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Economía y Sostenibilidad: El problema de los residuos electrónicos como externalidad negativa en el Ecuador

Economy and Sustainability: The problem of electronic waste as a negative externality in Ecuador

Economia e Sustentabilidade: O problema do lixo eletrónico como externalidade negativa no Equador

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Artículo de Investigación

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Resumen

Los hallazgos de este artículo exploran el concepto de externalidades negativas derivadas del uso de Tecnologías de la Información y la Comunicación (TIC) y dispositivos electrónicos, destacando los desafíos en la identificación y abordaje de estos costos externos dentro del proceso de producción. El artículo resalta el impacto ambiental significativo asociado con la generación de residuos electrónicos, incluyendo la contaminación durante las fases de producción, uso y eliminación. Se discute el papel de la fiscalidad como un mecanismo para internalizar las externalidades y promover prácticas sostenibles, al tiempo que se examinan las barreras al emprendimiento en el reciclaje de residuos electrónicos.

Palabras Clave: Tecnología; Basura tecnológica; Producción; Contaminación; Externalidades.

Abstract

The findings of this article explore the concept of negative externalities arising from the use of Information and Communication Technologies (ICT) and electronic devices, highlighting the challenges in identifying and addressing these external costs within the production process. The article highlights the significant environmental impact associated with the generation of electronic waste, including contamination during the production, use and disposal phases. The role of taxation as a mechanism to internalize externalities and promote sustainable practices is discussed, while barriers to entrepreneurship in e-waste recycling are examined.

Keywords: Technology; Technological garbage; Production; Pollution; Externalities.

Resumo

As conclusões deste artigo exploram o conceito de externalidades negativas decorrentes da utilização das Tecnologias de Informação e Comunicação (TIC) e dos dispositivos eletrónicos, evidenciando os desafios na identificação e abordagem destes custos externos dentro do processo produtivo. O artigo destaca o significativo impacto ambiental associado à geração de lixo eletrónico, incluindo a contaminação durante as fases de produção, utilização e eliminação. O papel da tributação como mecanismo para internalizar externalidades e promover práticas sustentáveis é discutido, enquanto são examinadas as barreiras ao empreendedorismo na reciclagem de lixo eletrónico.

Palavras-chave: Tecnologia; Lixo tecnológico; Produção; Poluição; Externalidades.

Introduction

In recent decades, the talk of a fourth industrial revolution, or the so-called Industry 4.0, has been growing, Information and Communication Technologies (ICT) and the Internet of Things (IoT) have spread through society and the economy imperceptibly. As (Baratech et al., 2018) explains that nowadays, knowledge and information make the economic process perceived as more immaterial, it is possible to see that the monetary value of the world's largest companies fundamentally resides in their intangible assets.

Regarding on the idea of a more immaterial perception of the economy, it become more complex to notice negative externalities that can arise from a production process. ICT according to (Torrent-Sellens & Díaz, 2019); is the foundation of new economic paradigm, which in the medium and long term could modify the structure of production costs, forms of employment, new professions, and everything that involves incorporating technology as a fundamental axis of capitalist productive mode, whether in countries with higher economic development or depressed economies. Environment can be considered as an economic good, since all natural resources are scarce, therefore, this becomes a problem of interest for economic science, according to (Chang, 2006) the best way to measure the impact of productive activity on society is through externalities it's known that they are positive when they benefit others, and negative when they harm them. The one to be studied should be the negative externalities, since they are costs of a private nature that firms pass on to society.

Likewise, on the same matter (Krugman & Wells, 2013) agree that it is the external cost that should be studied and analyzed because the environmental costs of pollution constitute the most important example of an external cost - a cost that an individual or company imposes on other agents without receiving anything in return" (Krugman & Wells, 2013, p. 456). From this same point of view, the problem of production is given by the collateral damage represented by production: "Supply and demand reach an agreement to purchase, but pollution and damage to the environment behind the production and transaction are never considered; hence it goes undetected" (Erickson, 2016, p. 16). A brief concept to add to the study to explain technological externalities by (Yáñez, 2016) , are those that result in market failure as an efficient instrument for resource allocation. As neither the positive or negative effects are captured, measured, or incorporated into the price system.

