SUSTAINABLE INNOVATION IN ICT COMPANIES

1 INTRODUCTION

An innovation-driven company focuses its efforts on developing its human resource competencies, relating the use of technology in its operations, and focusing its strategy toward innovation. (Simpson, Siguaw, and Enz 2006) With this, the company can harness the science of materials and digitization that have positive impacts on the economy, increasing productivity, reshaping the industry, and creating opportunities for overcoming, avoiding less efficient and more polluting stages of development. (Commission 2014)

This innovation acts as a driver for long-term growth and enables sustainable growth, especially when the use of materials science and digitization assists in potential economic development and mitigation of climate change. (Commission 2014) Innovation is understood as the ability to change the rules of the game, enabling organizations that make them demonstrate their competitive edge, embrace new markets or retain already conquered markets, and remain the innovative leader in the marketplace. (Edison, bin Ali, and Torkar 2013)

Technological innovation in the life cycle of software companies is an indispensable condition for the success and support of these companies in a scenario of digital transformation experienced in recent years. (Calabrese et al. 2018) At the same time ICT is considered a special case of new technologies that serve as enabling factors that lead to even greater innovations.(Cardona, Kretschmer, and Strobel 2013) On the other hand, the adoption of sustainable strategies imposed or required by stakeholders drives changes in the operations and life cycle of the products and services that these companies deliver to customers, and the sustainability requirements that ICT delegates to suppliers. (Calabrese, Forte, and Ghiron 2018)

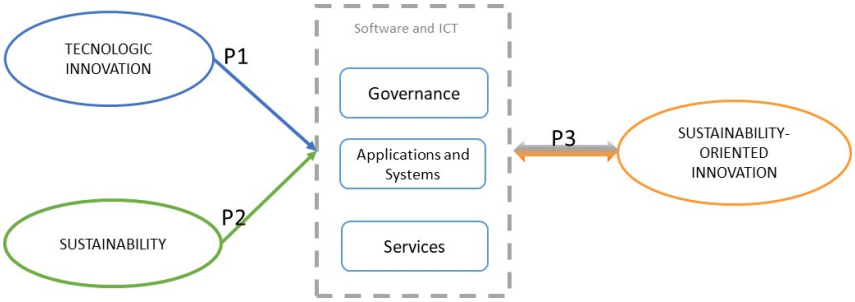
In the current scenario where information and communication between companies, people and governments are based on digital technology, Software and Information and Communication Technologies companies act as entities that enable these operations to take place on a large scale either by shared applications or databases, virtual, clustered or private and segmented networks, raising the research question that permeates this study - how sustainable innovation is embedded in the operational activities and underpinning of the digital platform that Software companies foster when delivering products and services?

To support this research, a systematic literature review was carried out aiming to provide the theoretical framework, and surveys were carried out in software and / or ICT companies using questionnaires and interviews, consultation of websites and electronic documents provided by them. After this introduction, section 2 presents the theoretical framework and systematic review of the literature. Section 3 shows the methodology used, followed by section 4 where the analysis and results of research in companies are presented, and finally in Section 5 presents discussions, conclusions, and suggestions for future work.

2 BACKGROUND

Aiming to shed light on the topic of sustainable innovation in software and / or ICT companies, a systematic literature review was carried out on the basis of Scopus and Web Of Science, providing insights to show which theories support sustainability studies. In this segment, as well as the guidelines of corporate practices that helped in the construction of the theoretical model (figure 1) to be applied in the field research.

FIGURE 1 - PROPOSED THEORETICAL MODEL



Source - elaborated by the authors

Because sustainability is a topic with varying definitions, this paper will use the vision of corporate sustainability that was presented by Dyllick and Hockerts as “meeting the needs of a company's direct and indirect stakeholders (shareholders, employees, customers, groups of pressure, communities, etc.) without compromising their ability to meet future stakeholder needs. ” (Dyllick and Hockerts 2002)

2.1 Literature revision

The research carried out to compose the theoretical framework of this study included a literature review in the main research bases that allowed the identification of the most relevant articles on the theme of sustainability-oriented innovation, so a protocol was established. review that delimited the search period from 1994 to 2019 performed in the main databases Scopus and Web of Science, having as sample published articles, seminal articles, and literature reviews, using selection filters and clear inclusion and exclusion criteria. of articles, establishing an analysis process for future replications. Because it deals with information technology of a discipline that permeates several areas, no specific area was selected, thus enabling the search results to bring the largest number of publications for analysis.

