumer products "*stimulate the economy partly by enabling the well-to-do …to replace their worn out or obsolescing durable goods with new ones and thereby increasing the total demand for them*". Indeed, recycling and reuse of e-waste has potential to lead to new product development (see Thomas, 2003). One of the unique features of an obsolete system and technology is that the design can be updated with new parts to keep it functional (Sandborn, 2008). There are second-hand markets for machine parts thriving on the back of e-waste (Bartels et al., 2012).

Another line of research suggests that the existence of a secondary market has the potential of generating cheap products that can compete with new products in the marketplace (cannibalisation effect) (Oraiopoulos et al., 2012; Zhao and Jagpal, 2006). Although used products are associated with lower prices compared with new ones (Oraiopoulos et al., 2012), such products enable poor consumers to afford certain EEE (Amoyaw-Osei et al., 2011). E-waste also has the potential to foster remanufacturing which is the process of "restoring a product to like-new condition by reusing, reconditioning, and replacing parts" (Kumar and Putnam, 2008, p. 312). Through repair, faulty products or components (e-waste) can be brought back into functional condition (Bartels, Ermel, Sandborn and Pecht, 2012; Kumar and Putnam, 2008).

The third stream, the unified perspective, contends that e-waste has both positive and negative effects on recipient nations. This depends on the capacity and capabilities of each nation to mitigate the negatives and capture the positives. This perspective rests on the assertion that

electronic waste, recycled in safer conditions and with harmful elements disposed of, can provide a platform for economic development and gainful employment.

4 Research design and data sources

To illustrate the theoretical analysis, we turn to the case of Ghana and the evolution of e-waste. The single country approach was favoured given its ability to provide a more in-depth and rich insights on how e-waste had impacted on the country and sectors of the economy (Saunders, Lewis and Thornhill, 2011; Bryman and Bell, 2015). The study relies mainly on archival records.

By archival records we are referring to "documents made or received and accumulated by a person or organisation in the course of the conduct of affairs and preserved because of their continuing value" (Ellis 1993, p. 2; see also Bryman and Bell, 2015). It encompasses government publications, trade magazines, policy documents and newspaper reports, which have been found to be "particularly suited to generating developmental explanations" (Welch, 2000, p. 198).

The used of archival records is strengthened by the fact that it "particularly suited to generating developmental explanations" (Welch 2000, p. 198; Saunders et al., 2009). It has also been established that the archival approach "allows research questions which focus upon the past and changes over time to be answered, be they exploratory, descriptive or explanatory" (Saunders et al., 2009, p. 150). In this direction, Ghanaian Government policy such as National Environmental Sanitation Strategy and Action Plan, and Sustainable Land and Water Management Project were examined. Reports by the Secretariat of the Basel Convention, United Nations Solving the E-waste Problem (StEP) Initiative and the United Nations Environment Programme (UNEP) on e-waste in Africa, in general and Ghana, in particular were also

examined. Taken together, these archival approaches provide rich data to provide new insights on the subject.

5 Overview of the evolution of e-waste in Ghana

In the last few decades, Ghana emerged strongly once again as one of the main destinations for foreign direct investments in Africa. Ghana's role as one of the gateways to Africa has been further enhanced by rapid economic development (Amankwah-Amoah and Debrah, 2010). Coincidently, Ghana, alongside other emerging economies such as Nigeria, China and Mexico, has overtaken many advanced countries as the main destination for e-waste. The amount of used EEE imported into the country has increased with varying consequences for businesses and the local economy.

In 2010, Ghana imported 31,400 metric tonnes of used electrical and electronic appliances which was a 74.6% rise from 17,987 metric tonnes in 2009 (B&FT, 2011). From these figures, an estimated 17,765 metric tonnes were imported from the United Kingdom which was an increase over the previous year (B&FT, 2011). A large percentage was designated for the second-hand market and the remainder for the repair industry. Indeed, the second-hand electrical sector has been surging for more than a decade. The importers of such used appliances sell these products across the whole country. The country is estimated to have around 300 importers and distributors of such EEE which is seen as a source gainful employment (B&FT, 2011). Although an estimated 15% of the second-hand imports are unsellable or unworkable, 20% of the imports are repairable to function (Amoyaw-Osei et al., 2011).

