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Socio-economic parameters that influence the disposal of refrigerators and televisions in an urban area of Colombia

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ABSTRACT

The article presents a correlational study conducted in 2018, with people from different socioeconomic strata in the city of Armenia, Quindío; intermediate city of Colombia, developing country. The study allows associating socioeconomic variables with the efficient management of waste from refrigerators and televisions, through the use of the Pearson coefficient, determination and the Durvin-Watson test.

The results show that people located in socioeconomic strata four, five and six are more willing to have direct control strategies applied to them, such as payment of penalties (through taxes), when making a non-efficient final disposal (against the applicable regulatory framework), while those located in strata one to three, the preference is given to non-economic sanctions and receiving subsidies as an incentive for their actions in favor of the ecosystem.

1. Introduction

The digital era has brought great development for industry and society, however, that same boom, manifested in an exponential growth of ICT (development of new versions and prototypes), leads to a shorter and faster cycle of product life; reason that has increased the pressure on the final waste management system. According to figures provided by the International Telecommunications Union, by 2014, in Colombia, 252.2 kilo-tons of Electrical and Electronic Devices Waste (EEDW) were generated, with a per capita production of 5.3 kilos; figure that exceeds the levels of countries like Peru, Ecuador, and others. (see Tables 1–8)

This gives rise to one of the main environmental problems in the 21st century, since the residual fractions of these elements contain some components such as lead, cadmium, tin, among others; which are highly toxic and can cause irreversible impacts to the ecosystem and human health. However, EEDW also incorporates some ferrous and precious materials, such as gold, which leads to processes of use and recovery of such materials, bringing them back to the production process as an alternative to contribute, in unison, to reducing access costs to materials with high market value and ecosystem protection [1,2].

The consumption related to electrical and electronic equipment is massive, its use in activities of everyday life, as well as in the business and social context, create a greater demand for its availability, generating a rise in the supply of products that constantly reduce their acquisition price [3]. In addition, the selling conditions of the product imply the need to make a thorough analysis of the risk and impact factors derived from this social trend that increasingly discards products, emitting waste from the generated residues [4].

The lack of a social conscience about the derived impacts on health, the environment and the pressure on ecosystems, motivate the realization of this study, which is structured, in principle, in a review of the state of the art, to later present the results through the correlation of variables. This allows inferring about the consumption and disposal habits related to Electrical and Electronic Devices (EED).

Finally, the discussions related to normative and cultural aspects about producers and the supply chain are presented, in order to generate changes in relation to the trend of use and discarding of this important line of domestic consumption.

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Table 1
Stratified sampling with proportional affixing.

Strata	Identification	Nº subjects in the strata	Proportion	Sample to do
1	socioeconomical Strata 1	60.949	20,4%	79
2	socioeconomical Strata 2	88.907	29,8%	115
3	socioeconomical Strata 3	88.587	29,7%	114
4	socioeconomical Strata 4	24.949	8,4%	32
5	socioeconomical Strata 5	30.659	10,3%	39
6	socioeconomical Strata 6	4.148	1,4%	5

Source: Prepared by the author based on the 2017 Municipal Basic Card

Table 2
Socio-economic stratum correlation - Tax payment.

		Socioeconomical strata	Tax payments
Socioeconomical Strata	Pearson Correlation	1	.890**
	Sig. (bilateral)		.002
	N	384	384
Tax payments	Pearson Correlation	.890**	1
	Sig. (bilateral)	.002	
	N	384	384

**. The correlation is significant at the 0.01 level (bilateral).

Table 3
Socio-economic stratum correlation - Subsidies as a benefit.

		Socioeconomical strata	Subsidies as benefits
Socioeconomical strata	Pearson Correlation	1	-.965**
	Sig. (bilateral)		.002
	N	384	384
Subsidies as benefits	Pearson Correlation	-.965**	1
	Sig. (bilateral)	.002	
	N	384	384

**. The correlation is significant at the 0.01 level (bilateral).

Table 4
Socio-economic stratum correlation - Tax reduction benefit.