2.2 Innovation

Innovation translation theory derives from the Network of Actors theory, which considers technological change as socio-technical projects, with the main actors being human and non-human entities (John Law 1987). The translation of innovation is described as the movement of innovation in space and time in the hands of people who deal with it in different ways (Latour 1996). For Dosi (1988) innovation refers to the search and discovery, experimentation, development, imitation and adoption of new products and processes, and new organizational models.(OECD 1991)

Innovation according to the definitions presented in the study by Edison et al. (2013) were organized into 4 categories, namely: incremental, market advancement, technological advances, and radical innovations.

- Incremental innovations are defined as small changes in technology that offer little benefit to users;
- Market breakthroughs refer to core technology innovations that move closer to existing products but offer customer benefits;
- Technological advances relate to the adoption of technology that is different from the existing technology, but which does not offer a financial benefit to the customer.
- Radical innovations are those that bring something new and totally different from what existed in the market. (Edison, bin Ali, and Torkar 2013)

Innovative development requires continuous change, which is not always incorporated into a definite plan, and requires analysis, simplification, restart, construction, decision making, and adoption of new models, not exactly in that order, but with frequent comings and goings, translated into constant change, ideas and innovations. (Ivan and Despa 2014)

Radical innovative capacity can be understood as the company's competence to generate innovations that transform existing products, services, and technologies. Companies that activate their information technology (IT) capabilities and capabilities tend to innovate and become more efficient, responding more quickly to changes and external variations. (van de Wetering, Mikalef, and Helms 2017)

Disruptive changes generated by new technologies, new business formats or policy changes act as gears forcing companies to adapt, reviewing their processes, product life cycle. An example is the zero-waste program adopted by the European community that directs companies to adopt the concepts of circular economy. In this context, new service-based business models incorporate the maintenance and repair, reuse, remanufacturing, and recycling of products and / or equipment used by companies to provide services (Wiener, Gattringer, and Strehl 2018).

Information and Communication Technology (ICT) assists companies and organizations in the generation, integration, development, and improvement of processes and fosters new forms of business, digital services, and supply chain. ICT-based innovations foster strategy, operational excellence, the creation of new services and products, and improved customer relationships. (Díaz-Chao, Sainz-González, and Torrent-Sellens 2015)

As Software / ICT companies are active in providing application and computer systems development services, storage, processing and distribution of voice, images and data operated by their own or client systems, having technology at the core of their business, and considering Since organizations that generate radical or incremental innovations make use of information technology, we come to the first proposition of this study. P1 - Software companies considered innovative keep in their strategy the frequent adoption of radical and / or incremental innovations.

2.3 Sustainability in Software Companies

Sustainability in software companies aligned with the three dimensions of the Triple Bottom Line (TBL) - Environmental, Economic and Social has been discussed in numerous articles and technical publications, given the importance that the theme has on this sector and on ICT. This can be observed by the constant technological changes and the interaction of these organizations with the whole civil

society, corporate environment, and governments, either through service delivery or by the fact that ICT accounts for 3% of global energy consumption (Ruth, 2009).

Observing the environmental aspects of TBL identifies a direct relationship with the equipment (hardware / device) and technological infrastructure with the environmental and economic aspects, since the production and distribution of a device requires the use of natural resources, and when inserted in the context of infrastructure (use) these equipment consume energy and water, besides producing high CO2 footprint, it was concluded in a comparative study on the environmental impact of the construction of a building versus a set of computers used in the same building, which computers consume 45% more energy resources than the building's civil works. (Jones et al. 2013)

To mitigate these environmental impacts, the adoption of energy efficiency labeling acts as a positive driver for reducing equipment energy consumption and as a consequence of the entire physical infrastructure of ICT. (Ruth 2009) In contrast to the strong adoption of cloud computing, currently the strategic focus of service offered by ICT ends up concentrating energy and water consumption in certain regions, while enabling sustainable practices to improve energy efficiency as well as proper disposal of obsolete equipment / devices through reuse. , remanufacturing or recycling represent the sustainable practice of ICT. (Mathews 2013; Melville 2010; Murugesan 2010)