In recent years, many African countries have sought to bridge the "digital divide" by encouraging or allowing imports of second-hand or used electrical and electronic equipment (EEE) such as computers, mobile phones and TV sets from advanced economies (UNEP, 2011, p. 9). The importation of workable second-hand equipment into the country has helped to "bridge the digital divide" and improve users' living standards (Carney, 2006). As the number of imports has surged in line with the increasing consumption of used electrical and electronic equipment across the continent, a corresponding increase in volumes of e-waste has also occurred with varying effects for countries (UNEP, 2011; Strother et al., 2012). Another pull factor is lack of effective laws and enforcement mechanisms governing importation of e-waste. As Amoyaw-Osei et al., (2011, p. xi) noted, "There is currently no specific policy or legislation for WEEE management in place". Indeed, there are no effective policies governing the importation, transportation, storage, recycling and disposal of e-waste (Darko, 2010).

One of the main sources of e-waste into the country is illegal importation (Baldé et al., 2015b). Across sub-Sahara Africa, e-wastes are often legitimately imported under the broad umbrella of "donation" and "second-hand goods" (UNEP, 2011). Most of the current challenges facing Ghana stem from the importation of e-waste and lack of effective enforcement of domestic and international laws. The country lacks the capacity to handle as well as treat all e-waste effectively. In much of sub-Saharan Africa, very few countries have effective legal enforcement mechanisms relative to e-waste (Baldé et al., 2015b).

Over the years, many African governments have demanded tougher measures to curtail the influx of electronic waste. As a result, most of the workers handling e-waste lack the expertise and training to help ensure efficient e-waste disposal (Darko, 2010). The government is in the early

stage of developing an effective policy to govern the importation of e-waste and reusable second-hand electronics (Pwamang, 2013). However, it is worth noting that the country has ratified the Basel Convention on Hazardous Wastes and their Disposal and passed the Environmental Protection Agency Act. For some time the inflow of e-waste was unabated due to the policy vacuum and lack of effective enforcement. Since the mid-2000s, however, a new genre of relationship has emerged with the government working increasingly with charitable and non-governmental environmental protection organisations to help reduce the inflow of unwanted e-waste. Table 1 summarises key legislative accomplishments and events relative to e-waste in the country.

Insert Table 1 about here

The large influx of such e-waste can be attributed to not only lack of effective laws and lax enforcement regimes in Ghana but also in the originating countries. It is the argument that advanced economies are a major contributory factor to e-waste developing countries. The United States and Western European countries are the world's leading exporters of second-hand EEE to Africa. Although Africa generated approximately 1.9Mt of e-waste in 2014, much of the e-waste in countries such as Ghana and Nigeria originated from developed countries (Baldé et al., 2015b). Around 250,000 tonnes and 1.3m tonnes of used electrical products are exported from the EU annually to the developing countries mainly in West Africa and Asia (Vidal, 2013).

One of the drivers is that the cost of recycling e-waste is relatively low in countries such as Ghana compared with the United States. This often means that companies are more reluctant to recycle at home in developed countries, thereby precipitating the surge to dispose of waste in the

developing world. Indeed, around 80% of electronic waste generated in the US is exported to developing countries in Africa and Asia with lax health and safety regulatory regimes (The Economist, 2014a). Approximately three-quarters of PCs sent from the US to Nigeria for reuse were subsequently found to be beyond repair and eventually dumped in the local area rather than recycled (Vaughan, 2009). This partly stems from the fact that the US remains the only developed country yet to ratify fully the 1989 Basel Convention treaty which controls the exportation of hazardous e-waste (The Economist, 2014a).

6 The positive effects

In this section, a range of explanations are offered to outline the positive effects of e-waste.

6.1 Valuable materials and precious metals

E-waste has been found to entail a number of valuable materials such as iron, copper and aluminium, and precious metals including silver, gold, platinum and palladium (**UNEP, 2011;** Baldé et al., 2015b). Indeed, e-waste contains around 40 to 50 times more precious metals than ores from mining (IBT, 2012). In 2014, the value of global e-waste was 48 billion euros, which has been projected to increase (Baldé et al., 2015b). The value of precious metals in e-waste is actually surging at about around $21 billion each year (IBT, 2012). A study by the UNEP (2011, p. 9) uncovered that e-waste often entails valuable materials such as indium and palladium and precious metals such as silver, copper and gold. These valuable resources can be recovered and utilised which helps to reduce the pressure on scarce natural resources and thereby minimise the total environmental footprint (Baldé et al., 2015b; UNEP, 2011).

