Theorizing the Economics of E-Waste Trade: Issues, Analysis and Strategies

Master of Arts in Law and Diplomacy Thesis

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Abstract

To many a perceptive mind, the trade in E-Waste products should ideally be termed 'illegal' in view of the social hazards and moral shortcomings involved in exporting used, unreliable ICT equipment to developing countries, and consequently exposing marginalized workers to health hazards. But in the face of lax regulations imposed by E-Waste trading nations and only ad-hoc attempts made to curtail E-Waste trade, such is the magnitude of this unregulated waste flow, that it may actually be characterized in quantitative terms as 'free' trade, despite multilateral treaties which regulate trade in 'hazardous' products.

This thesis investigates through trade economics the assumption that the economic gains harvested by e-waste exchanging partners are welfare-enhancing enough that it becomes economically viable to condone the environmental and social costs borne by E-Waste receiving nations. In other words, this thesis explores whether E-Waste trade does in fact bring overall mutual economic gains to participating economies, thereby providing a logic behind lax regulation by governments.

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1] PROBLEM & POLICY RELEVANCE

The recent fast growth of the Information & Communications Technology (ICT) sector in developing countries is driven primarily by national initiatives (or reforms) to enhance competitiveness in the global information society, which has lowered the cost of ICTs with taxation reduced or eliminated altogether in many countries.[1] The increased importance attached to information technology in the world economy has brought about a surge in demand for electronic equipment. It is estimated that over 364 million personal computers were in use around the world in 1998, compared to 98 million in 1990, and today, there are more than 1 billion desktop and notebook computers in use globally, with this number projected to increase up to 2.25 billion by 2015[2].

At the same time, the rapid pace of innovation in computing technology shortens the useful life of electronic equipment with each successive generation. For example, in 1997, the average life span of a computer was four to six years[3], and currently most computer users in developed countries replace their computers (including the monitor) every three years[4]. This high rate of ICT equipment obsolescence due to technological change implies a need to dispose of large quantities of computers.

Expectedly, electrical and electronic waste (e-waste) is the fastest growing waste stream in the world, with an estimated 20-50 million tons being generated annually.[5] After three years of use, the operating system is outdated, the comprehensive coverage is over and there is higher risk of the hard disk crashing. Used computers that have an outdated architecture can only be disposed off by selling (at

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[1] See Waema, Timothy *E-Waste Management in Kenya,* KICT ANet, 2008, Page 7
[2] See http://www.climatesaverscomputing.org/
[3] See http://www.sciencedirect.com
[4] http://creativebusinessstrategy.blogspot.com/2005/11/big-apple-importing-used-computer.html
[5] See http://www.unep.org

extremely low prices) or 'dumping' them in developing country markets where the demand for such computers still exists.[6]

A primary concern in managing this large quantity of obsolete electronics is that the hazardous materials they contain—lead, mercury and cadmium and other heavy metals—can be released into the environment during disposal with potentially adverse effects on human health. E-waste products potentially contain over 1000 different toxic substances[7] which are extremely hazardous to the environment and human health. Common health effects related to e-waste exposure include: cancer; nervous and reproductive system disorders; irreversible kidney and brain damage[8].

The process of recycling e-equipment is labor intensive[9], and developing countries being labor–abundant thus possess a comparative advantage in processing e-waste vis-à-vis developed economies. Expectedly, the export of e-waste products (also known as **'E-Waste Trade'**) from the developed world to developing countries (in particular China, India, and sub-Saharan Africa), has become a vast and growing business, as municipalities in capital-abundant, developed economies try to evade high e-waste processing charges associated with expensive labor costs and compliance with environmental laws (in other words, e-waste tax) that require e-waste be disposed responsibly[10]. As a result, hundreds of thousands of marginalized, unaware workers (especially women and children) in e-waste receiving countries, involved in informal e-waste scavenging and crude recycling activities, are exposed to e-waste toxins on a daily basis, which puts at serious risk their, as well as their communities', well-being.

On the other hand, developing countries accrue economic gains from accepting the E-waste by virtue of: recovering valuable materials from disposed PCs; putting into productive use working-order equipment; and at times, receiving payments from developed nations for accepting E-waste goods.

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[6] See *TakeBack Blues: An assessment of E-Waste Takeback in India*, Greenpeace, 2008
[7] http://www.isa.org/InTechTemplate.cfm
[8] http://www.bsu.edu/web/itedu510/HealthEffects.htm
[9] See http://blog.mlive.com/green-blawg/2009/07/afterlife_for_electronic_waste.html
[10] http://www.nytimes.com/2009/09/27/science/earth/27waste.html

This thesis is an attempt to explore through a trade-economics perspective whether it is safe to assume that the economic gains harvested by both e-waste trading partners are welfare-enhancing enough that it becomes economically viable to condone the environmental and social costs borne by e-waste receiving nations. In other words, does this underground trade, in spite of all its associated evils, in fact bring overall mutual economic gains to both trading economies, thereby providing a logic behind lax regulation by authorities to e-waste trade? If not, then this paper shall analyze (in terms of trade economics) potential solutions to maximize gains for both partners, to 'neutralize (some) toxicity'.

2] THE BASEL CONVENTION

In the late 1980s, a tightening of environmental regulations in industrialized countries led to a dramatic rise in the cost of hazardous waste disposal. Searching for cheaper ways to dispose the wastes, shipping hazardous waste to developing countries became common practice. Since developing economies in Africa and Asia lacked sound physical and legal infrastructure to effectively implement frameworks for hazardous waste management, international outrage led to the drafting of the 1989 "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal", negotiated under the United Nations Environment Program (UNEP). It entered into force on May 5, 1992 and currently has 168 Parties to the Convention.[11]

This multilateral environmental agreement regulates the import and export of hazardous waste among the Parties to it, and establishes legal obligations to ensure that such wastes are managed in an environmentally sound manner.[12] The Convention aims to minimize the generation of hazardous wastes in terms of quantity and hazardousness, to dispose of wastes as close as possible to the source of generation, and to reduce the movement of hazardous wastes to less developed countries (LDCs).[13].

[11] See http://escrapindiana.org/exportconcerns/baselconvention.html Accessed February 14, 2010.
[12] See *Basel Convention Background International Waste Activities*, U.S. Environmental Protection Agency, Basel Convention Website, http://www.epa.gov/osw/internat/basel.htm
[13] See http://www.ban.org/main/about_BAN.html Accessed January 23, 2010.

Parties to the Basel Convention must comply with basic notification and consent procedures and a requirement that each year they report, via a questionnaire, information on the generation and movement of hazardous wastes.[14] In addition, before an export of Basel-regulated hazardous waste can take place, the Parties to the movement must ensure that the waste will be managed in an environmentally sound manner in the country of import. Each transboundary shipment of hazardous waste or other waste must have a movement document along with it from the point its transit begins until its point of disposal. Under the Convention, waste shipments made without such documentation are illegal.[15]

Hazardous wastes span multiple categories such as toxic, poisonous, explosive, corrosive, flammable, ecotoxic, and infectious to include anything from pathological waste to wastes from dyes/paints.[16] However, the Convention is not exact on what kind of e-waste is considered hazardous. Basel parties thereby interpret their Convention obligations using their domestic laws. As a result, different nations have different views on which e-waste materials are hazardous under the Convention.