Also regarding the environmental aspect, the software / applications developed and used in the operation of the equipment can act as an energy efficiency promoter, minimizing the environmental impacts of the processes it manages, if included in its development processes sustainability as a non-functional requirement, adopting premise the directives of ISO / IEC25010. (García-Mireles et al. 2018)

In this area, green software can be defined as an application that produces the least possible waste during its development and operation, considering the development requirements established by SWEBOK 3.0 (obtaining / eliciting, analyzing, specifying and validating) that support the creation of a system.(Mireles et al. 2017)

Thus, it is suggested that the practical application of green IT strategies aimed at the outsourcing, operation and proper disposal of infrastructure devices, enables the reduction of the use of natural resources used in the production of devices, energy and water necessary to maintain the equipment and therefore, reduce costs in maintaining ICT infrastructure. (Loeser et al. 2017)

2.3.1 Sustainable Aspects in Life Cycle Analysis (LCA)

Life Cycle Analysis (LCA) is defined as a structured, comprehensive, and standardized method that quantifies emissions, resources used, and the environmental impact related to the depletion of natural and non-renewable resources associated with the production of the good or service. (IBICT, 2014).

FIGURE 2 - LIFECYCLE ANALYSIS FLOW DESIGN

The Brazilian Institute of Information in Science and Technology (IBICT) adopted a base model to promote the analysis of the life cycle of a product or service that includes - objectives, scope, inventory

analysis, impact assessment and results in data interpretation and on the impacts identified in each of the stages of the analyzed life cycle (see Figure 2).

Life cycle analysis requires clear boundaries of input and output systems, and the establishment of very specific impact categories, and comprises:

- concept design – develop based on eco-concept, classify eco-design, and explore environmental design;
- design of the parts – creating a time-weighted inventory, selecting materials, ecologically correct packaging, and identifying alternatives for the parts that improve the production process and use of resources;
- process design that verifies the emission of pollutants, the reduction of waste, and the improvement in production efficiency; and
- decision making which comprises decision tree analysis, scenario formulation and analysis, and economic benefit analysis. (CHANG; LEE; CHEN, 2014)

The analysis of the software product lifecycle established by the ISO14040 standard organizes the evaluation stages as follows: definition of the goal and scope; inventory analysis; impact assessment; and interpretation of results. This directive tends to assess the environmental impacts caused by the product's life cycle. (STIEL; TEUTEBERG, 2014)

For this study, the ICT lifecycle will be analyzed from the point of view of the services that make use of the infrastructure (hardware / software / operations) that make up the ICT technological environment, since the lifecycle of systems or applications, server and data storage system can be made more sustainable by reducing greenhouse gas emissions, eliminating, or minimizing the use and release of toxic materials into the environment. (MURUGESAN; GANGADHARAN, 2012)

2.3.2 Environmental and Economic Aspects in the LCA of Infrastructure and Manufacturing (hardware/devices/communication)

The lifecycle of a device/hardware can be grouped into five stages: design, fabrication and installation, packaging and transport, use, reuse or disposal, and at each of these stages it is possible to have a green/sustainable approach. Thus, in the device design phase, architectural decisions, use of components, materials and the layout of the equipment will have an effect on the environmental impact in the next stages of production, so it is necessary to establish impact reduction targets and map the entire cycle device life, and promote design and architectural adjustments that meet the established goals. (MURUGESAN; GANGADHARAN, 2012, cap. 2; p.23-38)

At the manufacturing stage, the environmental impact of the hardware lifecycle is most evident, as the manufacturing is resource intensive and consumes many raw materials, such as water and energy, and generates different toxic wastes. Following the lifecycle, packaging and transport strongly contribute to the carbon footprint. In order to mitigate this impact, the amount of material used, and the size of the packaging should be minimal, with the aim of using ecologically correct materials. (Kumar, Practices, Murugesan, S, 2012, p. 26)

In the final two steps that comprise use and reuse/recycling or disposal, it was identified that in use, the direct impact on energy consumption is related to how the user uses battery charges, and in the second when the devices are when reused the impacts are mitigated, as the useful life is being extended. However, when the material is recycled incorrectly, it generates environmental impacts resulting from

inappropriate disposal of the parts, as well as generating a social impact affecting the health of people involved in the recycling process, contributing to increased pollution. (KUMAR et al., 2012, p. 34)

2.3.3 Environmental, Economic Aspects in the Software/Application LCA

The life cycle of a software can be understood as an accuracy mechanism for the quality of the product delivered, since the software has its cycle started in the design of the application that meets a set of requirements, passing through its use and its disposal/retirement or renewal through upgrades and/or inclusion of new codes. (SHEPPERD, 1990)

This life cycle, when approached from the perspective of sustainability, is divided into seven stages and aims to guide companies and developers in evaluating and choosing methods and tools that contribute to making software green (SHENOY; EERATTA, 2011), as determined in table 1.