In 2014, around 300 tonnes of gold (equivalent to 11% of the global production in 2013), 1,000 tonnes of silver worth £400m and 16 megatons of steel were in e-waste (USGS, 2014; Baldé et al., 2015b, p. 50). This potential positive effect is further illustrated by the fact that a million discarded mobile phones can produce about 24kg (53lb) of gold, 9kg of palladium, 250kg of silver and over 9 tonnes of copper (Financial Times, 2013). The quote below exemplifies some of the hidden value in e-waste.

> "*Most phones contain precious metals. The circuit board can contain copper, gold, zinc, beryllium, and tantalum; the coatings are typically made of lead … Yet fewer than 10% of mobile phones are dismantled and reused … The failure to recycle is also leading to shortages of rare-earth minerals to make future generations of electronic equipment*" (Vidal, 2013, p. nd).

By developing a recycling infrastructure, countries such as Ghana would be able to mitigate the negative effects whilst concurrently helping to capture the positive effects. Through recycling, this potential wealth from discarded electronic products can be harnessed by countries for development.

6.2 The second-hand market and appliance repair industry

In the past few decades, many industries such as recordable media manufacturing and appliance repair have all declined in advanced economies (Amankwah-Amoah, 2015a; Economist, 2006). However, e-waste has become an engine fuelling the growth and development of appliance repair in Ghana. As many technologies and appliances are declared obsolete and faulty in the West, their lifespans are extended by firms and experts in the appliance repair industry. Up to 70% of all EEE imports into the country are second-hand products or products largely designated as e-waste (Amoyaw-Osei et al., 2011). Around 60–70% of second-hand products arrive in the

country in working condition and between 20–30% of such imports are repaired and reused, which leaves about 10–20% as informal recycling (Darko, 2010; Amoyaw-Osei et al., 2011). Interestingly, however, in 2009, out of the 280,000 tons of obsolete devices, 57% was repaired, 8% went to storage and 34% was recycled by the informal collectors (Amoyaw-Osei et al., 2011, p. x). One of the main drivers is that second-hand products are relatively cheap compared with new products, thereby providing opportunities for many to own EEE such as computers and televisions. Indeed, "functional" second-hand electronic devices often can be purchased in the local markets for less than 1/10th of the price of a new one (Darko, 2010). Many importers of second-hand goods have flourished given the appeal of such products.

In Ghana, most of the repairers are in the informal sector, characterised by limited professional training and limited use of protective equipment. They are also mainly individually owned or family-owned businesses. The repairers are situated in all the major cities across the country offering services such as fixing faulty and obsolete appliances and equipment as well as making use of parts of appliances which are un-useable (Amoyaw-Osei et al., 2011; see also Darko, 2010). Indeed, they have a very "high success rate" of about 70% in repairing EEE, thereby extending the product lifespan (Amoyaw-Osei et al., 2011). Many of the parts or components in e-waste are re-used to repair other electronic appliances such as radios, televisions and fridges. Stated colloquially, this is where "old turns new" when repairers engage in reengineering to fix and develop new appliances.

Nevertheless, there are associations of repairers and technicians of EEE in the country. For instance, the Ghana Electronic Service Technicians Association has around 500 registered members in Accra alone and about 1,200 repairers across the country (Amoyaw-Osei et al.,

2011). Approximately, 800 are specialised in general repair (large and small household devices and consumer electronics) and 400 involved in ICT repair (Amoyaw-Osei et al., 2011, p. 51). A recent study by the UN on Nigeria and Ghana uncovered that both countries had a well-developed repair and refurbishing sector which thrive on used equipment from imports and domestic sources (UNEP, 2011). Indeed, in Accra (Ghana), for instance, the refurbishing sector generates income for more than 30,000 workers (UNEP, 2011). However, around 30% of imports of second-hand products into the country are useless (The Guardian, 2013). This means that a substantial part of the electronic goods are not usable but can provide parts for televisions, machines and radios. Table 2 provides a summary of some the EE often repaired.

