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Analysis of green technology information from the perspective of individual's socio-environmental awareness

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Abstract: This study's objective was to analyze the influence of Green IT practices associated with individuals' perceptions regarding the conscious purchase, use, and post-use of technological equipment on minimizing IT environmental impact. An intervention instrument was applied among IT users. The model developed with Structural Equation Modeling (SEM) indicates that the practices: purchasing IT from "green manufacturers," economic efficiency of technological use, and properly discarding technological equipment make individuals more aware of technology environmental impacts. This study's main contribution concerns a scale to assess information technology sustainable actions from an individual perspective. The results can raise the scientific community's interest in developing new studies from this perspective.

***Keywords*:** Green Information Technology; Environmental impacts; Technological socio-environmental awareness; Green IT Practices; Structural Equation Modelling (SEM).

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1. Introduction

The concern with the environment, which in the past was based on personal reasons, not considering the collective benefit or future generations, started, from the 1970s onwards, to rely on the ecological movement, including conventions and conferences to deal with environmental issues, disseminating and raising the awareness of citizens toward environmental preservation (DU PISANI, 2006). Amidst ecological debates, a recurrent subject was, and still is, sustainable development, which concerns a notion that development cannot be stopped; however, current needs cannot compromise the means of future generations to meet their own needs (WCED, 1987).

With society's progress, the advancement technology has recently witnessed has not only resulted in benefits but also led to environmental damage (MURUGESAN, 2008) due to the poor use of resources, excessive energy consumption, electronic waste caused by the disposal of old and/or outdated appliances, increasing waste and technological scrap (NANATH; PILLAI, 2014; SANTOS, 2020). Since the first editions of "The Global E-waste" report, pollution generated by technological devices continues to grow despite attempts to reduce it. For example, in 2019, only 17% of 53.6 million tons of electronic waste were properly disposed of (FORTI et al., 2020).

Green Information Technology (Green IT) emerges as an attempt to control the problems caused to the environment by Information Technology (IT). It is based on the need to preserve natural resources, mitigate environmental damage, and raise awareness of those creating new technologies and home users (PRZYCHODZEN et al., 2018). Due to the subject's relevance, the debate regarding Green IT has gained attention. For instance, Freitas et al. (2020) concluded that not adopting Green IT practices causes a waste of resources and money and Dias et al. (2017) list the benefits resulting from adopting Green IT practices, including the saving of energy and reuse of devices, by extending their useful life, and decreasing the consumption of inputs, resulting in reduced pollution. However, Santos et al. (2020) note that the concern with the environmental impact of IT-related practices tends to focus only on the financial aspect, which prevents individuals from reflecting upon the use and discard of the equipment they use.

Devising a way to develop technology and enjoy its benefits while not disregarding socio-environmental awareness is the context on which this study was based. In 2019, the "digital world" corresponded to 34 billion devices, with 4 billion users; the use of domestic equipment, not only in organizations, is one of the primary sources of environmental degradation (BORDAGE, 2019). Hence, further research is needed to gather knowledge, mainly from the perspective of technology users, and seek a way to sensitize users to promote greater harmony between them and the environment. Raising awareness among users is especially relevant because it generates pressure on other spheres of society to adopt sustainable measures, fostering a culture capable of change (YOON, 2018). Unfortunately, even today, there is a lack of engagement and dissociation from the real benefits of Green IT and doubts about what Green IT practices are (ROSA; SMEK, 2017).

As for how society relates with Information Technology resources, organizations are nothing more than a scaling of individuals' purchasing, use, and disposal profile, though organizations use more diversified and powerful equipment, which cause a more significant impact on the environment. Nevertheless, we may assume that ecologically conscious individuals match their personal values with the organizational values; hence, reinforcing the notion, adoption, and dissemination of green IT practices (MARTIN et al., 2020). Considering the previous discussion, this study's objective was to expand knowledge regarding green IT and the users' relationship with Green Information Technology. Hence, this study presents an analysis of how Green IT practices influence the conscious purchasing, using, and disposing of technological equipment from the perspective of individuals to minimize the impact caused by technology on the environment.

2. Theoretical Framework

Green IT represents a set of practices that seek efficiently and effectively transform the production, use, and disposal of technology with minimum or no negative impact on the environment (MURUGESAN, 2008). Technology itself has been considered a destructive factor for the environment; however, with Green IT, something previously regarded as problematic, becomes a solution, considering that this new technology strategy seeks to meet both present and future needs (LOOS et al., 2011), while the optimism generated with technological revolutions may ensure a sustainable development scenario (SILVA, 2014). However, the ability to combine development with socio-environmental wellbeing depends on changing attitudes of governments, organizations, and citizens, or in other words, it depends on raising the society's socio-environmental awareness (SANTOS; VALENÇA, 2011).