The United States signed the Convention in 1990 and the U.S. Senate provided its advice and consent to ratification in 1992. However, the Convention has not yet been ratified by the U.S. Government, as domestic legislation must be enacted that would provide statutory authority to implement all of the Convention's requirements. The United States participates in the meetings of the Convention Parties, but as a non-Party is not allowed to vote.[17] To check the legal status on the U.S. side of E-waste exports, domestically the only relevant legislation is the cathode ray tube (CRT) rule associated with the Resource

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[14] See *Basel Basics: An Overview,* Secretariat of the Basel Convention website, http://www.basel.int/pub/basics.html.
[15] Ibid
[16] See Daly, Laureen *Recycling Technology Products: An Overview of E-Waste Policy Issues*, US Dept of Commerce, July 2006, Pp 62 – 63.
[17] See U.S. Environmental Protection Agency, *International Waste Activities,* Basel Convention Website, http://www.epa.gov/epaoswer/osw/internat/basel.htm

Conservation and Recovery Act[18]. As long as exporters in the U.S. file a notification with the U.S. Environmental Protection Agency, CRT monitors can be exported for reuse.

But despite the restrictions imposed by the Basel Convention on the trade in hazardous waste, increased trade in recyclable materials has led to an increase in the market for used products such as disposed computers. E-waste traders justify the export of used-PCs to developing countries as a means of moving waste to recycling destinations, consequently exposing marginalized workers to health hazards.

3] OVERVIEW OF LEGAL / PHYSICAL FRAMEWORKS IN DEVELOPING COUNTRIES

All E-waste importing nations are signatories to the Basel Convention. But each nation has individual domestic policies regulating the import of prohibited hazardous waste, and notably, used computers and parts are not included in their list of such articles. In general, there exists flexibility in the definition of products intended for reuse as input in the productive activity of the country, essentially exempting E-waste products from requiring prior notification under the Basel Convention.

3.1 China

Since the 1990s, the Chinese government has been strengthening legislation on natural resource protection and solid waste protection. E-Waste is regulated by the 1996 Act on 'Waste Imports for Environmental Protection and Management'. Article Three of China's Solid Waste law governs the import of hazardous waste as raw material, Article Four governs the management and disposal of hazardous waste, and Article Five sets forth the fines to be levied and the authority to conduct investigation for possible criminal violations. Yet, much of the energy regarding environmental concern dissipates as it diffuses through the multilayered state structure.[19]

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[18] See Kahhat, Ramzy & Williams, Eric, *Product or Waste? Importation and End-of-Life Processing of Computers in Peru,* Arizona State University (2009)

[19] http://ewasteguide.info/the_political_framework_in_china_impacts_on_the_e_waste_recycling_system

3.2 India

The guidelines for Environmentally Sound Management of E-waste were approved only in March 2008, by the Indian Ministry of Environment and Forests. These guidelines emphasize enhanced manufacturer responsibility regarding obsolete PC take-back; incorporation of best practices in E-waste recycling; and listing E-waste as a hazardous substance requiring prior notification for import.[20] Until the guidelines were approved, no specific law regulated E-waste recycling. However, enforcement of these guidelines has not yet taken place.

3.3 Sub-Saharan Africa

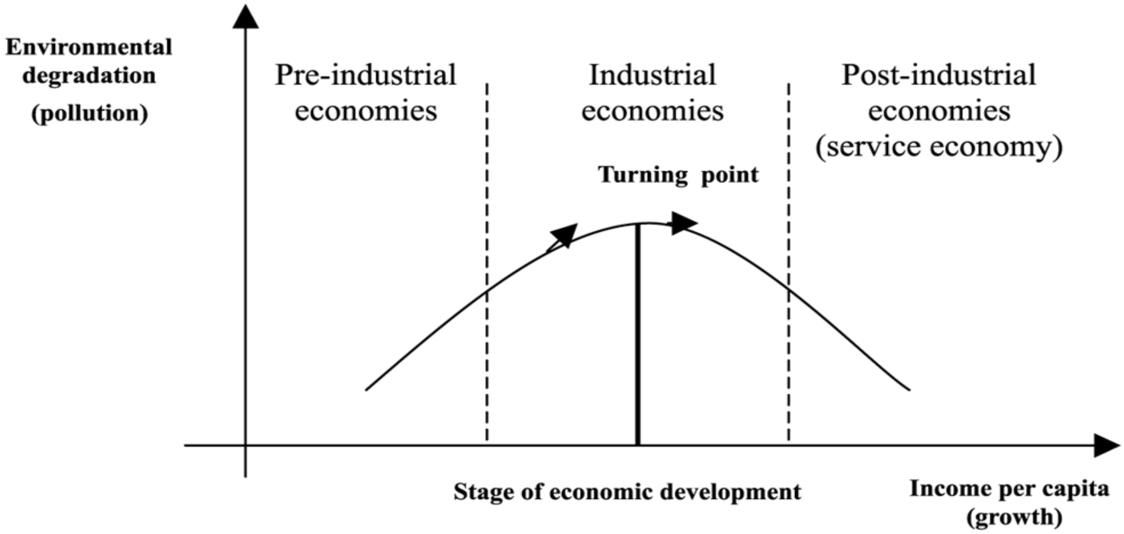
In sub-Saharan African countries, there exists legislation to ensure that importation of waste remains unauthorized unless there exists proper recycling or reuse facilities which avoid negative impacts to human and environmental health. But basic physical facilities necessary for recycling E-waste in this region is currently largely inadequate. To assess the current level of infrastructural preparedness in sub-saharan Africa towards adequately processing E-waste, the situation is summarized as follows[21]:

Material fraction	**Formal Recycling/disposal facilities in sub-Saharan Africa?**	**Possible downstream Partners**	**Comments**
Plastic	Partially	Plastic Recycling Industries	1: Needs investments for upgrading the local recyclers. 2: Selling the fraction generates income

[20] See Mehta, Vinnie *Environmentally Sound Management of E-Waste in India*, WEF 2008 presentation.
[21] See *E-Waste Assessment in Uganda,* .Final Report (2008), UNIDO