		Socioeconomical strata	Tax Reduction
Socioeconomical strata	Pearson Correlation	1	.984**
	Sig. (bilateral)		.002
	N	384	384
Tax reduction	Pearson Correlation	.984**	1
	Sig. (bilateral)	.002	
	N	384	384

**. The correlation is significant at the 0.01 level (bilateral).

The article presented is the product of the research project whose purpose is the generation of a Public Policy for the integral management of electrical and electronic devices waste (EEDW) in the municipality of Armenia, Quindío. This document presents the stage related to the establishment of the current state of waste management of electrical and electronic devices (EEDW), particularly of refrigerators and televisions, in the municipality of Armenia, Quindío; as well as the analysis of the factors that influence their efficient management.

All this as an important input to propose the public policy factors that enable the efficient management of electrical and electronic devices waste (EEDW) in the municipality of Armenia, Quindío, being aware that it is in default to design EEDW management systems, as a commitment to reach scenarios of efficient management of residual fractions that reduce pressure on natural resources and final disposal rates in landfills.

Table 5
Socio-economic stratum correlation - Perform community social service.

		Socioeconomical strata	Do social service or community work
Socioeconomical strata	Pearson Correlation	1	-.983**
	Sig. (bilateral)		.002
	N	384	384
Realize social service community work	Correlación de Pearson	-.983**	1
	Sig. (bilateral)	.002	
	N	384	384

**. The correlation is significant at the 0.01 level (bilateral).

Table 6
Socio-economic stratum correlation - TV life cycle.

		Socioeconomical strata	Television set life cycle
Socioeconomical strata	Pearson Correlation	1	-.747**
	Sig. (bilateral)		.002
	N	384	384
Television set life cycle	Pearson Correlation	-.747**	1
	Sig. (bilateral)	.002	
	N	384	384

**. The correlation is significant at the 0.01 level (bilateral).

Table 7
Socio-economic stratum correlation - Refrigerator life cycle.

		Socioeconomical Strata	Refrigerator life cycle
Socioeconomical Strata	Pearson Correlation	1	.131**
	Sig. (bilateral)		.001
	N	384	384
Refrigerator life cycle	Pearson Correlation	.131**	1
	Sig. (bilateral)	.001	
	N	384	384

**. The correlation is significant at the 0.01 level (bilateral).

Table 8
Education correlation, socioeconomic stratum - EEDW disposal channel.

	Traditional EEDW managers	Distribution chain
R^2	,318	,296
Durvin-Watson	1824	1908
F	36,448***	30,692***
Educacional level		
β	,530***	,464***
Socioeconomical Strata		
β	,121*	,227***

EEDW efficient management.
*p ≤ 0.1; **p ≤ 0.05; ***p ≤ 0.01.

2. Bibliographic revision and state of the art

According to Ciocoiu, Colesca, and Popescu [5] on average between 30% and 40%, of the devices are collected and officially reported at European level, highlighting Poland, where the collection rate is slightly higher than 40% [6]. To boost an efficient system, it is also important to recognize the imaginary aspects of the population, since strategies that are attractive and that motivate integral management through formal collection systems must be formulated; In that sense, Li, Ge, Liang, and An [7] and later, Qu, Wang, Liu, and Zhu [8]; proposed establishing the preferences of residents for the collection of electronic waste in China, taking as reference the mobile devices it was possible to determine that the collection price and quality certifications are the aspects that motivate users to access formal collection systems. This allows us to assume that in order to offer compensation alternatives to the attributes expected by society, it is essential to guarantee conditions of formality and security.

At the Latin American level, research in relation to electrical and electronic devices waste(EEDW) dates mainly from the first decade of the 21st century, particularly by Egea [9] with the doctoral thesis entitled "Thermal decomposition of electrical and electronic materials", whose results were achieved through kinetic studies and the analysis of the pollutants generated during these processes.The experimental research, presents the development of kinetic models, which describe the process under the exposure of pyrolysis and oxidation processes, characterizing the main toxic emissions, highlighting some light hydrocarbons, chlorophenols, polychlorodibenzo-p-dioxin, which are considered environmentally persistent, with some effects on human health, such as carcinogenic diseases.