Insert Table 2 about here

6.3 Aftermarket sources and afterlife

Aftermarket can be defined as "the period after the original manufacturer has phased a part out of production" (Bartels et al., 2012, p. 168). Aftermarket sources such as third party firms and repair businesses are actually thriving by disassembling some products and parts, and selling them. A large proportion of the e-waste is sold as second-hand computer components and some are recycled metals (The Guardian, 2013).

Another drive towards new product development has been to design products that suit the local needs. The used EEE is often absorbed by the processes of repairers leading to 'new' EEE. Although the used appliances can be repaired, many of the products have shorter lifespans. Many of the products considered obsolete in the developed world have had their lifespan extended by repairers. Many developing countries still lag behind advanced economies in some key areas,

thereby providing an avenue for new demand. The growth of the electronic repair business has helped to extend the lifecycle of many electronic products considered obsolete. Although old appliances may consume more energy, the gains in terms of ability to by-pass upfront costs may supersede the cost. Upfront cost has often become a barrier for many in the developing world to access the latest technology.

7 The detrimental effects

In this section, the analysis focuses on the health, social and economic impacts.

7.1 Social, health and environmental impacts

Over the last two decades, the large influx of e-waste to Ghana has been found to be harmful to some industries, water sources, etc. At the Agbogbloshie site in the country, some of the most common human health problems include dermatological, gastro-intestinal, respiratory and genetic systems, and other infectious diseases (Vidal, 2014). The people located close to the site have also been found to experience headaches, diarrhoea, chest pains, irritation of the skin, nose and eyes, typhoid and stomach ulcers (Asante et al., 2012; Vidal, 2014). The e-waste has also been found to increase the risk of land, air and water contamination with mercury, lead, arsenic and flame retardants (Hirsch, 2013). It also contains hazardous elements and toxic substances such as cadmium, lead, mercury, arsenic and flame retardants which impact the environment and human health (Asante et al., 2012; Vidal, 2013). The toxic materials have been found to seep out into the land and contaminate local sources of water (Vidal, 2013).

Rooted in this argument are suggestions that certain components of some electronic products entail hazardous substances which must be contained and dealt with in the most secure manner

(CALRECYCLE, 2015). The problem is exacerbated by the substances not being "safely sequestered" and then becoming hazardous for the environment (Mooallem, 2008). When some e-wastes are burned at low temperatures, "the brominated flame retardants used in circuit boards and casings create additional toxins, including halogenated dioxins and furans" (The Economist, 2014a, p. 9), which are linked to cancer and reproductive disorders.

An explanation for this is that the training and expertise required to handle e-waste are often lacking. Most of the recycling is carried out in the informal sector by untrained personnel and individuals. At Agbogbloshie and other parts of the country, some of the workers in informal recycling are youngsters between the ages of 5 and 18, and often use primitive tools or even their bare hands and a stone to extract metal aluminium and copper (Darko, 2010; Kuper and Hojsik, 2008). Some of the workers have been found to die of cancer in their prime, largely attributed to the toxic chemicals stemming from e-waste exposure (XYZ, 2014). At Agbogbloshie, workers "smash devices to get to the metals, especially copper … most workers die from cancer in their 20s" (The Guardian, 2011, p. nd).

7.2 Digital dumping

Many developing countries view e-waste as dumping (The Guardian, 2013). Dumping in this context broadly refers to the exporting of un-useable e-waste to the detriment of the recipient nations. Dumping of obsolete electronic goods has been found to be harmful to human health as many of the very poor rely on processing electronic waste as a source of income. In Ghana, waste treatment often occurs in the informal sector, thereby exposing untrained and unprotected workers to toxic chemicals. Indeed, up to 75% of second-hand electronics imported into the country are un-useable and end up in landfills (Darko, 2010). Indeed, stringent environmental

laws in many advanced economies and the high cost of recycling in Europe often mean that for global firms, it is relatively cheaper to export used goods to countries such as Ghana to be disposed of (The Guardian, 2013; Vidal, 2013). Although many countries in the developed world prohibit dumping, this does not apply to second-hand goods. A key source of unwanted waste stems from the activities of unscrupulous firms and agents. These agents can also mix useable and un-useable waste, thereby making it difficult to detect recyclable and non-recyclable equipment (Carney, 2006). Often such imported products are not tested for functionality, thereby providing an avenue for old and un-useable equipment to be exported to developing countries (Carney, 2006). In 2005, inspections of 18 European seaports uncovered that around 50% the e-waste destined for export to the developing countries was actually illegal and un-useable (The Economist, 2014a).