Ferrous metals	Yes	Steel mills	Selling the fraction generates income
Aluminum	Yes	Aluminum Industries	Selling the fraction generates income
Copper	Partially	Copper Smelters	1: Cable dismantling technique unclear (possibility that cables are burned for copper recovery) 2: Selling the fraction generates income 3: Exporting bears the danger of stimulating copper robbery
Printed wiring boards (PWB containing precious metals)	No	None available in sub-Saharan Africa	Although PWB need to be transported to the next harbor, it is expected that the sale of these fraction to a global refinery can generate income
CRT tubes (containing lead, beryllium, phosphor, etc.)	No	Needs a hazardous waste treatment facility which is not available in the region	Metal smelters might be able to use CRT glass partially as a substitute for sand as a fluxing material. However the environmental impacts of such a solution would have to be evaluated carefully.
Hazardous fraction (PCB in capacitors, mercury in backlights, batteries)	No	Needs a hazardous waste treatment facility (special incineration or controlled landfill) which is not available in sub-Saharan Africa	Needs either investment into a local hazardous waste treatment facility or needs to be exported to specialized facilities abroad (e.g. to Europe)

4] ENVIRONMENTAL KUZNETS CURVE & E-WASTE EXPORTS



The Environmental Kuznets Curve (EKC) hypothesizes that the relationship between per capita income and the use of natural resources and/or the emission of wastes has an inverted U-shape. According to this specification, at relatively low levels of income the use of natural resources and/or the emission of wastes increase with income. Beyond some turning point, the use of the natural resources and/or the emission of wastes decline with income. Reasons for this inverted U-shaped relationship are hypothesized to include income-driven changes in: (1) the composition of production and/or consumption; (2) the preference for environmental quality; and/or (3) increasing returns to scale associated with pollution abatement. However, the income-environment relationship captured by simple regression exercises cannot distinguish between the demand side and supply side forces that drive this relation. Grossman and Kreuger provide an intuitive explanation of these influences, as outlined below.[22]

[22] See Grossman, Gene M., and Alan B. Krueger *Environmental Impacts of a North American Free Trade Agreement*. National Bureau of Economic Research (NBER) Working Paper No. 3914. Cambridge, MA, 1991

The Scale of the Economic Activity: A larger scale of economic activity per unit of area, all else being equal, results in increased levels of resource use and waste generation. Here, income acts as an indicator of economic activity, encouraging a positive relation between environmental degradation and income.

The Composition of the Economic Activity: Different sectors of the economy have different pollution and resource use intensities. Industry, especially manufacturing, tends to be more pollution intensive than either agriculture or services. The share of industry in a nation's gross domestic product (GDP) first rises with economic growth and then declines as the country moves from the preindustrial to the postindustrial stage of development. This influence encourages an inverted U-shaped relationship between environmental pollution and income level.

The Technique Effect: At low income levels, people are more concerned with their basic material needs and less concerned with environmental quality. At higher income levels, people begin to demand higher levels of environmental quality to go with their increased prosperity. On the supply side, low incomes mean that countries and individuals cannot afford much expenditure on pollution abatement, even if the demand were there. Economic growth not only creates the demand for improved environmental quality, it also makes resources available to supply it, resulting in cleaner technologies. Stripped of the scale and composition effects, the technique effect predicts that environmental degradation would decline as per capita income increases.

4.1 EKC and E-Waste Management

The sum of all effects described above defines the observed income-environment relationship. We can extrapolate the concept of EKC to the trend of E-Waste exports from developed to developing countries. It may be assumed that higher-income countries are sensitive to the need of 'recycling' used / obsolete computing products - which leads them to export such products to developing countries in the pursuit of cost-effectively recycling E-Waste. On the other hand, lower income levels associated with developing countries leads them to import E-Waste from developed countries, as the economic benefits may be perceived as exceeding the environmental impact of toxic waste on human health in the poorer countries.

It may be concluded that such environmental economics constitutes the background for E-Waste trade to thrive.

5] METHODOLOGY

For purposes of convenient analysis, the trading parties are divided into 2 players – the United States which is the prime exporter of E-Waste, and the 'Developing Nations'(such as China, India, Kenya, etc) which are the prime destinations for E-Waste products.

The hypothesis will be considered by conducting a 'cost-benefit' analysis by taking into account the magnitudes of ICT equipment traded, the impact on local economies, in particular the economic value of e-waste processing jobs 'ousourced', and socio - environment costs.

Assumptions:

i. Selling price of used ICT equipment is small, so unaccounted.

ii. Transport costs are not factored into calculations.

iii. For initial analysis, all exported PCs are 'junk', solely sent abroad for recycling purposes.

iv. Assuming productivity levels to be similar across all developing countries, labor wages remain the same for each country.

v. Governments have no control over labor expenditures for E-Waste processing, as labor wages are determined by market forces.

Calculations:

i. The volume of E-Waste (in per unit terms) exported annually by the US.

ii. The value of Materials (in terms of PC unit exports) transferred to developing countries.

iii. The economic expenses associated with e-waste processing in developed and developing nations, in terms of payments to workers.

iv. The economic costs of socio-environmental damage

vi. Perform 'Cost-Benefit' analysis to conclude net economic benefits / loss resulting from E-Waste trade.

Conclusion:

i. Which government actions (tariffs/tax/subsidy, etc) could maximize gains from 'free trade'?

ii. Can e-waste product itself be processed, to maximize free-trade gain?

6] DATA & ANALYSIS

A] Comparative advantage of developing countries in E-Waste processing

The recycling of electronic components is an extremely labor intensive process[23] and developing countries are labor–abundant, rendering them with a comparative advantage in processing e-waste products with respect to the United States. Hence, it is natural for e-waste exports to flow from the US to developing economies in view of pressure to export these items to cheap labor cost destinations. In addition to cheap labor, there is little in the way of environmental regulation or worker health laws to protect the workers who actually attempt to extract valuable portions from used electronics.[24] As a result, it costs approx. $20 to recycle a PC in the U.S (and other developed countries)[25], while it costs $2 in India

[23] See http://blog.mlive.com/green-blawg/2009/07/afterlife_for_electronic_waste.html
[24] See http://www.hindu.com/2009/07/27/stories/2009072759450300.htm
[25] From Assumption iii

(and other developing countries)[26] due to factors such as prevailing low wages and lack of norms or safeguards for the unorganized sector in developing countries.

B] Total Volume of E-Waste Generated and Exported

According to UNEP projections, an estimated 20-50 million tons of E-Waste is being generated annually. But this figure includes E-Waste being produced by both developed and developing countries. For our purposes, we shall consider E-Waste generated and subsequently exported by the United States.

The National Safety Council estimates that more than 63 million computers (desktops + monitors) were disposed of in the United States in 2005, generating about 2.63 million tons of electronic waste, according to the Environmental Protection Agency.[27] Local municipalities in the US struggle to find a solution to the nearly 3 million tons of used computers and televisions discarded each year, and anticipate a further four-fold growth in e-waste in the coming years.[28]

Large amounts of e-waste are sent to countries such as China, India and Kenya, where lower environmental standards and working conditions make processing e-waste more profitable. Around 80 % of the e-waste in the U.S. is exported to developing countries for processing.[29] In this regard, we can predict that the US exported nearly 50 million used computers, or 2 million tons of e-waste in 2005.

C] Value of Materials Imported

In 2007, the average worth of valuable materials (such as metals, plastics) in a desktop computer (with monitor) was USD 20 [30] (Note that in practice recycling processes do not recover 100% of recyclable materials contained, in particular plastics).