In this case, Koo et al. (2015) affirm that technology users have awakened awareness toward Information Technology actions, showing the importance of understanding the impact of these actions on society. Knowledge from the perspective of Green IT users is incipient, and the literature is taking its first steps as no studies have specifically addressed this subject from this perspective (ZWICKER; LÖBLER, 2018; DALVI-ESFAHANI et al., 2020). However, we may say that the transformation of users into ecologically conscious individuals has raised interest in the study of practices in this field. Individuals become aware that their actions and choices toward technological devices impact the environment (MAIA, 2014) and play a crucial role in developing and disseminating green practices.

The literature addressing the relationship between IT and Green IT users is still incipient, and such practices have not been addressed from the users' perspective. For this reason, this study analyzes those practices reported in user guides developed by Information Technology organizations such as the *Guia do Usuário Consciente de Produtos Eletrônicos* [Electronics Eco-Conscious User Guide] developed by Guimarães (2011), which classify conscious purchase, use, and post-use. Additionally, the literature review by Ixmeier and Kranz (2020) highlights that studies addressing Green IT from the users' perspective are currently segmented into pre-use, use/adoption, and post-use technology.

Therefore, it was possible to determine the “green actions” an individual can perform when engaging with technology and this view is explained below:

An Eco-Conscious Purchase is based on the perspective of new equipment acquisition. For example, when buying new equipment, consumers research whether manufacturers use recycled raw material or material with a low rate of degradation (KERN et al., 2011) or investigate the existence of recycling programs, with a reverse logistics cycle, in which users may properly dispose of products after they become obsolete. Additionally, from this perspective, individuals should consider whether there is a real need to acquire new equipment, considering the possibility of extending the use of old devices (CAMPOS; OLIVEIRA, 2011).

The Conscious Use of energy is a relevant factor addressed by Green IT. It is based on the awareness that unnecessary use of electricity can be avoided, and there is a concern on how to use a technological device such as turning it off and unplugging it after its use; avoiding printing documents, unless really necessary, adopting double-sided printing, and using recycled paper (PINTO; SAVOINE, 2011). Finally, individuals must consider using devices that demand less power and always verifying the availability of multifunctional products or customized versions (KERN et al., 2011).

Finally, regarding Conscious Post-Use, despite laws demanding reverse logistics, most industries do not properly discard their material due to lack of information or negligence. Therefore, it is up to consumers to be concerned with the disposal of electronic waste, avoiding unnecessary equipment replacement, swapping products with other consumers, and seeking specialized e-waste recycling facilities (PINTO; SAVOINE, 2011).

The environmental damage caused by the purchase, use, and post-use of technological equipment results from the actions of users; hence, society must reflect upon today and tomorrow. Salles et al. (2016) note that the challenge of discussing Green IT is not only technological. Raising socio-environmental awareness toward green practices does not only benefits individuals at a personal level, but the entire society, impacting it at various levels (AMÉRIGO et al., 2017), even disseminating behavior that benefits the environment (ALMEIDA et al., 2017), and supporting analyses of the damage caused by technology on the environment.

3. Method

A research-diagnosis (ROESCH, 2013) approach was adopted with a quantitative survey. The intervention instrument was developed in the form of a form composed of 26 statements rated on a 5-point Likert scale. Likert scales are widely used in surveys, and a 5-point scale is preferable because it confers greater reliability with a good range of options, facilitating understanding and not boring respondents (LISSITZ; GREEN, 1975).

The instrument’s statements were segmented, highlighting situations related to individual behavior concerning the acquisition, use, and post-use of technological devices. The statements were also intended to encourage the respondents to reflect upon green IT practices and decrease the harmful impact on the environment. Note that the statements were based on a questionnaire developed by Lunardi et al. (2014); however, this questionnaire focused on the practice of organizations. For this reason, we adapted the statements and created new ones so that the variables would focus on users. Therefore, this instrument was based on theory, especially on the studies by Guimarães (2008), Pollack (2008), Loss et al. (2011), and Pinto and Savoine (2011).