Fernández [10]; offers information on the management of EEDW in Argentina, Chile, Bolivia and Venezuela. Highlights the fact that at that time the strong need to establish a specific legal framework for the sustainable environmental management of Electrical and Electronic Devices (EED) in the southern cone was considered, because to date, they are still in the process of regulating the EEDW in some countries of South America, such as Venezuela and Uruguay.

The project developed by the RELAC Platform [46], offers a management protocol in the EEDW life cycle, with the proposal of minimum safety standards, which guarantee the protection and safeguard of the labor safety of the participants and the minimization of anthropogenic impacts towards the environment. Similarly, it presents a proposal that contains recommendations on legislative techniques, regulations for EEDW management systems and the creation of regional work spaces to incorporate the needs of different actors, also guaranteeing their timely discussion, approval and feedback.

Miquel Solé [11]; with his doctoral thesis, proposes a new model for collecting and recycling toys, which contributes to the collection and reuse. Children from schools were taken as an analysis unit and with the support from their teachers, awareness programs were developed to boost the system.

A pilot test was carried out in three municipalities in the province of Barcelona for three years, where an environmental evaluation was carried out that comparatively justified an ostensible decrease in the impacts of the proposed model in relation to the current system.

In the same way, an economic evaluation was established for the system, through the cost-benefit methodology, which includes some indirect benefits due to social and environmental externalities that make the proposal attractive from a sustainability perspective.

An extrapolation of the geographic and temporal order model was carried out to extend its application in Catalonia and Spain to collect toys for 10 years.

Rodríguez, González, Reyes and Torres [12]; based on the design of an algorithmic model, conducted simulations to understand the dynamics of EEDW management from the perspective of various policies. As one of the most significant results, it was recognized that the recovery system that predominates in Bogotá is the informal one, resulting in greater barriers to the optimal use of residual fractions, according to the research, "the amount of material that can be used after this process is less than more technified ones found in formal recycling". This study also asserts that the most effective policies are those of a preventive nature, since they affect the product design, by replacing polluting materials with others of less impact and with greater recovery potential, favoring, in the end, their recycling in operational terms and cost-efficiency.

In 2014, a doctoral thesis by Pérez [45] proposes the incorporation of the environmental requirement into the life cycle of EEDW applied to toys. This project takes into account the integrated product policy (IPP), which is part of the European regulatory framework and which focuses on analyzing the aspects that characterize production, distribution, consumption and final destination.

The research interest was to propose solutions for each of the phases and a collection of these disused devices was carried out. It was concluded that the toys within their designs do not take into account the impacts of the life cycle, since they incorporate complex disassembly systems, together with the incorporation of some materials that cannot be reused.

The aforementioned led to the consolidation of strategies aimed at the design of the products analyzed, which would enable the reduction of adverse effects at different stages and that included considerations to sensitize consumers.

The doctoral research of Ortuño [13] at the University of Alicante entitled "Thermal decomposition of electrical and electronic devices waste", addressed a study oriented towards the consideration of thermal processes for the degradation of residual currents.

The study presents different models, including the correlation kinetics for experimental data, through vaporization processes and chemical reactions. This allows the design of reactors to advance third-generation chemical processes, such as pyrolysis, which allows the separation of materials for reuse [14].

It is noteworthy that the experiments were based on the analysis of printed circuit boards, for having fractions with potential danger and other precious materials.

According to Jiménez [15]; the integral management of solid waste in Latin America has presented flaws in the instrumentation and conception as a public policy, in such a way that they have been systematically disjointed from a context, characterized by the radical increase in the generation of waste and final disposal in landfills, which has triggered a series of problems, including public health. This highlights the consolidation of a new regulatory framework that recognizes these particularities, generating financial and socially sustainable alternatives.

