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Original Article

Analysis of the feasibility of reverse logistics in footwear production employing technologies RFID and Cloud Computing

Análise de viabilidade da logística reversa na produção de calçados por meio de RFID e Computação na Nuvem

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ABSTRACT

Purpose: To analyze the feasibility of a reverse logistics process in the footwear production, using two technologies from industry 4.0 – RFID and Cloud Computing.
Methodology: A case study was carried out in a large footwear industry, located in southern region of the country; qualitative approach, with data collection through semi-structured interviews, documental research (internal digital records/intranet) and non-participant systematic observation.
Findings: The empirical data showed that the two technologies analyzed, RFID and Cloud Computing, are already implemented in some operations in the company, and offer technical conditions to operationalize the reverse logistics process.
Originality/value: Industrial operations promote various actions to adapt to environmental standards, both legal ones, already in force, and the recommended ones, resulting from pressure from society, increasingly aware of the need for changes in processes that negatively impact the environment. Among these actions, the adoption of reverse logistics stands out, considered one of the structuring axes of the National Solid Waste Policy, enacted in 2010. This analysis, regarding the contribution of these two technologies is justified by intentions of footwear companies to employ these technologies in the manufacturing process.

Keywords: Footwear industry; Reverse logistic; RFID; Cloud Computing

RESUMO

Objetivo: Analisar a viabilidade de processo de logística reversa na produção de calçados, com respaldo de duas tecnologias da indústria 4.0 – RFID e Computação na Nuvem.
Metodologia: estudo de caso em uma indústria de calçados, de grande porte, localizada na região sul do país, abordagem qualitativa, com a coleta de dados por meio de entrevistas semiestruturadas,

levantamento documental (registros digitais internos) e observação sistemática não participante.
Resultados: Os dados empíricos evidenciaram que as duas tecnologias analisadas, RFID e Computação na Nuvem, já implantadas em algumas operações na empresa, oferecem condições técnicas para operacionalizar o processo de logística reversa.
Originalidade/ valor: As operações industriais promovem diversas ações para se adequar às normas ambientais, tanto as legais, já em vigor, como as recomendadas, decorrentes da pressão da sociedade, cada vez mais consciente da necessidade de mudanças em processos que impactam negativamente o meio ambiente. Dentre as referidas ações destaca-se a adoção de logística reversa, considerada um dos eixos estruturantes da Política Nacional de Resíduos Sólidos, promulgada no ano 2010. A análise das referidas tecnologias da indústria 4.0 quanto ao seu potencial de contribuir para a logística reversa, se justifica em virtude do planejamento da indústria de calçados, para introduzir estas tecnologias no sistema de manufatura.

Palavras-chave: Indústria de calçados; Logística reversa; RFID; Computação na Nuvem

1 INTRODUCTION

The precariousness of the environment, due to the predatory action of the human being, has contributed to the acceleration of climate change, as well as to several environmental disasters, which have occurred in recent decades. The social repercussion resulted in organized mobilization, in all political spheres, in academia and community, in practically all countries, requiring reconfiguration of the production and consumption, towards sustainability.

The aforementioned mobilization of organized civil society, at different levels and structures, was decisive for the design of environmental legislation, which was more restrictive to most polluting economic activities, as well as social practices that generate negative environmental impact. Brazil is among the countries where the environmental legislation introduced, mainly from 2010 onwards, under the National Solid Waste Policy, substantially modified the rules related to the disposal and treatment of waste, in addition to the norms related to the environmental management practices, both in private and public organizations (Tachizawa & Andrade, 2012).

In the aforementioned legislation, the set of legal provisions that deal with reverse logistics stands out, with the attribution of legal obligations and responsibilities to all those involved in the production chain. However, the deadlines for the operationalization of reverse logistics were defined only for the economic activities of huge environmental risk, not stipulating deadlines for the other productive sectors, even if some of these are characterized by expressive volumes of waste generated and disposed of in sanitary landfills (Abdulrahman, Gunasekaran, & Subramanian, 2014).

This is the case of footwear industries whose products are made up of inputs, which, for the most part, when disposed of in sanitary landfills, at the end of their use cycle, take many years to decompose and represent a significant volume, which reduces the landfill operating time. Reverse logistics, if adopted and operationalized, in that industrial activity, may contribute to mitigating the problem described (Plentz & Tocchetto, 2014).