The use of technology could lead to an example of negative externalities. Suppose that there is a young user of a smart phone, who bought his device in march 2023, it is very probable that the average user (BBVA, 2023) changes his device every two years, without recycling the old one, causing contamination in his own home given all of the CO2 emissions that keeps sending. What is not considered is that the manufacturing of this device causes 80% of pollution to the environment, because of the mining, refining, transportation and assembly of dozens of chemical elements to lead the new technology: iron for speakers and microphones, aluminum and magnesium for screens, copper, silver and gold for electrical circuits, graphite and lithium for the battery, etc.

For example, the single use of the smartphone to send an email brings pollution; each time we send a communication that is equivalent to 4gm of CO_2 this is because between 35% and 40% of the electricity of data centers, where everything is stored (the cloud), requires large cooling processes for the servers. (BBVA, 2023)

All of the above explains, that besides the private contract between the buyer and the producer, there is third, that was not consider in the negotiation and gets all of the negative externalities, or as explained by (Yáñez, 2016) "technological" externalities are those that result in market failure as an efficient instrument for resource allocation. As neither the positive or negative effects are captured, measured, or incorporated into the price system.

As a result of this market failure, these externalities are not reflected by market price, hence they cannot be used to measure benefits and costs in the social evaluation of projects because they do not contain such information. In consequence, this prices are not fair to calculate compensation or reparations for the damages, or harm done.

Electronic Waste

Before explaining the negative externalities that e-waste can cause, the meaning of electronic waste must be addressed.

Electronic waste or e-waste makes reference to electrical and electronic equipment (EEE) (Forti, Baldé, & Kuehr, 2018) and its parts that by one reason or another has been discarded without the intention of use.

Also, this EEE can be defined as any household or business item with electrical components (Parajuly, y otros, 2019), with battery or power supply. This can include any kind of product, from cellphones to kitchen devices.

It is important to consider that everyday more artifacts are becoming essentially integrated with many sectors in the economy, such as energy supplies, health, transportation, etc. All of them also come with a life expectancy and once is no more to use is discarded, as mentioned before without the intention of use.

Globally, around 50 million metric tons of e-waste is generated (Parajuly, y otros, 2019) with the reference that e – waste is the fastest growing solid waste stream, also it is possible to see a high demand for refurbished or use of e-products. According to (Wagner, 2022) it is possible that e waste is more commonly being used for recycling and reselling, since is a profitable growing business, artifacts are described in (Table 1).

Table 1: *Artifacts and categories classified for electronic waste*

ARTIFACT / DEVICE	CATEGORY
Temperature exchange devices	This category includes refrigerators, freezers, air conditioning units, and heat pumps.
Screens and monitors	Include liquid crystal display (LCD) and light-emitting diode (LED) TVs and monitors, laptops, and electronic tablets.
Lamps	LED lamps, high-intensity discharge lamps, and compact fluorescent lamps and straight tube lamps.
Large appliances	dishwashers, washing machines, ovens, central heating systems, professional printers, and photovoltaic panels.
Small appliances	microwaves, grills and toasters, personal hygiene products, speakers, cameras, audio equipment and headphones, toys, household tools, and medical and monitoring systems.

Small computer and telecommunications devices	This includes personal desktop computers, printers, cell phones, cordless phones, keyboards, routers, and consoles.

Source: (Wagner, 2022)

According to the Global Transboundary E-waste Flows Monitor - 2022 statistics (UN, 2022), it is projected that by the year 2030, electronic waste generated globally will amount to 53.6 million metric tons, which translates to an average of 7.3 kilograms per capita annually. Additionally, the projection for 2050, maintaining the current level of electronic device consumption, anticipates an increase of 110 million metric tons of technological waste worldwide (UN, 2022).

The reasons for this disproportionate increase in waste at the global level, as per (UN, 2022, p.16), can be summarized as follows:

a. Absence of clear legislation in countries regarding the management of technological waste.
b. Limitations in infrastructure and logistical handling of technological waste.
c. Competition between the formal and informal sectors for handling technological waste.
d. Legal and illegal importation issues.

Enviromental taxes as a compensatory extent to society

Taxation (Oxford , 2014) is one of the ancient practice that sustains the central pillars of our civilization, in a way it can be said that there is no structured or well organized society without taxation. On this matter it can be said that taxation is: “A compulsory contribution to the support of government, levied on persons, property, income, commodities, transactions, etc” (Oxford , 2014, pág. 3).

So, if taxation is one of the pillars of society, it is not a surprise that tax systems for any state are the primarily income that allows financing public expenditure, including social programs or economic matters of the state budget. And if environment is careless topic by consumers and producers, one of the ways of calling to their attentions it could be by introducing a tax as a way to reattribute to society the damage done by them.