Table 1 – LCA Green Software

Step	Description
requirements collection	Consider the lifetime of the software, minimize the use of vibrant colors on the screens that make up the application, which consume more energy, and avoid discarding prototypes developed for product presentation.
design and prototyping	Adopt simplicity as a premise for product design; reduce the number of trips using virtual/remote communication; consider code reuse and/or extension of entities/classes in the design; design an architecture that favors the adoption of cloud processing
Implementation	Adopt automatic code generation; avoid and/or minimize the use of specific APIs for certain devices seeking to scale the solution; use pair programming; generate electronic documentation to support deployment and maintenance.
Test	Use use case automation tools; involve users in validations and certifications to mitigate bug fix times.
Deployment	Reduce the size of packages to deploy; adopt online and/or license/subscription installations
maintenance	Use electronic documentation for support; apply electronic documentation for improvements and new versions.
Retirement	Store reusable codes and historical data; make the hardware available for other applications or reuse.

Source: Adapted from Senoy & Eeratta (2011)

The software industry, from which a significant part of ICT companies emerged, has been showing the best results and global financial valuation (for example – Amazon, Google, Microsoft, Oracle, IBM, Alibaba) due to its expansion into other domains such as e- mobility, communication infrastructure and internet of things (IOT), which are based on applications, artificial intelligence, cognitive computing, and other emerging technologies. (SIKDAR, 2015)

As can be seen in the theoretical references, it is observed that sustainability in software and ICT companies is directly linked to the life cycle of products and services, while it is verified that the most important drivers are related to use from natural resources and CO^2 emissions from infrastructure devices (environmental aspect), and to the energy efficiency of equipment and adoption of communication tools (economic aspect) that reduce direct costs for companies (BENGTSSON et al., 2011), leading to second proposition: P2- Sustainability in ICT is more focused on the environmental and economic aspect (energy efficiency and CO^2) than on the social aspect (people and communities).

2.4 Sustainable Innovation in ICT

Technological innovation that aims to generate business, especially those called "green" is still shy in Brazil, even though there is legislation that encourages such initiatives, in contrast to the exploitation of natural resources and the unrestrained expansion of certain sectors that aim for high gains and prevail strong in the Brazilian economy. (NOBRE; MARENGO, 2017)

Sustainable innovation can be defined as innovation aimed at processes in which the use of resources and the production of waste remain within adequate environmental limits, in which products or services or new businesses are planned from their inception to impose the least impact on the environment and society, generating returns for shareholders. (MALETIČ et al., 2015)

Sustainability-oriented innovation (SOI) can be defined as the "commercial introduction of a new product/service, product/service system that based on traceable comparative analysis brings benefits to the environment and/or people during the physical life cycle" (KLEWITZ; HANSEN, 2014), and involves making intentional changes in an organization's culture and values, in its products and/or services, processes and corporate practices, serving the purpose of generating social, environmental and financial return. With the life cycle as a driver, organizational innovation and innovation applied to products/services aims at operational optimization (eco-efficiency), organizational transformation (new markets/products/services/business), and the construction of systems (social and new changes business/products/services). (ADAMS et al., 2016)

The organizational innovation defined by Ashford (2011) suggests that “new changes in and between various organizational aspects of a company's functions” and was expanded by Jay & Gerard (2015, p.22) to “any innovation at the delivery level or in the model of the need to serve internal and external stakeholders”. (JAY; GERARD, 2015)

Based on sustainable innovation, Stamm et al. (2009) suggested the creation of the Sustainability Oriented Innovation System (SoiS) whose objective is to measure innovations that reduce pressures on the environment and global public goods (KILKIŞ, 2016). An organizational innovation system can be defined as “an innovation network of diverse actors, collaborating with an innovative focal organization in an innovation process, to generate, develop and commercialize a new concept, formed by institutions” (VAN LANCKER et al., 2016).