The investigation finally established that it is delayed in proposing comprehensive actions that address waste from an economic, social and environmental perspective, going to different programs, such as: separation in the source and classification of residual fractions, composting system, use and valorization, among others, which should be oriented towards the protection of the ecosystem from economic instruments that contribute to generate well-being in society.

Globally, the trend indicates a strengthening of the EEDW recycling potential, from the increasing investment, which went from the order of 10–22 billion dollars in 2010, to 26–58 billion dollars projected to 2020 and from 44.5 to 103.4 billion dollars planned for 2030 [2].

According to the research carried out by Kumar, Holuszko and Romano [16]; there is a linear relationship between the GDP of the nations and the waste of EED generated, in this way, the waste generated by each inhabitant increases to the extent that it improves well-being Individual and purchasing power.The research developed by the aforementioned authors also mentions that the life expectancy of electrical appliances is decreasing, mainly in small devices such as tablets and laptops.

Population growth turns out to be another risk factor to consider. Particularly in recent years, worldwide the number of people belonging

to the middle class has increased, which increasingly have greater purchasing power, helping to boost the consumption and disposal of EED. The research carried out by Awasthi et al., [17], demonstrates a strong correlation between GDP growth and EEDW volumes, using a simple linear regression model, with data from the European Union period 2009–2014. The model took the GDP as an independent variable and the weight of solid waste in tons as dependent, asserting that before an increase of 1000 Euros in the standard of purchasing power, 0.27 kg of collected waste and 0.22 kg of reused or recovered waste are generated.

Similarly, the investigation concludes that there is also a strong relationship between the volumes of EED residues (variable Y) and the population (variable X). The data obtained show an increase of 7.7 kilos of EEDW collected and 6.2 kilos of these devices will be reused or recycled, for each additional citizen.

This complex reality brings with it an ostensible increase in the amount of waste disposed, which deserves special treatment, in order to avoid irreversible impacts for society [18].

The global production of electronic devices, and in particular Information and Communication Technologies (ICT), faces the greatest industrial expansion in history: figures from the Organization for Economic Cooperation and Development (OECD) indicate that global trade in ICT reached 7.7% of the gross world product in 2004, mostly accumulated by China. It is estimated that in 2006, 230 million computers and one billion mobile phones were sold worldwide, corresponding to a volume of 5,848,000 tons [19].

Based on the National Survey on Quality of Life [20], regarding the possession of goods and services, it stands out that in 2017 93.9% and 86.5% of households said they had at least one type of television (conventional color TV, LCD, plasma or LED) and a refrigerator, respectively. According to the report, both devices presented a positive variation that can be considered statistically significant, which shows a high number of devices, which in a certain period of time, will enter the disuse phase and must be managed correctly.

Although progress has been made ostensibly in recent decades, Colombia does not have an adequate infrastructure for the use of EEDW, which imposes several challenges that must be solved from spin off processes, enabling the development of a public agenda that serves the peculiarities of the residual fractions of electrical and electronic equipment, as a problem with an exponential growth trend in the digital era [21].

The above helps to intensify the pollutant load, while mostly such residual fractions end up in sanitary landfills, resulting in multiple impacts, particularly due to their dangerous components [22].

Such connotation is part of a complex panorama worldwide; Generally, developing countries are characterized by final disposal in landfills, due to the low cost and simplicity of the process [23,24].

This scenario is worrying, especially when, according to the Superintendence of Public Home Services and the National Planning Department (2015), the landfill in Armenia has a useful life of less than five years, which highlights the need to guarantee recovery and exploitation actions that help reduce pressure at the final disposal sites.

In 2014, 252.2 kilo-tons of EEDW originated in Colombia, for a per capita production of 5.3 kilos (International Telecommunications Union et al., 2015). The Ministry of Environment - hereinafter Minambiente- (2016), points out that in 2014 the generation of 41.8 million tonnes of EEDW was generated throughout the planet; only 16% being properly managed.

For the Municipal Comptroller of Armenia (2017), in the 2016 period, all solid waste was disposed of in landfills, which shows the absence of strategies for use and recovery. In this way, it is necessary to strengthen the initiatives undertaken to increase the utilization rates, thus contributing to the conservation of the ecosystem.