Thus, an online instrument was developed and used to collect data in this study. It was applied to participants from social networks using a Google Drive tool. First, a pre-test was applied. During approximately one month, 30 social network users were conveniently selected to complete the instrument. After analyzing the feasibility of the instrument's adaptations, resulting from the answers obtained, data collection was initiated using the Google drive forms. Cross-sectional data were collected. The form was available online for a non-probabilistic sample from February 22nd, 2016, to May 17th, 2016; the link granting access to the instrument was disseminated in the social media, mainly Facebook, so that any individual could participate.

Primary data were collected from a sample of 265 respondents. Data were filtered to identify outliers, and 12 individuals were excluded for not properly completing the questionnaire. Furthermore, the Common Method Bias was adopted following the guidelines proposed by Podsakoff et al. (2003). Therefore, the confidentiality of the respondents' identities was ensured, and they received clarification on how to complete the questionnaire, including the concept of Green IT. In addition, the statements concerning the dependent variable were separated from those concerning independent variables. Finally, Harman's single factor test was performed, and its result indicated that more than one factor explained most of the variance (50% or more), implying that the study does not present a common method bias.

Therefore, after filtering data, the final sample remained with 253 respondents, which is adequate considering that at least 10 participants were needed for each variable addressed (FIELD, 2020). Table 1 presents the sample's characteristics.

Table 1 – Sample characterization

Characteristic	Total	Percentage
Age Group		
Up to 18 years old	8	3%
19 to 24 years old	80	32%
25 to 29 years old	55	22%
30 to 35 years old	51	20%
+ 36 years old	59	23%
Sex		
Female	134	53%
Male	119	47%
Education		
Middle School	0	0%

High School	37	15%
Higher Education	128	50%
Graduate studies	88	35%
Total	**253**	**100%**

Source: Study's data.

The analysis of data was predominantly quantitative. Assuming that the literature does not present a set of Green IT practices from the user's perspective, exploratory factor analysis was performed to investigate the actions the respondents reported as Green IT practices. SPSS v.20 was used in this analysis, enabling descriptive statistics techniques to present data. Next, SmartPLS 3.0 was used for the Structural Equation Modeling (SEM), which can be considered an extension of multivariate techniques, based on theory (SCHREIBER et al., 2006), which can prove the existing theoretical relationship between Green IT practices performed by individuals and the consequences on the environment caused by the purchase, use, and post-use of technological equipment.

4. Results

At first, data analysis was intended to explore and validate Green IT practices adopted by the respondents. After validation, the influence of these practices in terms of the impact they cause was analyzed.

4.1 Green IT practices from the users' perspective

The factor analysis procedures included extracting factors using the principal components method. Because this study addressed a seldom-explored perspective, the principal components method enabled the first few dimensions to explain most of the information collected (LATTIN et al., 2003). Additionally, the varimax rotation technique was followed by confirmation with an oblimin rotation, and the variables were grouped in the same way in both analyses. First, the varimax rotation and then oblimin rotation did not present differences in the values, presenting the same number of factors. Thus, we proceeded with data analysis based on the data obtained by the varimax rotation because it is a comprehensive and simplified approach to interpreting results. Additionally, the rotation model is usually adopted by studies addressing Information Technology (LUNARDI et al., 2014).

The constructs obtained in the factor analysis were conceptualized and characterized to discuss the details of practices and present the instrument's statements that form the factors. Note that the respondents rated their answers on a 5-point Likert scale ranging from (1) I do not adopt this green practice to (5) I always adopt this green practice. The following constructs were identified:

Purchasing technological equipment from a "green manufacturer": this factor encompasses statements that concern the acquisition of technological devices, making ecologically conscious purchasing choices. Note, however, that in this factor, the respondents analyze the behavior of suppliers of the equipment they wish to buy. The following statements compose this factor: verifying whether the manufacturer adopts actions aiming at the rational use of natural resources during the production of goods; verifying whether the manufacturer has an electronic waste takeback program or refers clients to an e-waste system after the end of equipment's useful life (scheduled disposal); and verifying whether the manufacturer encourages the recycling of computer products (e.g., paper, cartridges, computers).

Conscious printing: practices that concern ecologically conscious use. This construct represents an important practice of individuals: printing documents. It concerns the use of printers; whether there is a real need to print a given document, and any attempt to optimize the process by using sustainable resources. It is composed of the following statements: printing in black and white whenever printing a document is necessary, setting the printer in the economic mode whenever printing is necessary, and double-sided printing whenever printing is necessary.

Economic efficiency of technological use: practices related to eco-conscious use. The analysis of this factor portrays the way users show concern with the economic use of technological equipment, regarding the use of computers. It comprises the following statements: setting the computer in energy-saving mode (sleep or stand-by mode), complying with the manufacturer's guidelines to extend battery life or your laptop computer (notebook. Netbook, or tablet); and setting the monitor in power-saving mode (display contrast reduction).