Another tool that emerged from the concept of sustainable innovation was SOSI (Sustainability-Oriented Service Innovation), which aims to guide companies in conducting new services and/or innovative and sustainable products through a set of four stages and nine sub-levels direct the analysis of the new project focused on sustainability (CALABRESE; FORTE; GHIRON, 2018).

The dimensions of sustainability-oriented innovation in ICT focus on systems, design, technology, organization, and customers. In the case of services, the core business of ICT, network collaboration, integration, and co-creation partnerships, in addition to the insertion of interested parties, emerge as important drivers for service innovation. (CALABRESE et al., 2018)

Sustainable innovation in software companies comprises the creation, development or adaptation of systems/applications and is added to the use and generation of value for the company, customers and end users. Software innovation has strong links with the dynamism, flexibility, and speed in the distribution of the products/services generated, as well as the knowledge shared in developer forums, user communities and research and teaching institutions. (ROSE; JONES; FURNEAUX, 2016)

Based on the above reference, we proceed to the third proposition of this study that suggests: P3- The adoption of sustainability-oriented innovation in Software companies derived from the economic [cost reduction, market expansion, new products/business], environmental [energy efficiency, CO^2 footprint], and social aspects [mobility, access to information and communication].

3 METHODOLOGY

Addressing the theme of sustainability-oriented innovation in Software and Information and Communication Technologies (ICT) companies, the content of websites was considered as the unit of analysis using an exploratory method based on documental research that provides the disclosure of facts and derived analysis. (SÁ-SILVA; ALMEIDA; GUINDANI, 2009)

The empirical research that supports this study was carried out from September 2018 to June 2019, collecting the information on innovation, operation and sustainability made available on the companies' websites, electronic questionnaires sent to the representatives of these companies, and in the documents made available to study. (NAVARRO-GALERA et al., 2014)

The systematic review of the literature adopted for this study aimed to identify the state-of-the-art and sought to provide guidance on the research already carried out on the subject, providing the creation of a reliable knowledge base, as well as eliminating the subjective bias of the researcher, and by it is a structured method with the possibility of reproduction. To conduct this review, a review protocol and inclusion and exclusion criteria were established; defined the bases to be researched; reading of the abstracts for initial selection and reading of the selected articles. The review aimed to assist in the validation or refutation of hypotheses that aim to answer the research question that guides this study (KITCHENHAM, 2007).

As a guide for the analysis, the theoretical framework and the questionnaire were used, applying, as evaluation mechanics, the content analysis that is widely used in research involving corporate and governmental information. (SÁ-SILVA; ALMEIDA; GUINDANI, 2009)

The sample selection criteria established for this study comprised Software companies that use applications/software, communication infrastructure, storage, and data processing, carry out the operations of their services within their own facilities (data centers), enable digital services over the internet and cloud, and have entered new businesses motivated by the innovation adopted in their operations.

In order to carry out a comparative analysis, companies A and B selected for this study operate in the same segment (Software and Information and Communication Technology), develop and market ERP, Database, Cloud Services (SaaS, PaaS, IaaS, DBaaS) applications, ISVs), produce and sell hardware (servers, laptops), and have research laboratories aimed at generating innovation. Companies A and B are headquartered in the United States, maintaining a branch with operations in Brazil.

4 ANALYSIS AND PRESENTATION OF RESULTS

Incremental innovation characterized by small advances and improvements in processes and products/services finds a good anchor in Software companies, since they operate and make their products available to customers through Information and Communication Technologies (ICT).

The radical innovation that creates new businesses, jobs, communication and relationships between companies, employees, customers and suppliers combines the use of technologies generating disruptive transformations, such as the digitization of the economy and other transforming mechanisms, being considered strategic and participating in ICT business. (DAHLSTRÖM et al., 2015)

Thus, proposition P1- Software Companies considered innovative maintains in its strategy the frequent adoption of radical and/or incremental innovations, it was confirmed with the verifications carried out in the two analyzed companies, as shown in table 2.