As for electrical and electronic devices, figures on their use for the city of Armenia are not presented; At national level there is not enough information to recognize their current status. According to the estimates by the Minambiente (2016), the projected recycling rate of ordinary solid waste such as paper, cardboard, glass, metals and plastics, for the year 2018 will be 20%.

In this way, it can be assumed that the EEDW recovery rate hardly exceeds this threshold, and leaves the discussion open about the need to implement harvesting and recovery strategies that guarantee efficient management for these devices.

According to Minambiente (2017), EEDs can contain more than 1000 substances, from which around 3% can be considered potentially dangerous. What stands out within the composition of these products is the fact that on average 50% of the total EEDW composition is ferrous metals, such as iron and steel.

These metals are desirable in the national market for being potentially recoverable, being reincorporated into the production system, as second-order raw materials.

The benefits of this alternative, in addition to being an economic alternative generally developed by unqualified personnel that contribute to employment and income generation, are related to the minimization of rates of exploitation of natural resources, avoiding multiple impacts associated with intervention in the source -like the decrease in energy consumption-. However, recycling processes have not achieved maximum development, while challenges such as low investment in such sector, logistical problems and integrated smelting technology or refining facilities in areas close to urban areas persist [25].

Therefore, it is necessary to advance in the consolidation of an institutional framework that consolidates a system for the management and treatment of residual fractions. Since 2008, from the efforts made by the Ministry of Communications, with the study entitled “Pilot study of collection, classification, reconditioning and recycling of used Computers and printers carried out in Bogotá under the Project” inventory of e−waste in South America “from the Basel Regional Center”, through a collection campaign, allowed the collection, classification and characterization of some EED, determining the level of use from its potentially recoverable components.

In 2013, Colombia took a vital leap towards the integral management of EEDW, since it issued the first Law directly related to the issue, this is how Law 1672 of 2013 established guidelines for adopting an integral EEDW public management policy.

The sixth article of Law 1672 of 2013, establishes within the obligations that the Government must ensure that producers directly or indirectly develop actions that seek the collection and management of waste of the residues mentioned through the design of strategies and financial support, in the same way, it considers that producers must formulate efficient strategies for the effective return, reception and use of the devices and inform users about the prohibition of disposing of such devices through the traditional system of collection of household solid waste. Similarly, article nineteen determines that said elements cannot be disposed of in landfills.

The National Development Plan 2014–2018, in strategy three “To Improve the environmental quality from the strengthening of the environmental performance of the productive sectors, seeking to improve their competitiveness”, proposes the adoption of actions aimed at sustainable consumption, which recognizes the resilience of the ecosystem, as well as guaranteeing the reduction in the source, based on the increase in the utilization and recovery rates. Thus, within the aims of the planning instrument, it is announced that “the Law for Electrical and Electronic Devices Waste (EEDW)” (Congress of the Republic, 2015) will be regulated and implemented.

For its regulation, it is necessary to carry out a national and department diagnosis that provides updated information, in order to propose effective and timely strategies, since the most recent national information dates from 2014. In this sense, it is urgent to carry out rigorous studies that allow mapping a real scenario so that, based on the involvement and empowerment of various agents of interest, a structural system can be managed that can serve, in the long term, as a model in other regions.

In 2017, the advisory group of the National EEDW Committee, in

compliance with the precepts of Law 1672 of 2013, carried out a National Policy for the Comprehensive Management of EEDW, where from the recognition of the regulatory framework and a diagnosis of global and national level, they propose a strategic framework, as well as an action plan with strategies and lines of action, which will be periodically reviewed, with a projection until 2032.

The document proposes four strategies, sensitize responsible production and consumption; develop instruments for integral waste management; develop environmentally safe infrastructure; and boost public-private partnerships for the benefit of the system.

Each strategy defines goals for the short, medium and long term, with their respective compliance and responsible indicators. Where it stands out, among others, in the medium term, to design and apply an information collection instrument that captures estimated data on EEDW generation in Colombia.