Proper disposal of Electronic Devices: related to eco-conscious post-use. This construct concerns practices to properly dispose of technological equipment, regarding extending a device's useful life by donating it or by discarding it so that the material will be recycled or not harm the environment. The following statements compose this factor: extending the useful life of components by donating devices so that parts can be used to repair other IT equipment; properly disposing of technological equipment and its inputs, and taking equipment to an authorized recyclable waste facility in your city.

Once the factors were identified, a one-dimensional factor analysis (within block) was performed to validate data, confirming that the constructs are in agreement with the literature concerning adaptation for the eco-conscious purchase, use, and post-use of equipment. Note that in addition to these four factors, another factor was found concerning a reflection upon Green IT practices, enabling to verify the impact of these practices on the environment. This last factor was called Minimizing IT environmental impact, which is the dependent variable in the Structural Equation Modeling, developed at the end of the analysis.

Regarding the exploratory factor analysis validation, the sample presented an acceptable degree of adequacy of the factorial test, according to the KMO=0.773, indicating a high level of correlation among the model's variables. Another aspect to be highlighted in the analysis is the exclusion of dissonant statements due to their negative impact on reliability, factor loadings, and commonalities. Ten of the 26 questions were excluded to obtain reliable and relevant factors.

Continuing the analysis validation, we verified the convergent and discriminant validity of the factors. Hence, cross-loadings for all the instrument's questions showed that the items' factor loadings were higher in their respective constructs. Discriminant validity was complemented by Cronbach's alpha and composite reliability, indicating the items' reliability. Convergent validity was verified using Average Variance Extracted (AVE) considering the criterion proposed by Fornell and Larcker (1981), indicating that the questions that belonged to each construct should explain at least 50% of it. Table 2 shows that the indexes of both validities comply with the literature.

Table 2 – Assessment of the constructs: convergent and discriminant validities

Construct	a	CR	AVE	Purch - Tec	Enviro - Impact	Dispo - Tec	Econ - Tec	Consc - Print
Purch_Tec	.87	.92	.80	.89				
Enviro_Impact	.71	.82	.53	.42	.73			
Dispo_Tec	.71	.84	.63	.36	.33	.79		
Econ_Tec	.75	.86	.67	.40	.46	.25	.82	
Consc_Print	.64	.81	.58	.20	.22	.24	.40	.76

Source: Study's data.

Notes:

a = Cronbach's alpha

CR = Composite reliability

AVE = Average Variance Extracted

Purch_Tec = Purchasing technological equipment from a "green manufacturer"

Enviro_Impact = Minimizing IT environmental impact

Dispo-Tec = Proper disposal of electronic devices

Econ-Tec = Economic efficiency of technological use

Consc_Print = Conscious printing

Next, the existence of multicollinearity or collinearity between the variables was verified. According to Hair Jr. et al. (2009), it can be done by calculating the variance inflation factor (VIF) between the statements. Values above 5 indicate the presence of collinearity, and above 10 indicate the occurrence of multicollinearity. None of these two cases was verified in the variables considering that VIF values were between 1.176 and 2.874.

Once the factors corresponding to the IT users' green practices were presented, conceptualized, and validated, a descriptive analysis was performed to identify the aspects most frequently considered by the respondents. Table 3 shows each factor's mean and standard deviation and respective items. Note that the descriptive statistics of the construct Minimizing IT environmental impact are presented at the end of the results.

Table 3 – Descriptive analysis of factors and items

Item	Mean	Standard Deviation
Conscious printing	4.35	0.70
Printing in black and white whenever printing a document is necessary	4.61	0.67
Setting the printer in the economic mode whenever printing is necessary.	4.28	1.01
Double-sided printing whenever printing is necessary.	4.17	1.05
Economic efficiency of technological use	3.51	1.07
Setting the computer in energy-saving mode (sleep or stand-by mode).	3.59	1.31
Complying with the manufacturer's guidelines to extend the battery life or your laptop computer (notebook. Netbook, or tablet).	3.52	1.30
Setting the monitor in power-saving mode (display contrast reduction).	3.42	1.32
Proper disposal of Electronic Devices	3.22	1.11
Extending the useful life of components by donating devices, so that parts can be used to repair other IT equipment.	3.54	1.32
Properly disposing of technological equipment and its inputs.	3.42	1.40
Taking equipment to an authorized recyclable waste facility in your city.	2.70	1.45
Purchasing technological equipment from a "green manufacturer"	2.40	1.06
Verifying whether the manufacturer encourages the recycling of computer products (paper, cartridges, computers).	2.47	1.24
Verifying whether the manufacturer adopts actions aiming at the rational use of natural resources during the production of goods.	2.39	1.12
Verifying whether the manufacturer has an electronic waste take-back program or refers clients to an e-waste system after the end of equipment's useful life (scheduled disposal).	2.36	1.22

Source: Study's data.