Table 2 - Driver Innovation Issues

Driver	Proposed questions	Company A	Company B
INNOVATION	1) Has the company introduced innovations in its products and/or services in the last 24 months? Which?	Yes. Open cloud platform that can be public, private or hybrid; Cloud BD.	Yes. The company is expanding the datacenter providing cloud services available to 42 regions on the planet. We are at the forefront of innovation with mixed reality solutions that knowledge through immersive experiences.
	2) Does the company adopt metrics for evaluating the innovation of its products? Which?	N.A.	Simply put, the environment and our business benefit whenever we implement sustainability goals and objectives.
	4) When compared to the market, is the speed in adopting and implementing innovations in the company considered superior or equal to others?	There was a delay in product launch, but compensated by the new service (according to Gartner, 2018)	Above average cloud speed (according to Gartner, 2018)
	8) Does the company adopt any measure or set of measures that help identify points of improvement in production processes that can generate direct and indirect cost reduction?	Environmental sustainability is a fundamental consideration throughout the product lifecycle; We continue our work to reduce travel by taking advantage of the Company's products.	As we expand our global cloud infrastructure, we are increasingly turning to renewable energy because it is a clean energy source and gives us better financial predictability; Our cloud-based programs to reduce resource consumption have already contributed to our 20% reduction in global energy at our facilities, reducing emissions and our energy bill.

Source: data obtained in the interview

Sustainability in the innovation of products and services is found in the strategy of the analyzed companies, as well as the need to carry out an analysis of the life cycle of the products (hardware) that these companies produce annually and that are distributed to all continents.

Thus, proposition P2 - Sustainability in ICT is more directed to the environmental and economic aspect (energy efficiency and CO^2) than to the social aspect (people and communities) found greater adherence in company A than in company B, since the latter it has diversified its service portfolio and increased its involvement with the communities in which it has physical facilities. (see table 3)

Table 3 - Questions related to driver sustainability

Driver	proposed questions	Company A	Company B
SUSTAINABILITY	5) Does the company have metrics for evaluating the sustainability of its products and services? Which?	The Company periodically conducts a materiality assessment to identify and better understand the areas in which we should focus our resources.	We focus our environmental sustainability work on the five areas where we believe we can have the greatest positive impact – carbon, energy, water, ecosystems (including food, agriculture and biodiversity) and the circular economy (including waste reduction).
	7) Does the company have any recycling, energy efficiency or conscious consumption program? Do these programs involve employees and stakeholders?	Recycling and reuse - 95% of the material collected was recycled or reused; 90% of suppliers are ISO14001 certified; We adopted a robust transportation program that helps employees travel to and from our offices in a sustainable way.	Water = Partnerships with companies like Ecolab and technological innovations like the free, publicly available tool for the Water Risk Monetizer help assess risk; Ecosystems = Operationally, we are investing in the long-term viability of ecosystems in the communities in which we operate (42 regions); Circular economy and waste reduction = We design our products, buildings and operations around the reduction and reuse of resources, enabling more efficient savings in terms of resources and productivity.
	11) Does the consumption of water and energy have any metrics and/or reduction targets linked or motivated by the cost to these associates?	We continually invest in technologies and solutions to reduce our environmental impact at our facilities and data centers around the world. energy efficiency - 29% of the total energy consumed comes from renewable sources; 15% reduction in waste to landfill from 2015 to 2016; 1.07 energy use efficiency rating in our data centers. Our goals for 2020: 20% reduction in energy per dollar of revenue; 25% reduction of waste to landfill per square meter; 20% reduction in absolute emissions; 33% target for renewable energy; 25% reduction in drinking water consumption per square meter.	Energy = Committed to using 50% wind, solar and hydro power in our data centers and campuses by the end of 2018, to serve 60% by the beginning of the next decade; carbon = We achieve carbon neutrality annually by improving operational efficiency, purchasing clean energy and investing in community carbon offset projects. In 2017, the company promised to reduce its operational carbon emissions by 75% by 2030 and is on target to reach that goal.

Source: data obtained in the interview.

Sustainability-oriented innovation that directs companies to create new products and/or services, as well as contributes to improving the relationship between the company versus the environment versus stakeholders versus shareholders, as it enables cost reduction, reduction in the use of natural resources and improvement in people's quality of life was observed in the companies analyzed, as shown in table 4.

Proposition P3 - Sustainability-oriented innovation in ICT derived from economic (cost reduction, market expansion), environmental (energy efficiency, CO^2 footprint) and social (mobility, access to information, communication) aspects found a response in strategic actions adopted by companies A and B.