Recently, Decree 284 of 2018 was passed, which adds to the regulations of the Environment and Sustainable Development Sector, related to the management of EEDW, ratifying the restrictions, commitments and sanction regime established in the applicable regulatory framework.

For its part, the 2016–2019 "Let's move forward" development plan of the city of Armenia, considered the ICT and Environment subprogramme, which aims to develop awareness and promotion activities for the good management of EEDW, with a projected budget of $ 83, 672, 540 COP, for the legislative period.

In this way, the municipal administration intends to advance actions that contribute to the proper management of residual fractions. This means an opportunity to articulate research from the academy, aiming to generate critical mass for the consolidation of a new order against the management of EEDW.

3. Method

3.1. Design

For its realization the study considered a correlational investigation, based on the Pearson coefficient, coefficient of determination and the Durvin-Watson test, in which socio-economic variables associated with the efficient management of the refrigerator and television waste of home users were addressed in the city of Armenia.

The investigation was carried out by collecting information in situ, which was carried out on people in the city of Armenia. It is worth clarifying that the collection instrument was applied during the first half of 2018.

The municipality of Armenia, capital of the Department of Quindío, is an intermediate city, located in the central west of Colombia, on the coordinates 4.5170° north latitude and 75.6830° west [31]

3.2. Participants

For its realization, the study considered a correlational investigation, based on the Pearson coefficient, coefficient of determination and the Durvin-Watson test, in which socio-economic variables associated to the efficient management of the refrigerator and television waste by home users were addressed in the city of Armenia.

The investigation was carried out by collecting information in situ, which was carried out on people in the city of Armenia. It is worth clarifying that the collection instrument was applied during the first half of 2018. The information used here is part to the doctoral research entitled "Diseño de un sistema para la gestión de los RAEE en las IES en el municipio de Armenia, Colombia".

The municipality of Armenia, capital of the Department of Quindío, is an intermediate city, located in the central west of Colombia, on the coordinates 4.5170° north latitude and 75.6830° west [31]

3.3. Instruments

For the preparation of the instrument, the criteria and variables established in the special regulatory framework for EEDW in Colombia and Latin America were taken into account.

Likewise, the reports presented by official entities at national, departmental and local level, such as the Ministry of Environment, National Planning Department, and Comptrollers, which relate to certain criteria to consider, in order to promote an EEDW sustainable environmental management system, being a common denominator, among them, variables such as: availability to pay or accept benefits, life cycle and final destination of EEE that are in the market.

Within the investigative processes carried out in other cities and which have been successful, the urgent need to consider the implementation of management systems involving initiatives, policies is established: legal, operational and financial, among others; all this in order to prevent consumption, and improve the use and safe final disposal, thus contributing to the prevention of certain impacts on the environment and human health [26].

According to the Relac Platform (2011), it is suggested that when structuring a EEDW management system, aspects related to the life cycle, collection and treatment, and monitoring and control be considered; that under an administrative and financial framework, it will help boost the efforts of the different stakeholders in complying with the regulatory framework.

Similarly, information was collected on the willingness of respondents to receive incentives and benefits that facilitate favorable management of the waste under analysis.

The European Union Directive on EEDW, 2002, classifies electrical and electronic products or devices into 10 categories; of these ten categories, refrigerators and televisions were selected, taking into account that they are devices with a presence in homes, according to DANE [20]; 86.5% of households surveyed in 2017, have a refrigerator, which represented an increase of 2.1% compared to 2016.

Likewise, when comparing the results of said survey with other referents, highlighting the diagnosis of household electrical appliances and consumer appliances, carried out by Blaser and Empa [27]; it is concluded that of the total number of appliances considered, 34% and 23% of imported products correspond to refrigerators and televisions, respectively.

The devices that show a greater weight with respect to the totality of the analyzed equipment, also present a potential of significant contamination. Above all, it is noted that refrigerators and televisions, which lead the list with 34% and respectively 23% of the total weight, have a high potential for contamination [27]; p. 17).