Interpretation of the results from the descriptive analysis shows that the individuals adopt sustainable actions concerning conscious printing (4.35), with significant differences. The practice most frequently disseminated was printing documents in black and white (4.61), though all the actions concerning this construct obtained a mean higher than 4.10. A comparison between these results and literature in the field, considering data obtained in interviews and questionnaires applied by Pinochet et al. (2015), Salles et al. (2016), and Matsuda and Pinochet (2017), shows that printing practices, specifically double-sided printing, are widely disseminated in the professional and educational spheres and also in the users' routine.

An analysis concerning the economic efficiency of technological use and proper disposal of electronic devices revealed similar practices among users, except for taking electronic equipment to an authorized recyclable waste facility, which obtained a mean of 2.70. It indicates that either the individuals do not adopt this practice or cities do not have or disseminate these e-waste systems.

Finally, the respondents obtained the lowest mean in the analysis individuals perform of the manufacturers' behaviors when acquiring new technological equipment (2.40). The respondents revealed they are not concerned with the "origin" of the product they want to buy, so it interferes little in their purchasing decision, i.e., the respondents are not interested in knowing whether the manufacturer uses sustainable resources, encourage the recycling of products, or provides a system to collect old equipment. Santos et al. (2020) also found an opportunity in this aspect as they verified that these are practices not always adopted by manufacturers.

4.2 IT environmental Impact

The construct Minimizing IT environmental impact was intended to understand the individuals' perception of the impact information technology cause on the environment by analyzing ways to reduce damage to the environment. Its definition is:

Minimizing IT environmental impact: this factor reflects the individuals' attitudes when purchasing, using, or discarding technological equipment, considering the consequences it causes on the environment. It concerns a sense of responsibility and equity toward future generations, doing the best use of devices, optimizing their consumption, and understanding that reducing environmental damage not only promotes monetary benefits. It is composed of the following statements: My actions toward IT consumption will benefit future generations; I am generating less technological waste than I used to; I am consuming less electricity than I used to, and I am paying more for products that cause less harm to the environment.

The descriptive analysis (Table 4) shows the most relevant attitudes of users toward technology.

Table 4 – Descriptive analysis: Minimizing IT environmental impact

Item	Mean	Standard Deviation
Minimizing IT environmental Impact	3.55	0.84
My actions toward IT consumption will benefit future generations.	3.74	1.05
I am generating less technological waste than I used to.	3.61	1.19
I am consuming less electricity than I used to.	3.59	1.20
I am paying more for products that cause less harm to the environment.	3.28	1.14

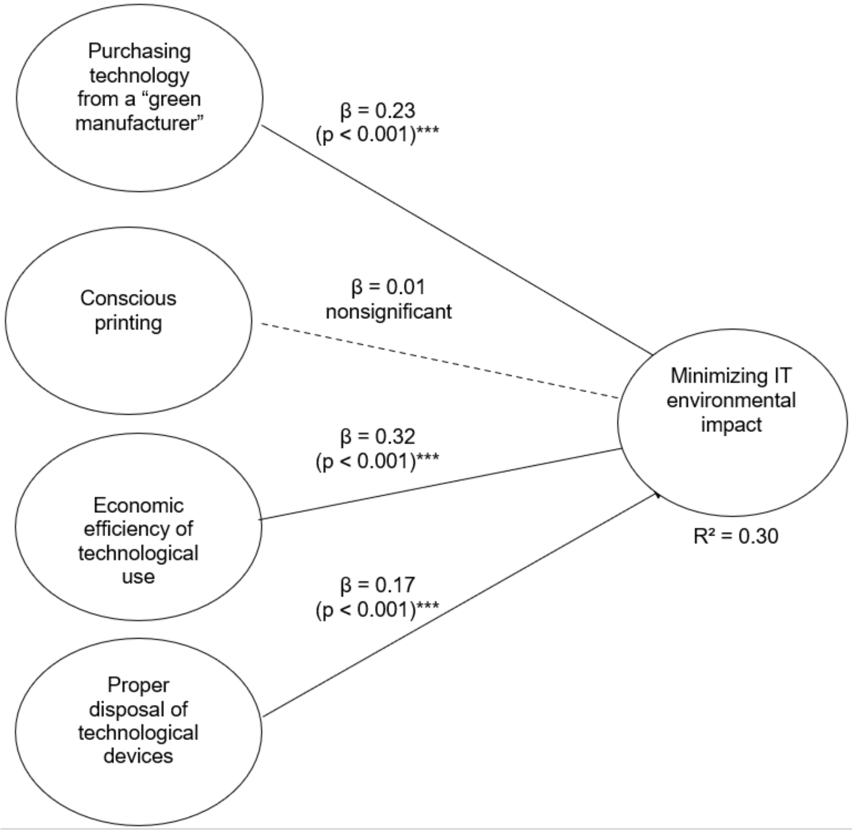
Source: Study's data.