Table 4 - Issues related to the sustainable innovation driver

Driver	proposed questions	Company A	Company B
SUSTAINABLE INNOVATION	3) Do the innovations consider the environmental aspects? What aspects are considered?	We incorporate environmental considerations into the design and development of our hardware products before they reach the manufacturing stage; Design, manufacture, packaging = environmental; Operational health and safety and ethics = social;	Artificial intelligence, mixed reality and quantum computing will come together and shape the future of our industry and others for generations to come. Integrating sound environmental practices into all aspects of our supply chain and manufacturing functions; We perform a lifecycle assessment (LCA) to calculate the environmental impact of our products and hardware activities;
	6) When evaluating an innovation, are sustainable aspects considered? To what extent does this occur?	Design for Environment, where our hardware engineers learn about sustainable design principles and circular economy; acquisition of certified equipment; contracts with certified suppliers; More than 4.1 million software installations in FY 2016 and 2017 were performed electronically, eliminating all previously needed physical media	Artificial intelligence (AI) and the cloud are enabling businesses and governments to make smarter, real-time decisions that reduce emissions and reduce resource consumption in areas such as construction, transportation, production, agriculture, and electricity production and distribution. Our cloud saves energy = Moving to our cloud services can help businesses reduce energy consumption by 30-90% per user compared to running services on-premises. An app built on our cloud is helping companies assess water risk to make better decisions about current and future water needs.
	9) Have the innovations implemented in the last 24 months contributed to the reduction in the consumption of resources such as water, energy, and electricity?	Sustainability is at the heart of our business operations; Customers see our data centers as models of how to build, manage and build their own efficient data centers.	Last fall (2017), we shared our ambition to substantially simplify the datacenter. Today, we are pleased to announce our partnership with McKinstry and Cummins to build the world's first gas datacenter. In this pilot, racks are connected directly to natural gas pipes and are fully powered by integrated fuel cells rather than traditional electrical equipment. What makes this project so disruptive is how radically simplifies the server provisioning process and how it nearly doubles the energy efficiency of data centers – all while reducing costs and increasing reliability.
	10) Do the innovations adopted by the company represent a competitive advantage or did they enable	Open standards enable innovation, facilitate fair competition, and enable interoperability with legacy and third-party systems.	A new technology paradigm is emerging, one with a smart cloud and a smart edge, our hybrid infrastructure consistency spans identity, data, compute, management and security, helping to

	the opening of new markets and/or businesses?	The evolution of cloud computing has provided significant environmental gains, in addition to the business benefits inherent in a service-based delivery model;	support real-world needs and evolving regulatory requirements for business customers and enterprise-focused SaaS ISVs.

5 DISCUSSIONS AND CONCLUSIONS

Innovation, whether incremental or radical, implemented in companies as part of the market advancement strategy, or to meet legislative guidelines as reported in the studies by Edison et al. (2013), Ivan & Despa (2014) and Wiener et al. (2018) were confirmed in surveys carried out in the surveyed companies. As well as the innovative capacity and disruptive changes were also verified in the products and services offered, such as the use of ERP (SaaS) and Database (BDaaS) systems in the cloud, integrated with the client's office automation tools (ISVs).

The approach to sustainability in software and ICT companies has greater adherence to environmental and economic aspects, given its operational characteristic, which is supported by electronic equipment, software/applications, and technological infrastructure. In addition, this structure requires the intensive use of natural resources from the production and use of equipment/devices, through the development and use of operating systems and applications, to the construction of buildings where these companies install all the infrastructure that serves customers/users, as observed in their studies Jones et al. (2013) and Ruth (2009). This approach finds total synergy with the analyzed companies.

Studies suggest that practical actions such as the acquisition of equipment with the energy efficiency seal and other decisions related to the positioning of buildings and adequate refrigeration techniques (Ruth, 2009), as well as the adoption of ISO/IEC25010 directives (García-Mireles et al. 2018), and the inclusion of sustainability as a non-functional requirement of a system, or the use of SWEBOK 3.0 as a directive and support for sustainability (Mireles et al., 2017) lead the company to sustainability. The analyzed companies are building new data centers conceived from the perspective of sustainability, for the park already installed, companies focus on replacing equipment with new, more energy-efficient ones, while in the equipment manufacturing process, they adopt an eco-efficient design.