Although some used products can be reused or refurbished, a large proportion of the exports are rather un-useable (Vidal, 2013). Unscrupulous operators who engage in dumping have flourished in the absence of effective regulatory systems (Metcalfe, 2011). It is also noteworthy that across the country, the devices and tools used by informal recyclers to dismantle items are often primitive, thereby hampering workers' ability to contain the potential effects. Our analysis thus far demonstrates that if e-waste is properly regulated, positive externalities can emerge to help countries lift people out of poverty.

8 Discussion and implications

The paper sought to examine the effects of e-waste in emerging economies. Through a review and conceptualisation of the literature, the study identified three perspectives on the subject, i.e. the detrimental, positive and the unified view. It utilised a review of the Ghanaian experience to

shed light on the conceptualisation. Contrary to the popular belief that e-wastes sent from advanced economies to developing countries are generally detrimental, the paper uncovered some positive externalities of e-waste in sectors such as the second-hand market, aftermarket and the repair industry. In these sectors, the growth of e-waste has had positive effects and fostered indigenous innovation. However, the positive effects have been accompanied by some negative effects which stem largely from poor treatment of the waste, lack of effective government policy and lack of skilled professionals to handle such waste.

In a nutshell, the analysis demonstrates that e-waste can concurrently have both negative and positive effects on developing countries. The analysis suggests a need for a fundamental shift from the traditional notion that e-waste was detrimental for developing countries towards the unified perspective of the effects. The analysis lends support to the view that a unified perspective of e-waste effects provides a more complete picture of the subject. Taken together, it is safe to conclude that the unified perspective offer a much more robust explanation of the effects of e-waste in emerging economies.

From a theoretical standpoint, the article presented a unified framework which articulates the stages inherent in product life and afterlife cycles. This helps in illuminating our understanding of technological obsolescence. It also laid further groundwork of e-waste towards a more balanced perspective of the effect of used products. From a practical standpoint, there is a role for national governments in creating conditions to capture the positive effects of e-waste. Perhaps more importantly, there is a need to create a recycling infrastructure to help mitigate the negative effects whilst concurrently creating conditions for firms to capture the positive effects. Professional waste treatment companies with certification would help to provide employment

opportunities and mitigate the spread of the harmful substances. Our analysis also indicates that recipient countries need recipient firms (processor of e-waste) designated and certified to handle and treat e-waste. Another implication of the present findings is that there is a need for an effective regulatory framework and enforcement to help tackle illegal shipment of hazardous waste to help mitigate the negative effects of e-waste.

One limitation of the study is that it focused mainly on e-waste originating from developed countries. A useful line of inquiry is to examine effects of home-grown e-waste which appears to be a looming problem for developing countries. Although a number of studies have focused on e-waste (Prakash & Manhart, 2010; Lepawsky and McNabb, 2010), relatively unexplored is the period to which repaired equipment can function after they have been resold. This issue of "near-end-of-life" equipment is particularly important given that many of the equipment turn out to be a waste immediately after they have been repaired (UNEP, 2011). This issue warrants further scholarly works to help shed light on the process and final stage of technology obsolescence. A further possibility exists for future study to seek a larger sample from multiple countries.

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Figure 1: A unified stage model of e-waste flows