As aforementioned, one of the main reasons to have a careless behavior with environment it is that laws are not strong enough or have too many legal loopholes, so it stablishes a gray area where one

can be penalized or not. It is in this scenario where the ideas of Arthur Pigou become viable since he stated that once an environmental tax is designed and charged to industries, they will try to pollute just as convenient as possible, so they do not have to pay high amount of money for penalization.

In the midterm, according to (Mendezcarlo, Medina, & Becerra, 2010) the firms will have to modify their producing processes and adopt cleaner technologies, which encourages more environmentally friendly environmental behavior.

It is important to stand out that Piguivian taxes were the way to create the very popular principle “who pollutes pays”; this idea was accepted by the international community as a guiding idea to promote economic instruments for sustatainable development.

According to (Olmedillas & Cabañes, 2000), "the problem of externalities is ultimately a problem of rights and their dual nature: the allocation of a right to one party simultaneously exposes other parties to the effects of the exercise of that right." Hence, the Coase theorem speaks of the duality of externalities, whereby even when rights are assigned to the company, the relationship between it and society will bring both benefits and costs.

Contemporary society has found benefits in the use of ICTs in its daily life. It is nearly impossible to imagine daily life without cell phones and, consequently, without fast information.

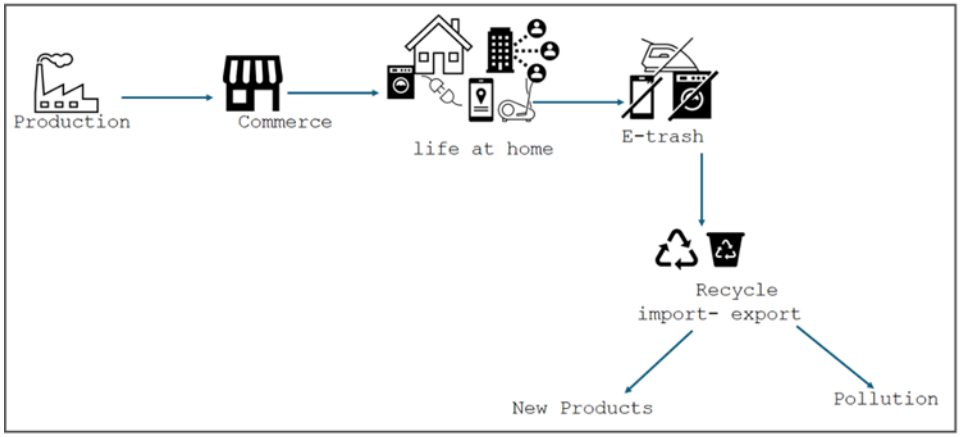
As (Gómez, 2016) puts it, "ICTs can be considered as a social relationship that facilitates the process of information and communication in order to build and extend knowledge that satisfies the needs of the members of a given social organization" (p. 62). However, this same benefit carries high environmental costs for society once discarded.

Another problem with the collection or recycling of technological waste is that it has collateral effects, which often go unnoticed. For example, the waste generated by data centers to keep digital platforms operational is often overlooked. A study on servers stored in digital centers explains, "the energy consumption of data centers ranges from 1% to 2% of the total global consumption. It is estimated that the consumption by 2030 will be 30%." (González, 2023). Additionally, when these companies no longer require computers, they are subject to disposal and export to countries with less developed economies, initiating a value chain that brings with it a social cost for the destination country.

It is important to note that all electronic devices and equipment used in industry and households have a lifecycle, which "depends on the characteristics of each equipment; its disposal (...) depends

on various factors, among which are: the lifespan of the goods, consumption trends, and the speed of technological change, among other aspects." (ILO, 2019) This lifecycle is explained in Figure 1. Thus, technological waste will continue to be generated as technological advancements promote the rapid disposal of electronic equipment and devices.

***Figure 1**: Lifecycle of Electronic Devices*



Source: Autor

These devices, once they have reached the end of their useful life, pose a danger to society if their recycling is not managed properly, as they all contain Persistent Organic Pollutants (POPs), which according to (Wagner, 2022), "Electronic waste may contain Persistent Organic Pollutants such as PCBs, polybrominated diphenyl ethers (PBDEs), and other halogenated flame retardants." (page 21). All these POPs act harmfully on people's health, as described by (Wagner, 2022) in the study conducted on electronic and technological waste in Latin America, based on samples from thirteen countries in the region.