This means that, taking into account 2007 prices of valuable metals, the United States exports about USD 1 billion (50 million computers x USD 20) worth of computer E-Waste materials to

[26] From Assumption iv
[27] See http://www.eaglevalleyalliance.org/e-waste-recycling
[28] See California Department of Toxic Control website: http://www.dtsc.ca.gov/
[29] See http://www.eaglevalleyalliance.org/e-waste-recycling
[30] Kahat, Williams *Product or Waste? Importation and End-of-Life Processing of Computers in Peru*,, 2008, Pg 4

developing countries. Assuming metals and plastics to be freely tradable commodities, the value of this trade remains constant internationally.

D] Processing / Labor Expenses in the United States

The average cost of recycling a computer in the United States is approximately USD 20 [31]. If E-Waste processing were to take place at home, the US must pay its workers nearly USD 1 Billion (50 million computers x USD 20) to recycle its' computers. This amount represents the opportunity cost of recycling discarded PCs at home.

E] Processing / Labor expenses in Developing Countries

The average cost of recycling a computer in a developing country is approximately USD 2 [32]. This implies that, the combined economy of e-waste receiving developing countries must pay nearly USD 100 million to their workers on account of importing 50 million units of E-Waste from the United States. In other words, the opportunity cost borne by developing economies to recycle such imported PCs is USD 100 million.

F] Socio-Environmental Costs

In terms of the direct costs and environmental effects associated with E-Waste handling, there exists a high degree of uncertainty surrounding much of the available data on quantities of electronics, disposal costs, and environmental effects. This paper makes use of data provided by industry surveys to estimate the environmental costs of E-Waste, and largely focuses on the effect of lead releases on health damages from incineration of cathode ray tubes (CRTs) in computer monitors—one of the largest components of the electronics waste stream.

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[31] Refer Page 5, 'Comparative Advantage'
[32] Refer Page 5, 'Comparative Advantage'

F.1] Socio-Environmental Costs: US

Base case analysis predicts that if E-Waste handling were to take place in the United States, the total cost of handling monitor waste is about $13.5 million and the associated total health damages are about $2.7 million[33], which brings total associated costs to $16.2 million. (Note: These costs are exclusive of US labor costs stated in D]: USD 20 per used PC).

F.2] Socio-Environmental Costs: Developing Countries

For developing countries, the environmental costs associated with E-Waste imports is less clear. For a quick analysis, since the total population of e-waste receiving developing countries exceeds that of the US by a factor of 10, total associated costs in developing countries is estimated to be $162 million[34] (as 10 times more people are exposed to E-Waste hazard). Adjusting this value for PPP, these costs are estimated at: $162 million / 1.50[35] [36] = $108 million.

G] Cost-Benefit Calculations

If 'Gain $_{\text{E-Waste}}$' indicates a country's net gains from E-Waste trade, and 'Loss $_{\text{E-Waste}}$' indicates the country's net losses associated with indulgence in such trade, then the net effect of E-Waste trade on a country's economy could be calculated as follows:

$$\Delta \text{Net Income}_{\text{E-Waste}} = \text{Gain}_{\text{E-Waste}} - \text{Loss}_{\text{E-Waste}}$$

G.1] Cost-Benefit Calculation for the US

Gains: The US economy gains through: the revenues generated by the sale of E-Waste articles (for initial analysis we assume this value to be 0); the savings attributed to 'outsourcing' E-Waste processing tasks to

[33] See Journal of Environmental Management *Dealing with E-Waste: Modeling the costs of computer monitor disposal* Volume 68, Issue 1, May 2003, Pages 13-22
[34] It is later revealed that the accuracy of this figure is not of prime concern.
[35] The mean devaluation rate of the Indian Rupee, Chinese Yuan & Nigerian Naira w.r.t USD is approx. 50%.
[36] See Feenstra, Robert *International Macroeconomics* Worth Publishers (2008), Pg 81

developing countries; and savings realized through diverting socio-environmental costs (associated with E-Waste exposure) to importing nations.

This can be expressed as:

$\text{Gain}_{\text{E-Waste (US)}} = \text{Revenues}_{\text{E-Waste Sale (US)}} + \text{Savings}_{\text{Processing Cost (US)}} + \text{Savings}_{\text{Socio-Economic Cost (US)}}$

$= 0 + \$ 1 \text{ Billion} + \$ 16.2 \text{ million}$

$= \$ 1.0162 \text{ Billion}$

Losses: The E-Waste trade leads to the 'transfer' of valuable E-Waste materials from the US to developing countries. This loss incurred by the US may be expressed as:

$\text{Loss}_{\text{E-Waste (US)}} = \text{Transfer}_{\text{Materials}}$

$= \$ 1 \text{ Billion}$[37]

⇒ $\Delta\text{Net Income}_{\text{E-Waste (US)}} = \$ 1.0162 \text{ Billion} - \$ 1 \text{ Billion}$

$= \$ 16.2 \text{ million}$[38]

G.2] Cost-Benefit Calculation for Developing Countries

Gains: Not taking into consideration growth effects associated with enhanced ICT penetration levels, Developing economies gain from the acceptance of valuable materials transferred from the US, and this may be expressed as:

$\text{Gain}_{\text{E-Waste (Dev)}} = \text{Transfer}_{\text{Materials}} = \$ 1 \text{ Billion}$

Losses: Developing economies lose through: E-Waste purchase payments to the US (for initial analysis we assume this value to be 0); costs associated with E-Waste processing expenditures; and socio-environmental costs on account of E-Waste exposure.

[37] Refer Section C: Value of Materials Transferred, Pg 8
[38] Note: This amount is equivalent to $\text{Savings}_{\text{Socio-Economic Cost (US)}}$

This loss incurred by Developing economies may be expressed as:

$\text{Loss}_{\text{E-Waste (Dev)}} = \text{Expense}_{\text{E-Waste Purchase}} + \text{Expense}_{\text{Processing Cost (Dev)}} + \text{Expense}_{\text{Socio-Economic Cost (Dev)}}$

= 0 + \$ 100 million + \$108 million

= \$ 208 million

⟹ $\Delta\text{Net Income}_{\text{E-Waste (Dev)}}$ = \$ 1 Billion - \$ 208 million

= \$ 792 million

Final Results:

Annual ΔNet Income $_{\text{E-Waste (US)}}$ = \$ 16.2 million

Annual ΔNet Income $_{\text{E-Waste (Dev)}}$ = \$ 792 million

G.3] Sensitivity Analysis

1: Varying E-Waste Disposal Price per PC (in \$Million), keeping constant Expense $_{\text{Socio-Economic Cost (Dev)}}$

E-Waste Disposal Price / PC	Expense $_{\text{E-Waste Purchase}}$	Expense $_{\text{Processing Cost (Dev)}}$	Expense $_{\text{Socio-Economic Cost (Dev)}}$	ΔNet Income $_{\text{E-Waste (Dev)}}$
Free	0	100	108	792
\$2 / PC	100	100	108	692
\$3 / PC	150	100	108	642
\$4 / PC	200	100	108	592
\$5 / PC	250	100	108	542
\$6 / PC	300	100	108	492
\$7 / PC	350	100	108	442
\$8 / PC	400	100	108	392
\$9 / PC	450	100	108	342
\$10 / PC	500	100	108	292
\$11 / PC	550	100	108	242
\$12 / PC	600	100	108	192
\$13 / PC	650	100	108	142
\$14 / PC	700	100	108	92
\$15 / PC	750	100	108	42
\$16 / PC	800	100	108	-8
\$17 / PC	850	100	108	-58

Analysis: If the US levies a price for its E-Waste, this trade remains profitable for developing countries as long as the E-Waste purchase price remains below \$16 per disposed computer[39] or \$396 per ton[40].