Disposal of equipment requires sustainable actions for proper disposal when it becomes obsolete, whether through reuse, remanufacturing or recycling (Mathews et al, 2013; Melville, 2010; Murugesan, 2010), which are aligned with the green IT strategies that they aim at adequate outsourcing, operation and disposal, aiming to reduce the use of natural resources and, at the same time, the costs of maintaining the ICT infrastructure (Loeser et al., 2017). The findings, described in the previous references, are supported by the companies surveyed, as they adopt clear metrics for reducing energy, water, recycling, and carbon footprint, both for the services offered through data centers as well as in the manufacturing processes of the two companies.

In the LCA approach to manufacturing processes, the researched articles infer that the life cycle analysis of technology equipment (hardware/devices) are organized into phases or steps for which there is a check to keep the entire process in compliance with the environmental waste rules and disposal, as well as for energy efficiency technical regulations and ecological design guidelines (Chang, Lee & Chen, 2014; Murugesan & Gangadharan (2012); Kumer & Kannegala (2012). to be understood as an accuracy mechanism for the quality of the delivered product, as well as to be verified through seven

steps that aim to guide companies and developers in the evaluation and choice of methods and tools that contribute to making the software green, as presented in the inserted articles in the context of this study (Senoy & Eeratta, 2011; Shepperd, 1990).

In the companies surveyed, the life cycle analysis (LCA) of manufactured equipment is fully aligned with the indications of the articles, going a little further, as they seek to improve the impacts during use with the end customer, especially with the provision of services in cloud, however it has not been clearly identified how the LCA-software/application is performed.

Regarding Sustainable Innovation, previous studies define that it is focused on processes in which the use of resources and the production of waste remain within adequate environmental limits (Maletic et al., 2015). Sustainability Oriented Innovation was defined as the introduction of new services, products, which involve organizational cultural changes and the creation of sharing networks, expanding into new markets and meeting the needs of internal and external stakeholders. (Kelwitz & Hanse, 2014; Adam et al, 2016; Jay & Gerard, 2015; Calabrese et al., 2018).

In a comprehensive way, software companies that also provide Information and Communication Technology (ICT) services are seen as innovative companies, as they present in their portfolio services supported by technological and disruptive innovations that combine to a greater degree the environmental and economic aspects of sustainability – carbon footprint, energy efficiency and water consumption, and to a lesser extent the social aspect – actions aimed at employees and only in the case of company B with some actions aimed at communities.

In the analyzes carried out on the adoption of sustainability-oriented innovation by software/ICT companies, it was verified, through the projects announced, the direction in the search for solutions that improve the energy efficiency of the equipment produced, the devices acquired and the entire data infrastructure -center, as well as carrying out analysis of the life cycle of equipment, seeking to mitigate points that may cause damage to the environment, improving the use of resources with eco-efficient design.

Our verifications also revealed that the use of metrics to monitor the targets for reducing water and carbon footprints are present and make up the short, medium, and long-term strategy of these companies. It was also observed that the circular economy is being incorporated into new projects and/or new businesses that the analyzed companies are or will act.

Finally, we observe that the objective of this study was to answer the question “how is innovation oriented towards sustainability inserted in the operations and strategies of Software/ICT companies?” and validate the three propositions on the adoption of innovation, the application of sustainable practices, and the insertion of sustainability-oriented innovations. The propositions were confirmed, as described in detail in the analysis and presentation of results section.

As for the research question, the observations and analyzes carried out suggest that sustainability-oriented innovation reinforces the direction of sustainability actions that envisage the environmental (energy, carbon, water, recycled materials) and economic (new businesses, circular economy, remanufacturing) aspects), keeping the social aspect with less emphasis (employees' quality of life, occasional social actions, volunteering, free training and qualification for people and/or communities) or treated as a result of another aspect such as the environmental.

This study has some scope limitations as it is restricted to analyzing in general the life cycle of manufactured and/or developed products, and sustainable practical actions adopted in two software/ICT companies. The analyzes were performed based on information provided by the companies and/or disclosed through their sustainability reports, access links to ongoing projects, and recent publications by Gartner, which has high credibility. Another limitation that this study presents is the limited number of responding companies and the absence of national companies.

For future studies, it is suggested to promote the analysis of the adoption of sustainability-oriented innovation in smaller companies and/or based in other locations, especially in Brazil, aiming to generate a comparative base, and consequently new results and expansion of knowledge.

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