The statements obtained a mean higher than 3.0, indicating that users are concerned with the impact of their actions on the environment and social wellbeing. It reflects a positive attitude as individuals assess their actions toward the consumption of technology and its consequences for future generations (3.74). Other noteworthy aspects include reducing technological waste (3.61) and power consumption (3.59), both with similar means. Analysis of the economic aspect addressed in part of the statements shows that the financial aspect interferes in the actions of users because as the individuals adopt environment-friendly practices, they also save money, which is aligned with the principles of sustainable development. However, there is some room to increase and disseminate the practice of paying more to be "green," as the individuals obtained the lowest mean regarding spending more for products with a lower impact on the environment (3.28).

Finally, the Structural Equation Modeling was performed to investigate the influence of the practices identified here and their relationship with minimizing IT environmental impact. Hence, bootstrapping was used to estimate the statistical significance of the parameters and relationships. In this procedure, simulations are performed with the data set to obtain the result of the Student's t-test, measuring the significance of the relationships. Blindfolding was also used to analyze the indicators measuring the quality of the structural model.

Bootstrapping test was performed with 500 bootstrap replications at 5% ($p < 0.05$), 1% ($p < 0.01$) and 0.1% ($p < 0.000$) significance levels. Therefore, the test results should be higher than 1.96, 2.58, and 3.29 to indicate significance between the relationships (HAIR JR. et al., 2009). Figure 1 shows the structural model, indicating the constructs' path coefficients. The model is considered formative because of the nature of the construct addressed here, i.e., change in one of the green practices causes a variance in the impact generated, while one practice does not depend on the other; hence, the characteristics of a formative model (PODSAKOFF et al., 2003; DIAMANTOPOULOS, 2011).

Figure 1 – Structural model of technological socio-environmental awareness from the perspective of IT users



Source: Developed by the authors.

*p < 0.05; *p < 0.01; ***p < 0.001

The interpretation of the model's results shows that only the construct "conscious printing" was not statistically significant ($p < 0.39$), indicating that the practices involving the use of printers are not perceived as practices that decrease the damage caused to the environment, though the respondents do adopt these practices. This finding shows a need to inform people that double-sided printing saves a considerable amount of paper. It is necessary to clarify that in addition to power consumption, the paint, toner, and cartridges used in printing (regardless of whether black and white or color paint are used) are harmful because the production and improper disposal of this material are harmful (LETLONKANE; MAVETERA, 2014). Sustein and Reisch (2014) note that printing both sides is a practice people adopt without realizing its importance, i.e., these practices have been so widely disseminated in companies and at home that people no longer consider the minimization of damage caused to the environment. Additionally, when people reflect on it, their decisions are based on economic reasons. This is a potential explanation, considering that the construct was not significant, even though these practices were the most frequently adopted by the respondents.

The remaining practices make individuals more aware of their involvement with IT. The economic efficiency of technology use is linked to routine actions, and a concern with the use of technological devices strongly influences ($\beta = 0.32$) the factor minimizing IT environmental impact, standing out as its main predictor. The negative impact caused on the environment by unsustainable energy consumption combined with pollutant gas emission was considered one of the primary needs Green IT needs to heed. This problem concerns the past, present, and future (KUMAR; KAUR, 2015) and resulted in an interest in verifying the energy efficiency of technological devices (BEKAROO et al., 2012). Additionally, turning off monitors, computers, notebooks, and TVs, or even setting them on the stand-by mode, or unplugging them, can considerably decrease energy consumption, and consequently, save on electricity bills, and reduce gas emissions (CO_2) resulting from the use of appliances (DURHAM et al., 2019).