[39] From Section B, the US exports 50 million disposed PC units. So \$ 792 million / 50 million = \$ 16 / PC (approx).
[40] From Section B, the US exports 2 million tons of E-Waste. So \$ 792 million / 2 million = \$ 396 / ton

2: Varying Expense $_{\text{Socio-Economic Cost (Dev)}}$ in $Million , keeping constant E-Waste Disposal Price per PC

E-Waste Disposal Price / PC	Expense $_{\text{E-Waste Purchase}}$	Expense $_{\text{Processing Cost (Dev)}}$	Expense $_{\text{Socio-Economic Cost (Dev)}}$	ΔNet Income $_{\text{E-Waste (Dev)}}$
	500	100	50	350
	500	100	100	300
	500	100	150	250
	500	100	200	200
$10 / PC	500	100	250	150
	500	100	300	100
	500	100	350	50
	500	100	400	0
	500	100	450	-50

Analysis: Assuming that the US levies a price of $10 / PC for its E-Waste, this trade remains profitable for developing countries as long as Socio-economic costs inflicted by E-Waste fall below $400 million.

7] FINDINGS

The literature on E-Waste has been rich in yielding a variety of facts and figures on the magnitude and dangers of E-Waste trade. Since such trade in disposed electronic products is associated with environmental and social hazards, international law (such as the Basel Convention on Hazardous materials) attempts to regulate it. But little is known to explain the incentives for nations to only loosely regulate such trade.

The analysis carried out in this paper offers a first-hand trade-economics perspective to explain the prevailing phenomenon of (mostly illegal) e-waste trade. It is seen that:

1: The E-Waste trade has evolved on account of the high, net positive income gains bestowed to both trading parties. This indicates the motive behind permitting this ‘illegal’ trade to remain in the ‘core’ through loose bilateral regulations.

2: From the US perspective, savings associated with the avoidance of socio-environmental costs provide the prime incentive to indulge in E-waste trade.

3: From the Developing Economy perspective, greater profitability is realized from lower purchase price of E-Waste articles, and lower socio-environmental costs. This analysis justifies the following recent trends:

⇨ Tariff levels on importation of all ICT items (including E-Waste) from the developed world are approaching zero.[41]

⇨ Developing economies are seeking ways to mitigate health and environmental hazards / costs associated with E-Waste processing.[42]

8] GROWTH EFFECT OF ICT

The impact of E-Waste trade on economies of importing countries need not be limited to gains associated with the above cost-benefit calculations. It has been proven beyond doubt that ICT penetration has a salient positive impact on the aggregate production efficiency of countries. But depending on geographical location, the effects of ICT dissemination are different.[43] Empirical findings suggest that increasing the per capita ICT capital in the form of land line and mobile telephones, computers, Internet access and the like is likely to increase productive efficiency considerably in case of the developing nations, while in the more developed countries such gains have been largely exhausted.

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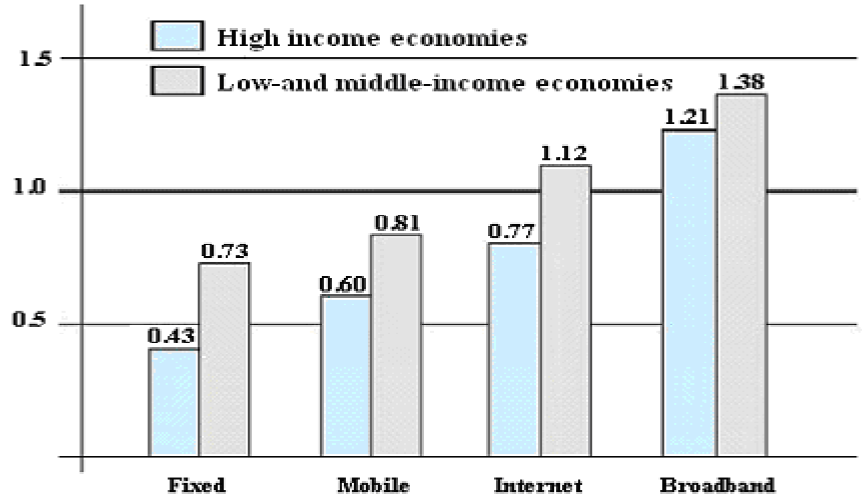
[41] See http://www.e-to-china.com/tariff_changes/global_tariff_changes/2009/1027/63060.html

[42] See *E-Waste Assessment in Uganda*, .Final Report (2008), UNIDO

[43] See Repkine, Alexandre *ICT Penetration and Aggregate Production Efficiency: Empirical Evidence for a Cross-Section of Fifty Countries,* MPRA (2008), Pg 8.



Percentage point increase in GDP per capita for every ten percentage point increase in ICT penetration, 1980-2006 [44].

So if the millions of tons of imported E-Waste products can be responsibly refurbished to put them into good effective use, empirical evidence (as shown in the graph above) suggests that every 10 percentage point increase in ICT penetration leads to a 1.12 percentage point enhancement in GDP levels for developing countries.

9] A COMPARATIVE WASTE MANAGEMENT MODEL

To many a perceptive individual, it may seem that in view of the physiological effects of E-Waste exposure on human and ecological well-being, obsolete e-waste equipment should ideally be treated at the home country with responsible reuse and recycling solutions. However, as discussed in Section 1, labor abundant developing countries possess a comparative advantage in recycling e-waste products, and can perform this more cost effectively vis-à-vis developed countries (as discussed in Section 6.A). Also, note that the trade in E-waste bestows significant net economic gains (as observed in Section 6.G) on both trading partners, in particular for the developing country.

So is reform in E-Waste trade policy necessary to guarantee the preservation of both economic as well as environmental prosperity in e-waste receiving developing countries? Several studies show that a

[44] See http://www.ictregulationtoolkit.org/en/Section.2659.html

range of policy instruments can achieve a socially optimal amount of waste disposal and recycling. To advise concerned policy-makers, a waste management model based on combined output tax and recycling subsidy, i.e., a "Design for Environment" model [45] is researched, and its applicability in E-waste management is analyzed.