"The adverse effects of POPs include cancer, allergies, and hypersensitivity, damage to the central and peripheral nervous systems, reproductive disorders, and immune system alterations. Some POPs are also considered endocrine disruptors that can damage the reproductive and immune systems of exposed individuals, as well as their offspring, as they alter the hormonal system; they can also have carcinogenic and developmental effects." (Wagner, 2022, pág. 20)

The adverse effects described are not factored into commercial transactions, nor are they taken into account. These are the social costs that neither the producer nor the buyer considers, directly affecting third parties, thus becoming a negative externality.

Electronic Waste in Ecuador

Ecuador, according to (González P., 2023) produces 87,575 tons of electronic waste are generated annually, which when disuse, does not have an adequate collection and recycling process. Causing a huge footprint of contamination because this waste ends up in landfills, streams, estuaries, landfills, etc.

In addition, it is important to note that, despite the poor management of electronic waste collection and recycling, as stated by (Wagner, 2022), Ecuador has advanced environmental legislation compared to other countries in the region; it includes national legislation, international conventions and instructions for handling mobile phones and electronic devices Table 2.

***Table 2**: Environmental Legislation in Ecuador*

Ministerial Declaration	**Number**	**Date**
"Procedures for Registration of waste generators hazardous waste, prior hazardous waste management to environmental and transportation licensing of hazardous materials"	026	May 12th 2008
National listing of hazardous chemicals and dangerous waste.	142	December 21st 2012
National Policy of Post consumption of Electrical and Electronic Equipment in Disuse	--	January 29th 2013
User guide of extended responsibility and regulations for prevention and control of pollution by chemical substances hazardous waste,	---	January 29th 2013

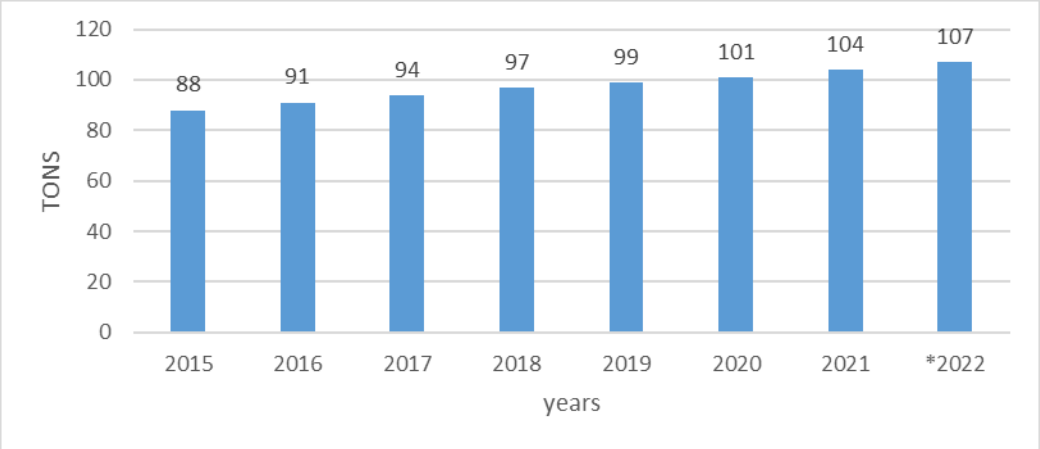
hazardous and special waste, for obsolete cellular equipment.	
-Organic Code on Environment **-Regulation of the Organic Code on the Environment**	April 17th 2017 June 12th 2019

Source:Global TBM

Another significant topic on Ecuador's environmental legislation, according to Wagner (2022), it is that since 2013 has advanced and new policies on health, security and environment, related to products chemicals and hazardous waste related to electronic waste.

Electronic waste and its consequences is a new field to be studied and explored in Ecuador, explained by Pesantes (2022), since of all the obsolete electric appliances disused and throw to waste in Ecuador, only the 5% it is recycled properly, and the rest keeps creating a bigger footprint of pollution in the country, not only by the manufacturing sector but citizens in general. (Figure2)

Figure 2: *E-Waste by Tons*



Source: Monitor Electronic Waste United Nations

To set an example of the problem with e waste and electronic devices, there will be an idea of how much waste and pollution cab be created by using a mobile phone.