Purchasing technological devices from a green manufacturer is also a positive influence ($\beta = 0.23$) and is the closest link of individuals' socio-environmental awareness to the responsibility organizations assume. The individuals are aware of their actions and analyze how companies work to improve social well-being, mainly to decrease the impact caused on the environment by the production, sales, and disposal of technological products. Molla (2008) also notes the green supply chain when considering manufacturers from the Green IT perspective, which is crucial to decrease companies' environmental impact (CHIN et al., 2015). However, even if consumers demand sustainable actions from companies (HOJNIK et al., 2019), as individuals, they often struggle to understand the manufacturers and their supply chain as a whole, either because these aspects are not entirely transparent or easily perceived by consumers (ESPER; PEINKOFER, 2017). Hence, manufacturers often adopt the Green seal to certify the "green" quality of their processes and products or services (PINOCHET et al., 2015).

The practices concerning the proper disposal of electronic equipment present a positive influence ($\beta = 0.17$), though it is the smallest among the practices, indicating a concern with e-waste disposal. The individuals try to minimize the impact of incorrectly discarding electronic equipment by either donating its parts or the equipment itself or properly disposing of it according to guidelines or taking them to authorized facilities. Considering that less than one-quarter of e-waste is appropriately recycled worldwide (FORTI et al., 2020), and the fact it presented the lowest influence in decreasing environmental impact in the model addressed here, there is a need to keep educating individuals about the consequences of disposing of electronic equipment in regular trash (AHMED; NORDIN, 2014). Instead, the "3R" philosophy, reducing, reusing, and recycling (DEBNATH et al., 2016), should be encouraged whenever dealing with electronic equipment.

Focusing on the magnitude of the relationship between Green IT practices from the individuals' perspectives and minimizing IT environmental impact, we verified the coefficient of determination (R^2), noting that values above 0.26 represent strong relationships (COHEN, 1988). The coefficient found ($R^2 = 0.30$) indicates that these practices strongly support a decrease in the environmental impact of technology, highlighting the importance of the eco-conscious purchase, use, and disposal of technological equipment, and responsibly consuming natural resources, considering the consequences for future generations, taking responsibility for the amount of e-waste produced when buying new devices and replacing old ones, being responsible for the emission of polluting gases, and preferring technological products that have a less harmful effect on the environment even if paying more, therefore, working toward a better world.

Other studies addressing Green IT corroborate this model's results. For instance, Ali et al. (2019) verified that users aware of the problems concerning exacerbated energy consumption and the possibility of technological devices becoming scraps engage in sustainable practices to avoid or decrease environmental damage. Moreover, sustainable practices make users more aware and sensitive to adopt even other ecological practices (ZWICKER; LÖBLER, 2018). However, even if conscious consumption supports other practices, the environmental impact analysis shows that the proper disposal of e-waste is usually more visible and more frequently adopted; hence, more likely to effectively and positively impact the environment (QUEIRÓS et al., 2020). Hence, Kim (2012) states that by adopting a "green" design in their products, manufacturers of technological products inform users by publicizing and sensitizing consumers regarding the correct disposal of electronic devices, facilitating the proper collection of these devices, and minimizing harmful impacts on the environment.

Note that this study's results reveal the relevance of economic aspects of the practices addressed here. In addition, the analysis indicates that by allying money savings with eco-friendly practices, consumers become more aware of their actions. Regarding this last aspect, note that potential endogeneity problems were found due to omitted variables in the model, mainly because the financial issue is very relevant in the purchase, use, and post-use of electronic equipment. Therefore, this is a limitation in this study, and future studies should address this aspect.

Finally, as for the quality of the model, we first analyzed the coefficient of productivity validity (Q^2), which confirmed the assumption that the model portrays what it was expected to, with an index of 0.31. Regarding the analysis of the effect size (r^2), the usefulness of each practice in the model was confirmed, whereas only the economic efficiency of technological use presented a moderate effect in the construction of the model (0.156); the remaining practices presented a small effect (COHEN, 1988).

5. Conclusions

This study enabled analyzing the Green IT practices social network users know and apply and their influence on minimizing IT environmental impact. We assume that these practices raise the awareness of individuals, so they align to a sustainable development model seeking to cause less impact on the environment. This study's analysis was based on key aspects: purchasing technology from "green" manufacturers; conscious printing; economic efficiency of technological use; and properly disposing of electronic equipment.