A] Exploring the 'Design For Environment' Model on Waste and Recycling

Assumptions:

1] For local communities, the paramount waste-management goals are:

i. Waste needs to be managed properly without the high social costs of litter and illegal disposal;

ii. Legally disposed waste should be reduced to a level that accounts for its own social costs;

iii. Hazardous or toxic wastes need to be disposed separately, not directly thrown in the landfill.

2] A 'Pigouvian' tax, i.e., a charge a tax or fee per pound of trash exactly equal to the social damages imposed by that trash, would reduce waste in landfills.

Findings:

In the US and elsewhere, some communities levy a Pigouvian tax for each can or bag of trash, under a system commonly called "Pay as You Throw" (PAYT). Results suggest that PAYT towns have experienced reductions in garbage collection.[46]

However, the big question for PAYT communities is what households are doing with the garbage they no longer place at the curb (due to higher associated PAYT expenses). To avoid paying the fee, households often reduce their waste by recycling. But while recycling does increase with PAYT, its volume is not enough to account for all of the reduction in disposed waste, especially related to hazardous items like E-waste.

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[45] See Calcott, Paul *Waste, Recycling, and "Design for Environment": Roles for Markets and Policy Instruments*, Resources for the Future (2002), Pp 1 – 30.

[46] See Fullerton & Walls, *Trash Talk*, RFF Weekly Policy Commentary (2007), Pp 1 - 2

Such hazardous waste products are often candidates for a deposit refund system (DRS). Experience has shown great success with a DRS applied to certain products: beverage containers in "bottle bill" states have recycling rates that range from 60-95 percent, significantly higher than in states without such a program.[47]

Thus the "best" policy in this case is to establish a two-part instrument - a general Pigouvian tax on disposed items, plus a subsidy (DRS) for recycling hazardous waste. These policies provide the proper incentives to consumers and recyclers to generate a socially desirable outcome.

B] Application to E-Waste Trade Model

From the E-waste importing country's perspective, there is a benefit and a cost associated with each unit of E-waste. So to ascertain whether a Pigouvian tax ought to be levied on the E-Waste exporter, it needs to be determined whether the optimal trade criterion for the E-waste importing country holds true.

In other words, from the perspective of the developing country, we need to analyze whether:

I: Marginal Social Benefit = Marginal Social Cost ➔ Optimal Trade

II: Marginal Social Benefit < Marginal Social Cost ➔ Excess Trade: Levy Tax

III: Marginal Social Benefit > Marginal Social Cost ➔ Deficient Trade: Levy Subsidy

Assumptions:

i. Marginal Social Benefits are constant, as price paid per discarded computer remains constant.

ii. Marginal Social Cost increases with each discarded computer received , as every additional E-waste unit renders clean-up more difficult.

iii. Marginal Social Cost related to importing E-waste products remains constant, and is equivalent to $ 12 / computer.

[47] See Fullerton, Don,*Garbage Has Costs, So You Ought To Pay*, Accessed at http://businesspublicpolicy.com/?p=90

iv. Marginal Social Cost related to processing E-waste / labor expenses remains constant, and is equivalent to $ 2 / computer (from Section 6.E).

iv. Potentially productive uses of ICT (Growth Effects) are ignored.

Calculations:

1] From Section 5.B, we have:

Total Volume of E-Waste Exported = 50 million units

2] From Section 5.G.2, we have:

$$Gain_{\text{E-Waste (Dev)}} = \$ 1 \text{ billion}$$

Considering that: Social Benefit $_{(Dev)}$ = Gain $_{\text{E-Waste (Dev)}}$

➔ MP Social Benefit $_{(Dev)}$ = MP Gain $_{\text{E-Waste (Dev)}}$ = 1 billion / 50 million = 20

Social Cost $_{(Dev)}$ = Loss $_{\text{E-Waste (Dev)}}$

= Expense $_{\text{E-Waste Purchase}}$ + Expense $_{\text{Processing Cost (Dev)}}$ + Expense $_{\text{Socio-Economic Cost (Dev)}}$

= 0 + 100 million + 108 million

➔ MP Social Benefit $_{(Dev)}$ = MP Expense $_{\text{E-Waste Purchase}}$ + MP Expense $_{\text{Processing Cost (Dev)}}$ + MP Expense $_{\text{Socio-Economic Cost(Dev)}}$

= 12 + [100 million / 50 million] + [108 million / 50 million] F(x)[48]

= 12 + 2 + 2.16 F(x)

= 14 + 2.16 F(x)

Conclusions:

Case 1: For Optimal E-Waste trade,

Marginal Social Benefit = Marginal Social Cost

➔ 20 = 14 + 2.16 F(x)

➔ F(x) = 2.78

Case 2: For Excess Trade,

[48] F(x) is the polynomial describing Socio-Environmental costs for each E-waste unit disposed

Marginal Social Benefit < Marginal Social Cost

➔ $20 < 14 + 2.16\ F(x)$

➔ $F(x) > 2.78$

Case 3: For Deficient Trade,

Marginal Social Benefit > Marginal Social Cost

➔ $F(x) < 2.78$

Observations:

If, upon empirical analysis, it were concluded that Marginal Social Cost associated with conducting E-Waste trade is greater than its Marginal Social Benefit (Case 2 above), then applying the 'Design for Environment' waste management model on E-waste generated in the US (i.e., at the source) might be the best possible measure to achieve a socially desirable outcome, by bringing E-waste trade back to optimum levels. Alternatively, the levying of a 'Green Tariff' by developing countries on E-waste imports could achieve the same result.

However, discovering the most appropriate option to achieve optimum E-waste trade levels in this case lies beyond the scope of this thesis.

C] Implications for E-Waste Trade

Since the Green tariff levied (which could be considered as a Pigouvian tax on waste) could help subsidize developing countries[49] in recycling 'difficult-to-process' e-waste, it is expected that such 'Pigouvian' tax will influence developed countries to encourage their respective computer manufactures in designing more environmentally-friendly, easily recyclable products.

As a consequence of this effect, marginal social costs associated with disposing E-waste will reduce, and pareto-optimality shall be achieved when:

$$\text{Marginal Social Benefit}_{\text{(E-waste)}} = \text{Marginal Social Cost}_{\text{(E-Waste)}}$$

[49] Because $\text{Import Tariff}_{\text{(Dev)}} = \text{Recycling subsidy}_{\text{(Dev)}}$

10] SHORTCOMINGS OF METHODOLOGY AND DATA

A] Precise data pertaining to socio-environmental costs inflicted by E-Waste on developing countries remains challenging to obtain / generate.

B] Environmental damage costs for processing PC components other than the monitor unit[50] is not taken into account.

C] Transport expenditures are not factored in calculations

D] Surveyed literature provides scant indication of prevailing selling price of E-Waste articles. Consequently, formulation of favorable trade policies (such as suitable tariffs or subsidies) for achievement of pareto optimality remains difficult.