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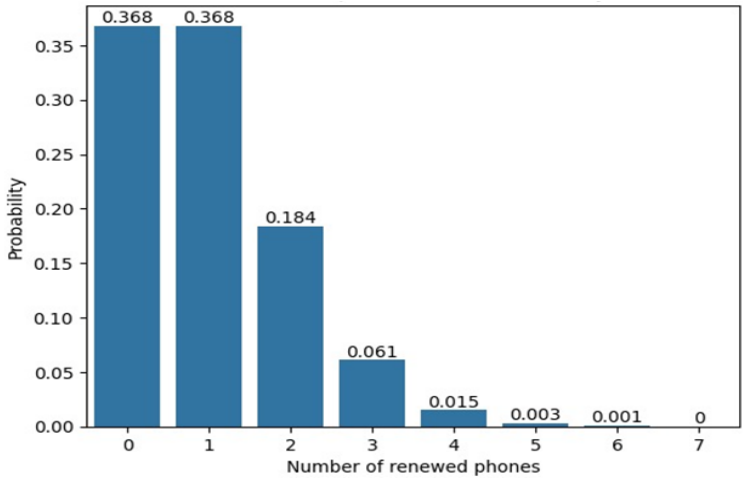
According to collected data by (INEC, 2023) in Ecuador, around fifteen million people is connected to internet through a mobile phone. This possibly means that there is the same number of mobiles available in the country, that might be renewed every two years.

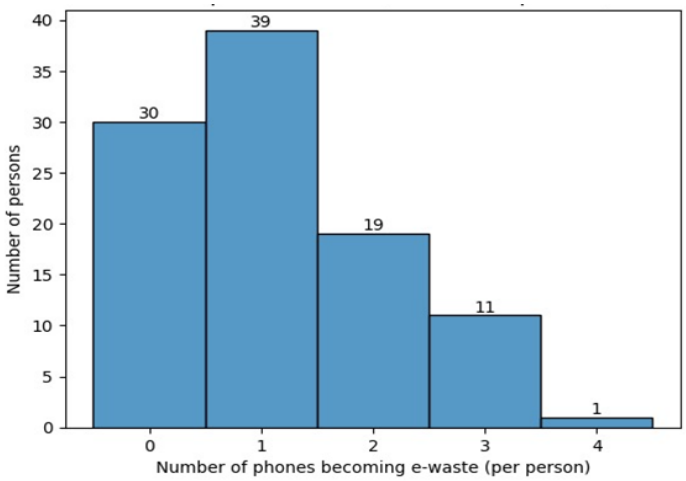
If the Poisson distribution of probabilities is used, considering that the result gives the probability of an event happening a certain number of times (k) within a given interval of time or space. We could have the probability of not changing a mobile is almost the same as renewing in one year. (Figure 3)

Figure 3: *Probabilities of phone renewals over 2 years*



This experiment could be done for a hundred people and have the result of 114 mobiles that will turn into e- waste. (Figure 4)

Figure 4: *Mobile phones e-waste*



Based on previous example, we can say that for the case of Ecuador and its data of 15M people and a life cycle of a mobile phone of two years, with a 95% of certainty that the amount of e-waste created only by the consumption of mobile phones it is around 14´998.887.0 – 15´000.287.0.

All of those phones, are not properly collected or are not recycled, and creates a silent pollution in the environment that is not considered or noticed. It will be the same if we collect data for laptops, PC's, tablets, electronic boards, TV's or any other electronic device that might be used for the production of good and services.

Regarding this situation, the questions to be studied are as follows: Q1: Why if Ecuador has one of the most advanced legislations, there is a small percentage of electronic waste recycling? Q2: Which are the barriers in Ecuador to consider entrepreneurship in electronic waste?

Legislation and poor electronic waste recycling

As said before, Ecuador does have a legislation in order to manage and promote a proper collecting and recycling of electronic waste, as explained by (Litardo, 2012) it seems like the regulations are not enough, due to lax of judicial system and the poor effectiveness of the institutions when it comes to environments. Environmental misconduct like having open sky dumps in urban areas, are not properly sanctioned by the government or its institutions.

It's easy and very common to see in the city or in little towns, dumps with electronic waste, mixed with every day home garbage which is not properly separated either. According to (Paredes, 2023) there is regulation in the Constitution (2008), Penal Code and in the Organic Code on Environment, but at the time it has not become effective, and their applicability is quite controversial.