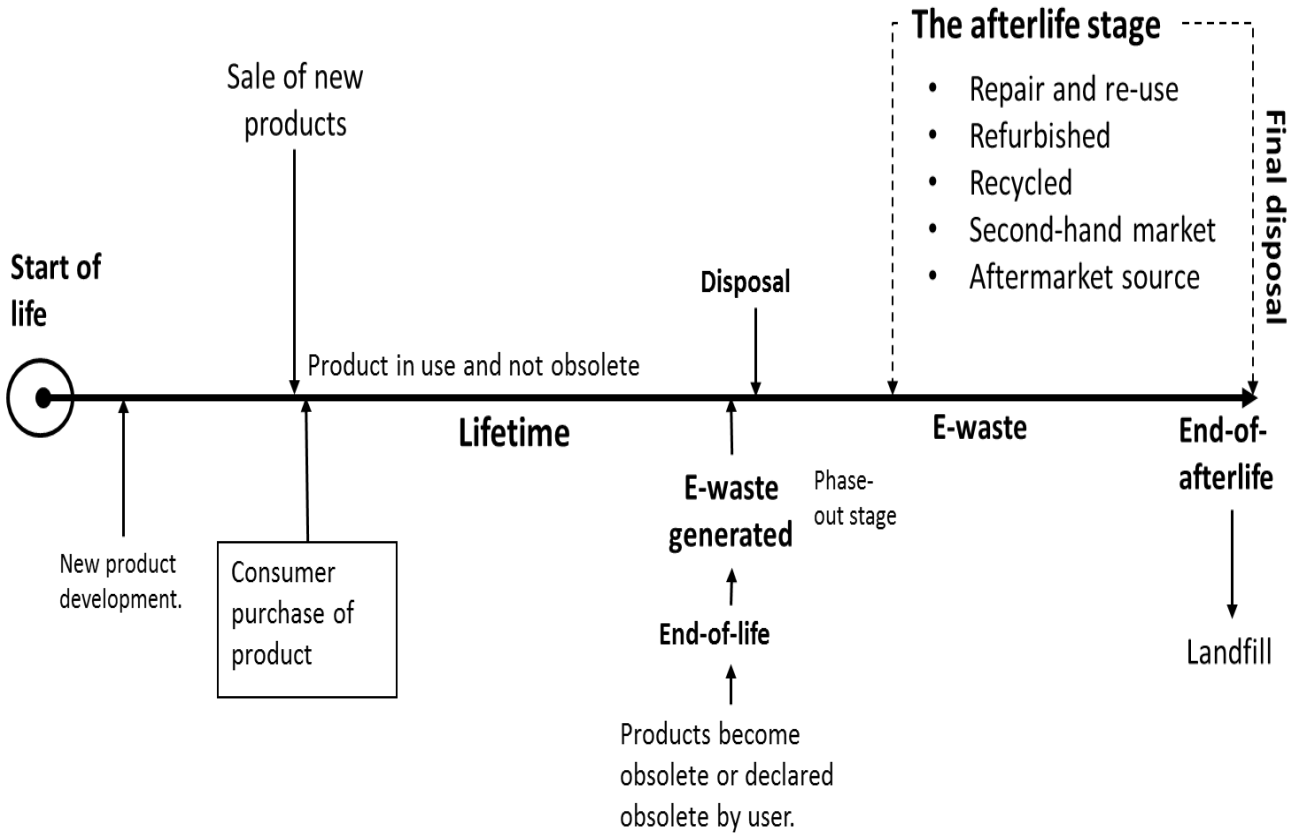

Figure 2: The integrated perspective of the effects

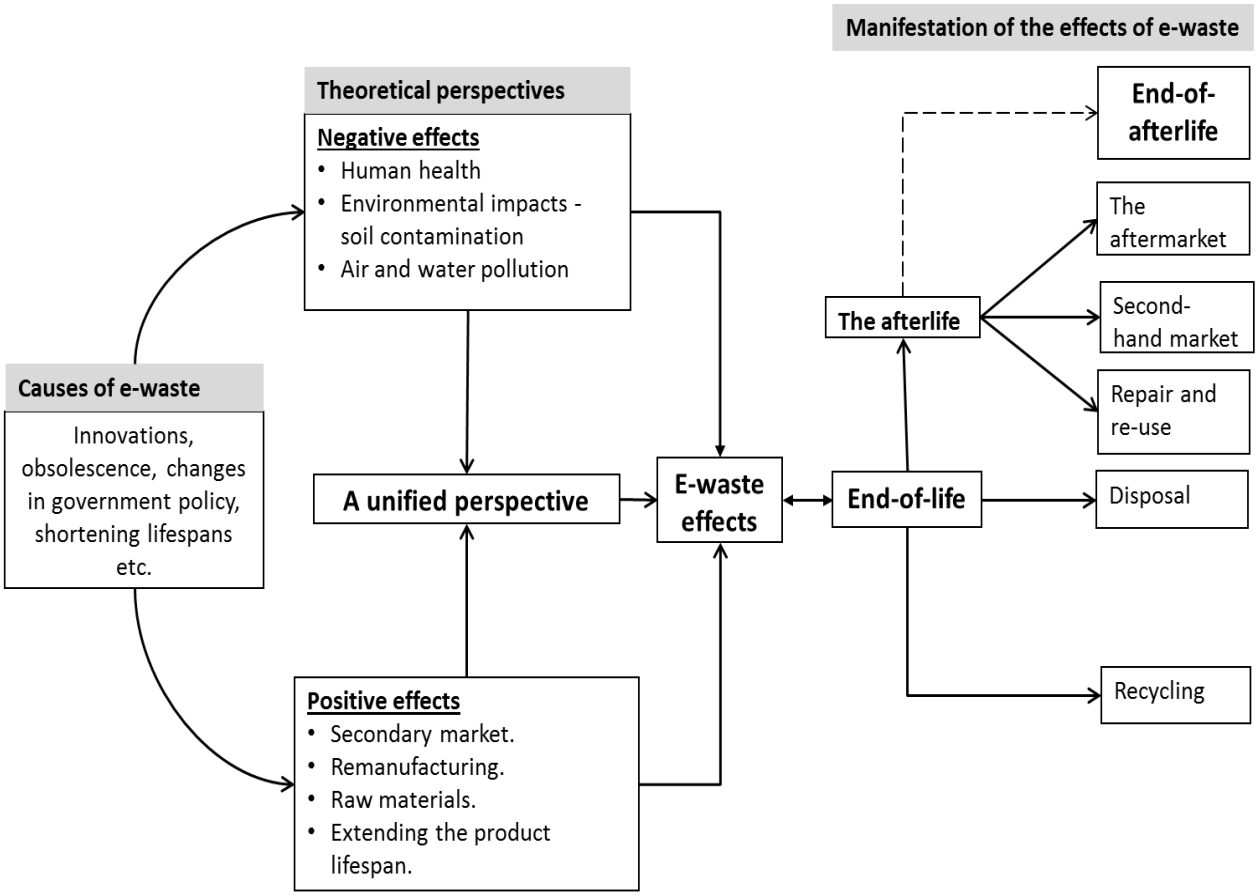

Table 1: The evolution of environmental policies in Ghana

Dates	Key events and government policy
1970s	• In 1974, the Environmental Protection Council was established to advise the government on environmental issues.
1980s	• In 1989, the Basel Convention treaty on the Control of the Trans-boundary Movement of Hazardous Waste and Their Disposal was adopted.
1990s	• In 1993, the Ministry of Environment, Science and Technology was established to help bring science and technology together in meeting social, environmental and economic challenges. • In 1994, the Environmental Protection Agency was founded with regulatory powers by the Environmental Protection Agency Act (Act 490). • The Environmental Assessment Regulations 1999, LI 1652 emerged.
2000s	• In 2000, the opposition were elected to power with protection for the environment and science development some of the pillars in their policy. • In 2000, the Ghana National Science and Technology Policy was introduced with the aim of achieving sustainable development. • New government came to power with renewed focus to reduce shipping of harmful waste to the country. • In 2011, the Environment Protection Agency (EPA) in tandem with Ports and Harbours Authorities, Customs, Excise and Preventive Service and the Ports Environmental Network Africa organised the first African national training workshop of the SBC e-waste Africa Project was held in the country.

Sources: Amoyaw-Osei et al., 2011; Amankwah-Amoah, 2016a, 2016b; Pwamang, 2013; Hens and Boon, 1999; Oteng-Ababio, 2010; UNEP, 2011, 2015; Loonstra & Rufener, 2011; Ministry of Local Government and Rural Development, 2010.

Table 2: Commonly repaired electrical and electronic equipment

Nature	Equipment
Medium-size appliances	Computers, electric cookers, televisions, washing machines, dishwashers, air conditioners, refrigerators, tumble dryers, sewing machines, microwave ovens, etc.
Small appliances	Mobile phones, MP3 players, irons, kettles, digital cameras, hair dryers, etc.

Data sources: synthesised from: Amoyaw-Osei et al., 2011; Baldé et al., 2015b.