Due to the interest represented by the aforementioned devices, the decision was made to analyze their management from the perspective of home users, in order to provide relevant data that serve as input for decision-making agents related to the issue, in public and private order.

4. Discussions and results

Next, the analysis of the variables that are part of the instrument applied in the investigation and that account for the variables mentioned in the materials and methods section is presented.

The relationship between the socioeconomic stratum and the willingness to pay taxes, as a sanctioning strategy, for actions that go against the applicable regulatory framework; denotes a statistically significant correlation and a strong positive relationship. In that sense, there is a greater willingness to pay taxes in higher socioeconomic strata, while in the pyramid base the aversion to the payment of tax rates is evident.

Regarding the relationship between the willingness to receive subsidies as benefits for delivering EEDW to companies authorized for efficient management, a strong negative relationship is observed, which results in recognizing an inversely proportional relationship.

In that sense, people located in the socioeconomic strata that form

the pyramid base prefer to receive subsidies, while the greater the socioeconomic status, the lower the preference to receive subsidies as consideration for carrying out comprehensive waste management.

By observing the correlation between the socioeconomic stratum and the willingness to accept the decrease in the payment of taxes, as a stimulus to carry out a management in favor of the conservation of the ecosystem, a strong and significant positive relationship is recognized; therefore, when formulating schemes that promote favorable waste management; It should be borne in mind that people in socioeconomic strata four, five and six have a greater willingness to receive tax benefits than people in lower strata.

The Pearson coefficient allows inferring the presence of a strong inverse relationship, being statistically significant; therefore, when considering the types of non-economic sanctions, which should be imposed from public policy, it should be borne in mind that the population with less income prefers to perform social service or community work, since they do not efficiently manage EEDW, while the higher the level of socioeconomic status, the lower the willingness to perform this type of action. In this way the arguments described in the investigation are reaffirmed, which shows that the population with higher incomes are more prone to paying taxes.

In relation to the life cycle of televisions, a moderate inverse relationship is observed, which leads to the assumption that the greater the socioeconomic stratum, the shorter the useful life of these devices in homes.

In strata five and six, which represent 11.46% of respondents; the average useful life is between seven (7) months and twelve (12) months; while in strata one and two, which represent 50% of the sample; The average time of use of such devices is more than twenty-five (25) months.

Regarding the life cycle of refrigerators; there is no significant correlation with the level of socioeconomic strata. According to the low ratio, expressed by the Pearson coefficient (0.131), it is not possible to assume that there is an association between both variables. This is due to the fact that in a transversal way to the population, refrigerators are considered as a product with an extended useful life; In fact, the results of the investigation indicate that 98% of the respondents change their refrigerators in their homes, in a period exceeding 25 months.

The table above lists the linear regressions between the level of education, belonging to the socioeconomic stratum and the efficient management of EEDW, through the managers or directly through the distribution chain (producers and traders); the latter, obliged to have channels for the reception of said waste, according to the terms provided in Law 1672 of 2013.

In all cases, the models in general have a highly significant global relationship. In addition, it was evident in the regression coefficients typical of the socioeconomic stratum, mainly through the traditional distribution ecosystem, a significant explanation of the variance in the orientation to efficient management.

The level of education has positive and significant coefficients for the integral management of the observed devices ($\beta =$, 530 *** with $p \leq 0.01$) with a highly significant global validity ($F = 36{,}448$ ***), in this way it is assumed that at a higher level of education, greater environmental awareness is acquired. Similarly, the socioeconomic stratum to which the subject belongs also significantly influences the consideration of EEDW managers as a disposal method. ($\beta =$, 121 *, with $p \leq 0.1$).

Finally, the second model (traditional distribution chain) explains a significant amount of variance, in the orientation to the traditional distribution chain; as an accepted system of disposition ($F = 30{,}692$ ***), with regression coefficients of the variable level of education, significant enough ($\beta =$, 464 ***, with $p \leq 0.01$); In contrast to what happened in the first model, the socioeconomic stratum has a better level of significance ($\beta =$, 227 ***, with $p \leq 0.01$).