11] CONTRIBUTION FROM THIS WORK

As per the analysis presented in this thesis, it can be reasonably concluded that e-waste trade does constitute, in economic terms, as a type of 'free trade' where both parties stand to experience mutual gains. As a result, attempts to curtail such trade may reduce net income for a developing country. However, an actual analysis of marginal social benefits and marginal social costs accrued to e-waste receiving developing countries needs to be surveyed in order to develop future reforms pertaining to this trade.

In the present scenario, most beneficial strategies would be: Construction of amendments to existing treaties (such as the Basel Convention); or effective actions by trade bodies (such as the WTO) aimed at instituting health, environmental regulations in developing countries to mitigate negative consequences of e-waste trade.

12] THE 2008 GLOBAL CRISIS: EFFECTS ON E-WASTE & ASSOCIATED LIVELIHOODS

The United States exported $22 billion worth of recycled materials to 152 countries in 2007.[51] It is estimated that the recession caused the value of American recyclables to decrease by 50 to 70 percent[52],

[50] Monitors comprise the most toxic components of a PC unit.

with dealers grappling with mounting stockpiles whose value continued to sink. To introduce further distortions in the E-waste trade, E-waste importers demanded the renegotiation of contracts drastically downwards.

When the economic downturn nosedived in the second half of 2008, the talk was primarily about macroeconomic trends, causes and impacts on the formal economy. In E-waste receiving developing countries where thousands of livelihoods rely on the informal E-waste processing sector, the worldwide crash in commodity prices of different scrap materials caused the informal economy indulged in E-waste processing to be negatively impacted.

The crash in prices is shown in the table below[53]:

Sr. No	**Discard Type**	**% Price Decrease (April – Dec. 2008)**
1	**PET**	**40.8**
2	**Hard Plastic**	**37.6**
3	**Soft Plastic**	**36.7**
4	**Metals**	**41.9**
5	**Glass**	**5**

In the context of waste recyclers, PC materials that were part of the global trade circuits, such as metals, were the worst impacted while lesser-traded, ‘easy-to-domestically-produce’ materials such as glass were less impacted.

The specific Socio-Environmental impacts are unclear. While the volume of imported used-PCs remained intact during the recession[54], the reduction in labor force required to process these PCs entailed

[51] See http://www.ban.org/BAN_NEWS/2009/090311_chinas_big_recycling_market.html
[52] Ibid
[53] See Chaturvedi, Bharti et all, *Scrap Crash*, Chintan Environmental Research and Action Group (2009) Pg 4
[54] See http://www.nytimes.com/2009/03/12/business/worldbusiness/12recycle.html

that while fewer people were exposed to E-waste toxicity, the ultimate victim had been the environment on account of enhanced seepage of chemicals from the larger stock of disposed PCs.

12.1] Assessment of crisis on E-waste Trade

A] Cost-Benefit Calculation for the US

Gains: From the previous table, we see that the value of tradable scrap contained in E-waste articles declined by almost 40%. Therefore, it is assumed that the selling price of exported E-waste also declined by 40% from $10 to $6 per PC.

Since the volume of e-waste exports is intact, we conclude this is 50 million units.

The Gains to the US economy is expressed as:

$\text{Gain}_{\text{E-Waste (US)}} = \text{Revenues}_{\text{E-Waste Sale (US)}} + \text{Savings}_{\text{Processing Cost (US)}} + \text{Savings}_{\text{Socio-Economic Cost (US)}}$

= 50 million x $6 + $ 1 Billion + $ 16.2 million

= $ 1.3162 Billion

Losses: The losses associated with E-waste trade incurred by the US is expressed as:

$\text{Loss}_{\text{E-Waste (US)}} = \text{Transfer}_{\text{Materials}}$

As noted, the value of US recyclables has reduced by 50 - 70%. Therefore, the value of exported articled per PC falls from $20 to $8 (assuming the decline in value is 60%).

⇨ $\text{Transfer}_{\text{Materials}}$ = $400 million[55]

⇨ $\Delta\text{Net Income}_{\text{E-Waste (US)}}$ = $ 1.3162 Billion - $400 million

= $916 million

B] Cost-Benefit Calculation for Developing Countries

Gains: Developing economies gain from the acceptance of valuable materials transferred from the US, and this may be expressed as:

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[55] 50 million x $8 = $400 million

$\text{Gain}_{\text{E-Waste (Dev)}} = \text{Transfer}_{\text{Materials}} = \$400 \text{ million}$

Losses: We know that the loss incurred by Developing economies is expressed as:

$\text{Loss}_{\text{E-Waste (Dev)}} = \text{Expense}_{\text{E-Waste Purchase}} + \text{Expense}_{\text{Processing Cost (Dev)}} + \text{Expense}_{\text{Socio-Economic Cost (Dev)}}$

$= \$300 \text{ million} + \$100 \text{ million} + \$108 \text{ million}$

$= \$508 \text{ million}$

$\Rightarrow \Delta\text{Net Income}_{\text{E-Waste (Dev)}} = \$400 \text{ million} - \$508 \text{ million}$

$= -\$108 \text{ million}$

Final Results:

Annual ΔNet Income $_{\text{E-Waste (US)}}$ = $916 million

Annual ΔNet Income $_{\text{E-Waste (Dev)}}$ = -$108 million

12.2] Impact evaluation of crisis on E-waste workers

From a random sample of 600 E-waste scavengers in Delhi, India, an assessment of the livelihood impact is presented as follows[56]:

1] Vulnerability of informal workers in E-waste sector against economic shocks:

• 70% of interviewees stated that they were forced to sell expensive metals such as copper at significantly lower prices. Hence, their income margins from work had deteriorated immensely.

• Over 65% wastepickers liquidated their assets, including those kept aside for emergencies.

• Over 80% of migrated E-waste workers affirmed that their remittances sent to families declined significantly, so rural assets had to be liquidated.

2] Labor-market analysis in this sector:

• Unexpectedly, only 1% of those interviewed were planning a permanent shift in profession.

[56] Ibid

• Over 60% stated that they were not looking for a change.

• 66% of the recyclers interviewed were not doing anything to enhance their income.

• Only 7% reported working harder. Instead of scavenging from a given area for 3 hours, they now put in 4 to 5 hours. Some of them also reported going out twice a day to look for waste, including at night.

3] Coping strategies of people in this sector:

• All women had begun looking for work as maids in nearby areas, as it ensured steady income.

• A few wastepickers returned to their village and began to work as part of an Employment Guarantee Scheme, which provides one hundred days of guaranteed wage employment in the financial year.

• 80% of the families interviewed had cut down on luxury foods, which they defined as milk, meat and fruit. This change impacted children most of all, especially the girl child.

• Significantly, while many children reported leaving school / classes earlier to work more, there were no school dropouts reported.