To begin with, criminal regulations classify and punish crimes perpetrated against nature and the environment by imposing custodial sentences against those responsible for the damage. However, when talking about compensation and indemnities, it provides that "*the competent authority dictates regulations related to the right of restoration*." (Paredes, 2023). Creating a legal vacuum that makes the law lax and in most of time not effective, and there for the misconduct against environment stays unpunished.

This situation leads to explain the application of environmental law in Ecuador under negative externalities. In this case producers and citizen's disregards of punishments because the law it is

written and exist, but since there is a legal vacuum and it is very difficult to prove who did the damage, therefore the restoration could be a few pennies, or remodel a park in the case of industries. The examples suggest that pigouvian practices are more effective in societies like Ecuador's, since damage to environment is still not acknowledge by the population and it is difficult to achieve an electric waste recycling culture without a huge effort in collective education.

According to Pigou theory, taxes are intended to serve as counterbalance, in order to increase the companies' private marginal cost of polluting, in a way that economic agents acknowledge the fact that they are responsible for the external cost they transfer to society. In the case of Ecuador, the only taxes for environmental pollution are for use of both plastic bottles and bags; there is not penalty, admonish or tax for electronic waste.

Hence, the problem on having a poor electronic waste recycling is growing and seems not to have a proper solution in the short term. As said before, there is law about this inconvenience, in the User guide of extended responsibility it is expressly indicated that: "are subject to compliance and application of the established law in this agreement any citizen or firm, public or private, national or foreign responsible for the first placing on the national market of electrical appliances and electronic devices" (MAATE, 2022, pág. 23)

The law establishes all of the responsible for the correct recycling of electronic waste; but since there is a strong believe that the only polluters are industries, there is not a tax or a clear reprimand against citizens who also throw away electronic waste without care for environment, and this task is harder for the government since it needs to be controlled and there is no plan available to actually educate and admonish citizens.

Barriers on entrepreneurship of electronic waste

Ecuador's economy is mainly extractivist, the productive activities that creates high rates of income to the country are related to oil and mining extractivism, both create a high footprint of pollution to the environment. On regard of this matter, the Economic Commission for Latin America and the Caribbean (ECLAC), recommended to Ecuador that the best way to improve extractivism or linear economy, it is to open a possibility to circular economy where the electronic waste could be a way to promote entrepreneurship and new jobs in the medium-term growth.

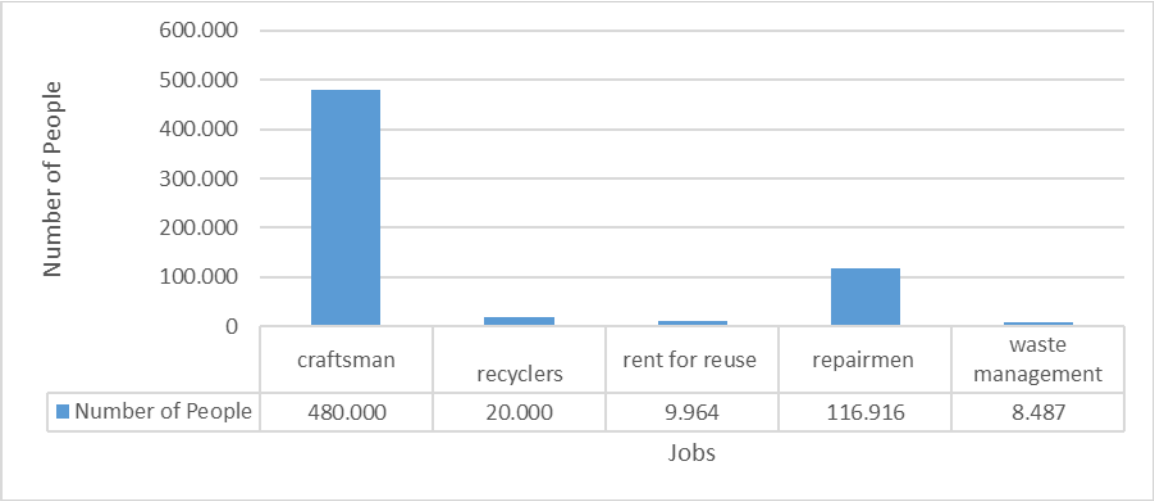
According to (MAATE, 2021), ECLAC considers that a transition to circular economy, will create new jobs in steel reprocessing, aluminum, wood and other metals, which in the term can

compensate with profit the losses associated with disinvestment in mineral's extraction. Also, in data presented by (MAATE, 2021) it is suggested that "repair, recycling, and remanufacturing can generate 200, 50 and 30 times further jobs than the implementation of landfill or incineration"(pag.37).