5. Conclusions

With the advent of computer science and the era of knowledge, a series of events have arisen that have deepened a serious problem around the indiscriminate production of waste, without taking the required corrective and preventive actions. These circumstances, which have been gaining increasing importance due to their high degree of impact and pollution in the environment, have forced the scientific community, and society in general, to give greater importance to the production and excessive use of elements of electronic origin, taking into account the risk, impact and damage the concentrations of electronic waste or technological waste may have in human health and the environment, conceived as a set of hazardous waste due to the presence of some toxic compounds in its structure (ie heavy metals, plastics with brominated flame retardant materials), from waste such as televisions and refrigerators, among other types of appliances that have been consumed or discarded.

Without a doubt, the accelerated process of economical growth due to the high consumption rates, especially that of the technology and information technology industry, has triggered a new social and environmental crisis, which forces us to adopt measures aimed at implementing controls and monitoring of waste, through the implementation of efficient collection systems and the guarantee of an environmentally friendly treatment. Given this scenario, it is essential to implement measures based on the precepts of the environmental economy, which facilitate the adoption of management mechanisms that are based on the availability to be paid or accepted by users, in relation to the impacts they cause; from the results achieved, various public policy instruments may be implemented, among which were observed, those of direct control (payment of sanctions) and other market-oriented ones (taxes, non-pecuniary sanctions).

The results indicate greater acceptance among strata four, five and six, to receive benefits associated to the decrease in the payment of taxes, for efficient management, as well as paying tax rates for actions against the applicable regulatory framework; unlike strata one, two and three, which have a greater preference for subsidies as an alternative to stimulate the correct disposition; while they agree on performing social service as a possible punishment.

One of the main concerns of emerging countries has been the issue of access to information and communication technologies as a mechanism to reduce high rates of exclusion and illiteracy, such a situation has led to the adoption of a speech in which the extreme need to achieve higher rates of ICT penetration is promulgated, a situation that led to the non-consideration of some externalities from such massification.

Even though progress has been made ostensibly in recent decades, the reality of Colombia, where there is no adequate infrastructure for the use of EEDW, imposes several challenges that must be solved from spin off processes, enabling the development of a public agenda that addresses the particularities of the residual fractions of electrical and electronic equipment, as a problem with an exponential growth trend in the digital age.

In addition, the information on the life cycle of refrigerators and televisions is key to the efficient design of device collection systems, since it allows recognizing, in the case of televisions, a tendency for strata four to six, the life cycle is less than in the lower strata; therefore, the actors that are part of the environmental management system should focus their efforts on the population with the highest purchasing power, while a greater flow of discarded devices is likely to occur. In the case of refrigerators, when a significant relationship is not observed, it is inferred that it is a long-lasting device.

In relation to the education correlation, socioeconomic stratum versus the chosen EEDW disposal channel, it is concluded that the level of significance of the statisticians, of education is better for EEDW Managers, in relation to the explanation of the variance for efficient management of EEDW ($F = 36{,}448$ ***, $\beta =$, 530 *** with $p \leq 0.01$), than for the traditional distribution chain ($F = 36{,}448$ ***, $\beta =$, 464 ***,

with $p \leq 0.01$). Contrary to what happens with the level of education, the socioeconomic stratum is less significant in EEDW Managers ($\beta =$, 121 *, with $p \leq 0.1$) than in those of the traditional type ($\beta =$, 227 ***, with $p \leq 0.01$). The latter suggests that belonging to the socioeconomic stratum has more influence on the orientation to the efficient management of the devices.

It is considered imperative to carry out socialization processes in society and raise awareness about the high impact generated in the ecosystem as a result of the excessive increase in the generation and consumption of EEDW, for this purpose we must go to various disciplines, so that it is possible to build an environmental mindset that understands the genesis of the problem and makes it possible to overcome the environmental crisis through new civilization bases, which as a result can modify the current consumption paradigm.

Declaration of competing interest

The authors declare that the paper is unpublished and there are no copyright problems Cordially.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.techsoc.2020.101450.

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