12.3] A Solution

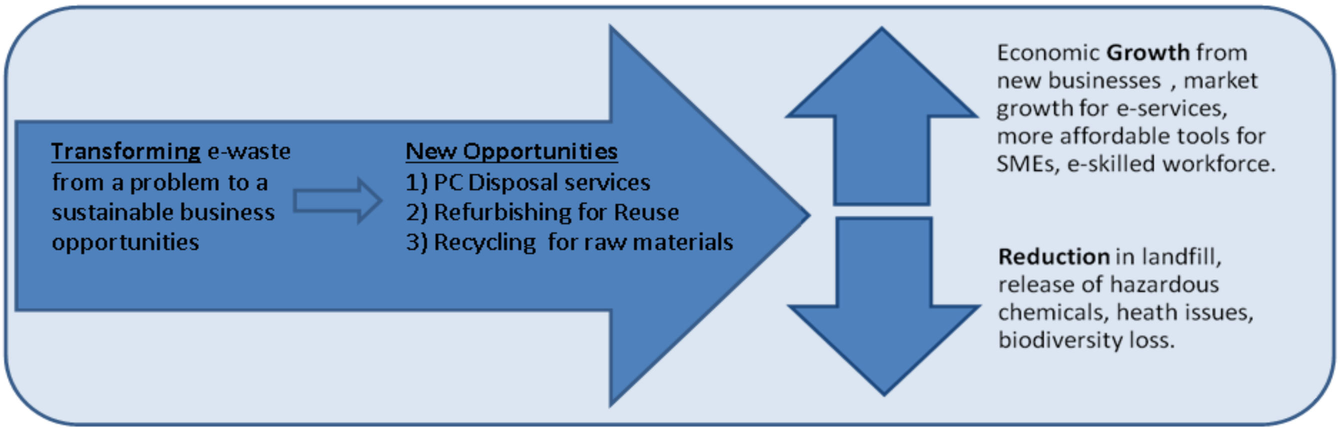
In order that distorted trade volumes return back to pre-recession levels, E-waste importing countries could offer domestic E-waste dealers import subsidies to the order of $108 Million. This subsidy could be utilized towards offsetting the purchasing price of E-Waste goods.

13] E-WASTE MANAGEMENT

As noted in ***Section 7: Findings***, and ***Section 8: Growth Effect of ICT***, the desire to 1] increase net income gains from E-Waste trade; and 2] improve ICT penetration rates for enhancing GDP levels, has led developing economies to seek ways for mitigating health, environmental hazards and costs associated with E-Waste processing, as well as refurbishing used PCs to put them into productive use.

Well designed e-waste management solutions not only mitigate health and environmental hazards, but also trigger a whole range of additional economic and social opportunities by providing an affordable entry point to PC ownership for people lower down the economic pyramid. All of this grows economies and reduces environmental pressures.[57]

However, an evaluation of diverse project finance strategies suitable for international private enterprises to set up E-waste Processing/Recycling centers in developing countries points to the importance of partnerships with 'neutral' multilateral institutions to mitigate political risk factors.[58] [59]



In this regard, developing economies have approached 'credible' international development bodies such as the United Nations Indutrial Development Organization (UNIDO) to devise environmentally sound business models, processes and technologies for PC recycling and refurbishment.[60]

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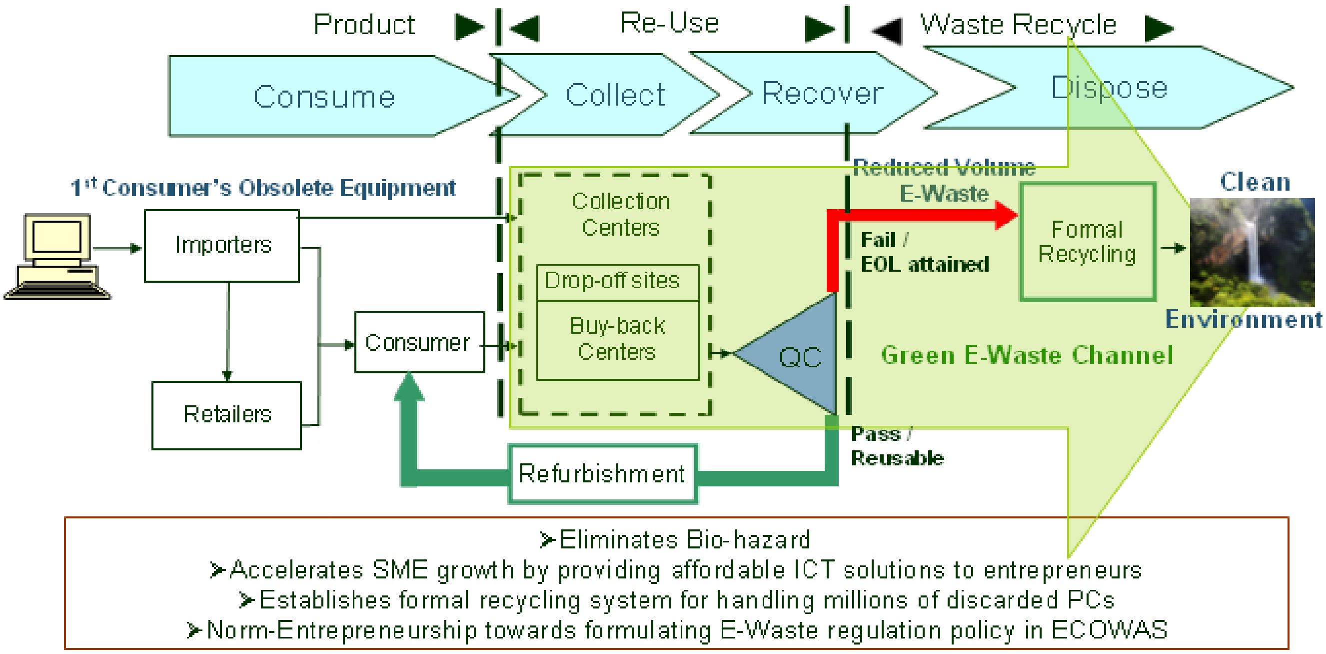
[57] See UNIDO Factsheet, http://www.unido.org/fileadmin/ext_media/Services/PSD/ICT/factsheet.pdf
[58] See Etsy, Benjamin, *Modern Project Finance – A Casebook*, John Wiley & Sons (2004) Pp 1 - 100
[59] Since Refurbished ICTs easily percolate into all societal layers, a foreign, privately-operated refurbishment center may be viewed as 'economic' colonialism in developing countries
[60] See *E-Waste Assessment in Uganda*, .Final Report (2008), UNIDO



A proposed business model developed by UNIDO for recycling E-waste in developing countries.

UNIDO has established Computer Refurbishment centers in Uganda (for instance, the Uganda Green Computers Company Limited (UGCCL)) which reduce the stream of direct e-waste to manageable capacities of Formal Recycling centers and provide affordable PCs to SMEs / consumers for bridging the digital divide.

It would be a worthwhile pursuit to further research the initiatives being undertaken by International Organizations & NGOs towards enabling sustainable E-waste trade and analyzing the corresponding impact on this trade.

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