In Ecuador, there is around 135.367 jobs related to repair, recycling and refurbishing. This data represents approximately 1.7% of the Economically Active Population (EAP) in 2020; it is important to specify that this numbers includes only people who have formal employment, hence, it could be said that there might be a statistical bias.

On top of that, it is necessary to notice that Ecuador has several commercial agreements that benefits small business, like EXPORT –DES which is supported by CORPEI and the European Union (EU). Its aim is to introduce electronic waste from Ecuador to the EU, in a sustainably way. There is also the Protocol of Sustainable Finances supported by the Association of Private Banks in Ecuador, with the only purpose of helping sustainable artisans that works with electronic waste o circular economy as shown on figure 5.

Figure 5: *Number of people working on electronic waste o circular economy*



Source: Ministerio de Ambiente, Agua y Transición Ecológica

Regarding previous explanation, it seems like there might be no problem when it comes to start a business in electronic waste, but according to some working in the field, it is not that simple. According with an interview with the magazine (Líderes, 2019) the CEO of Intercia S.A, had to made an investment of $800.000 including licenses and technologies to start the business.

In the web site of MAATE, there is an explicit detail of all the initial minimum cost to start operations, if the entrepreneur wants to open a recycling firm, the category which it is classified is according to (MAATE, 2023) is Issuance of environmental license for projects, works or activities considered to have medium or high impact and environmental risk.

Table 3: *Cost operations on Environmental Taxes*

ENVIROMENTAL TAX	AMOUNT(APROX)
Review, Qualification of Environmental Studies, and Issuance of the Environmental License	• 1x1000 of the total amount of the project (if it represents high environmental risk) based on $1000 minimun. • 1x 1000 of the total amount of the project (if it represents low environmental risk) based on $500 minimun
Review, Qualification of Expost Environmental Studies and Issuance of the Environmental License	• 1x1000 of the total amount of the project (if it represents high environmental risk) based on $1000 minimun. • 1x 1000 of the total amount of the project (if it represents low environmental risk) based on $500 minimun

Source: Portal Único de Trámites Ciudadanos. Ministerio de Ambiente, Agua y Transición Ecológica.

Also, (ForbesEC, 2023) shows another problem for entrepreneurs in electronic waste; it is not profitable to work Business to Consumer (B2C), because the cost of implementing a recycling plant for electronic waste in Ecuador are very high and the B2C model will not give the desired result. So, the best it is to implement the Business to Business (B2B) and it has its challenges, this was explained by Johana Rosales the CEO of Vertmonde to an interview to (ForbesEC, 2023). For example, her company, in 2021 invested $180.00 in a crusher e- waste, which is a machine to destruction and processing of electronic waste, so far it is unique in Ecuador. Also, she had to invest in certifications, local and international in order to obtain the trust of the market in her company.

Bearing this two examples in mind, it could be said that electronic waste it is a business with a future, but it is also safe to say, that there is a long way to work in, because it is still expensive,

not available for everyone and it needs a strong education program for citizens in order to know that there are opportunities in this field.

Conclusions

The paper discusses the implications of the Fourth Industrial Revolution, characterized by the careless use of technology in society and industry, particularly focusing on the negative externalities arising from the widespread adoption of Information and Communication Technologies (ICT) and electronic devices. One of the highlights is the complexity of identifying and addressing negative externalities in the production process amid technological advancements, emphasizing the importance of considering environmental costs.

An important concern raised is the significant environmental impact associated with the production and disposal of electronic devices, particularly smartphones. The lifecycle analysis of electronic devices reveals the substantial pollution generated throughout their production, use, and disposal phases, with notable contributions from data centers and the extraction and processing of materials. Using Pigouvian principles, the paper tries to support environmental taxes as a means to incentivize firms to internalize the costs of pollution and invest in cleaner technologies. However, it also acknowledges the limitations of existing regulatory frameworks and enforcement mechanisms, particularly in countries like Ecuador where lax enforcement and legal loopholes undermine environmental protection efforts.

Effective policy interventions, coupled with investments in infrastructure, education, and entrepreneurship support, are essential to mitigate negative externalities and foster sustainable development in the era of Industry 4.0.

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