The adoption of factor analysis and a structural model enabled determining and classifying the practices addressed here and validating the instrument used to collect data. Therefore, initial contributions are provided to the development of future models to measure Green IT behaviors, considering that this model presents practices toward technology that individuals perform in their daily routine, indicating a strong influence of these practices on minimizing IT environmental impact.

Future studies addressing this subject are suggested to add new constructs to the model, including new practices, which were not understood in the current model, and adopt other variables to broaden understanding regarding how the economic issue affects the practices of users. Additionally, cluster analysis can be performed using the scale developed in this study to identify correlations between the users' characteristics and their practices.

With increasing concerns about environmental issues, this study seeks to explore a relatively new subject, which has been mainly addressed from the perspective of companies instead of directly considering users. Its contribution concerns the fact that it addresses a gap in the literature, i.e., there is a lack of scales assessing the behavior of technology users at an individual level (ZWICKER; LÖBLER, 2018). The results can improve understanding of how much individuals pay attention to green IT practices (the ones most frequently adopted, and the factors users deem to be the most important) and how aware individuals are that their actions toward technology impact the environment, mainly reflecting on the minimization of damage caused to the environment.

Green IT practices should be disseminated at all levels of society, and interest in this subject from users' perspectives should gain more attention from the scientific community. This study's results show that the users of Information Technology have been more attentive to eco-friendly aspects when buying, using, and discarding technological products. Hence, the model developed here is expected to support researchers, raise interest in developing future studies, and encourage organizations to contribute to sustainable development. Furthermore, this study presents opportunities for organizations to introduce activities in their organizational routines for employees to practice and become aware of the consequences on the environment, collaborating with the perspective that sustainable corporate responsibility is linked to what every individual does, based on the individuals' actions, minimizing the organizations' environmental harm.

This study's limitations include the fact that a convenient sample was used. Additionally, the Google Drive tool was used to disseminate the instrument in social media, which, even though it is accessible worldwide, most respondents were from the southern region of Brazil because of the authors' relationship networks.

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Análise da tecnologia da informação verde sobre a perspectiva da consciência socioambiental do indivíduo

Tiago Machado Castelli
André Andrade Longaray

Resumo: O presente artigo tem por objetivo analisar a influência de práticas de TI Verde associadas a compra, uso e pós-uso conscientes de equipamentos tecnológicos, sob a percepção do indivíduo, quanto à minimização dos impactos causados ao meio ambiente pela tecnologia. Para atingir esse objetivo, elaborou-se um instrumento de intervenção aplicado à usuários de TI, e com o auxílio da Modelagem de Equações Estruturais (MEE), estruturou-se um modelo indicando que práticas de aquisição de TI por "fabricantes verdes", práticas focadas com a economicidade de uso tecnológico e práticas de descarte tecnológico correto tornam o indivíduo mais consciente com os impactos ambientais causados pela tecnologia. Como principal contribuição, este estudo traz uma escala de avaliação de ações sustentáveis referentes à Tecnologia da Informação em nível individual, cujos resultados podem despertar interesse na comunidade científica a desenvolver novos estudos sob a perspectiva adotada.

***Palavras-chave*:** Tecnologia da Informação Verde; Impactos ambientais; Consciência socioambiental tecnológica; Práticas de TI Verde; Modelagem de Equações Estruturais (MEE).

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Análisis de la tecnología de la información verde sobre la perspectiva de la consciencia socio ambiental del individuo

Tiago Machado Castelli
André Andrade Longaray

Resumen: Este artículo tiene por objetivo analizar la influencia de prácticas de TI Verde asociadas a la compra, uso y posterior uso conscientes de equipamientos tecnológicos, bajo la percepción del individuo, en lo que se refiere a la minimización de los impactos causados al medio ambiente por la tecnología. Para alcanzar este objetivo, se elaboró un instrumento de intervención aplicado a los usuarios de TI, y con el auxilio del Modelaje de Ecuaciones Estructurales (MEE), se construyó un modelo indicando que las prácticas de adquisición de TI por "fabricantes verdes", enfocadas con la economicidad del uso tecnológico y en el descarte tecnológico correcto, tornan al individuo más consciente de los impactos ambientales causados por la tecnología. Como principal contribución, este estudio presenta una escala de evaluación de acciones sustentables referentes a la Tecnología de la Información en nivel individual, cuyos resultados pueden despertar el interés de la comunidad científica para desarrollar nuevos estudios bajo la perspectiva adoptada.

***Palabras-clave*:** Tecnología de la información verde; Impactos ambientales; Conciencia socioambiental tecnológica; Prácticas de TI ecológicas; Modelado de ecuaciones estructurales (MEE).

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