To enable the reverse logistics process, alternatives for the adoption and operation of digital technologies are evaluated, which have already been successful in helping to solve other problems, such as reducing waste of inputs, the average time of operations execution, better control of operational and management processes, with consequent improvement in productivity and efficiency (Bouzon, Govindan & Rodriguez, 2015). Among the digital technologies, the set of technologies of industry 4.0 stands out.

Identified and defined in 2011 by German researchers, the technologies of Industry 4.0 are characterized by their feasibility through connectivity, offering various benefits, both for the operational processes of manufacturing, as for the management and control of administrative processes. Among these technologies, cloud computing and RFID (radio frequency identification) are among those that currently find more alternatives for their adoption in the manufacturing environment (Ávila, 2012).

For this reason, the research, whose results were used to prepare this scientific article, aimed to analyze the feasibility of implementing reverse logistics in the production of shoes, through RFID and Cloud Computing. To achieve this objective, the authors opted for the single-case study strategy, in one of the largest footwear industries in Brazil, collecting empirical data through semi-structured interviews with company sector managers involved with reverse logistics, in addition to research in internal documents and non-participant systematic observation.

The work begins with a theoretical review consisting of three topics, namely, sustainability in the Brazilian footwear industry, radio frequency identification technology (RFID) and Cloud Computing. The methodological procedures used in the collection of empirical data are detailed below. Analysis and discussion of research results, based on empirical evidence, analyzed in the light of the theoretical review, are presented after. The work ends with the topic of final considerations and the list of consulted works in references.

2 THEORETICAL BACKGROUND

In order to provide theoretical foundations for research, the authors searched theories about issues related to the study. The first topic produced showed the status related to the adoption of sustainable practices in the Brazilian footwear industry. To accomplish this, several works, seminal and also more recent ones, were selected. The following topic explores the technology RFID, demonstrating how it works and how it can help companies to organize operations. Cloud computing is analyzed after with the same objective.

2.1 Adoption of sustainable practices in the Brazilian footwear industry

According to the Ministry of the Environment, in Brazil, the footwear industries need an environmental license to carry out their productive activities following norms of the National Council for the Environment (CONAMA), which is a consultative and deliberative body of the National Environment System (SISNAMA). In its Resolution no. 237/97, it registers the activities subject to licensing, but it is up to the environmental agency to detail and complement this norm, according to each situation, taking into account the environmental risks, the size and other characteristics of the enterprise or activity (Ministério do Meio Ambiente, 2009). The PNRS aims to reduce the use of natural resources in production processes and intensify environmental education actions, in addition to increasing recycling and promoting social inclusion. For this, the priority is not to generate, reduce, reuse and treat solid waste (Ruppenthal, 2014).

Companies in the footwear sector are highly polluting and, because of that, they are responsible for implementing measures to reduce the impacts caused on the environment and on society, being able to introduce, for example, the concepts of eco-design in products and processes, including the search eco-efficiency (Plentz & Tocchetto, 2014). Tachizawa and Andrade (2012, p. 177) highlight the main actions taken by companies in the footwear sector to reduce environmental impact:

a) reduction of energy use per quantity of manufactured products;

b) reduction in the use, recovery or recycling of water per manufactured products;

c) change in the design and packaging composition of the product to make its use less harmful to human health and the environment;

d) control, recovery or recycling of liquid discharges from industrial activity;

e) control, recovery of gases and gaseous emissions generated by industrial activities;

f) reduction in the use of raw materials by quantity of product manufactured or replacement of energy source;

g) adequate disposal of solid waste and industrial waste;

h) recycling of scrap, residues or refuses;

i) changes in storage, transport, handling and logistics procedures for hazardous products and materials;

j) selectivity of environmentally correct suppliers and distributors;

k) expansion of investments in environmental control;

l) development/improvement of environmental audit systems;

m) qualification of the organization for environmental labeling;

n) environmental image of the company for marketing purposes.

As pointed out by Tachizawa and Andrade (2012), among the main actions of the footwear industry is the concern with water and energy consumption, atmospheric emissions, waste and hazardous materials. They are looking for changes in their products and processes in order to improve aspects related to the environment and human health. In addition, they adopt reverse logistics, invest in recycling programs, energy saving measures and other ecological innovations (Plentz & Tocchetto, 2014).

According to the level of disassembly and separation of components, the options for reuse of post-consumer waste, according to Demajorovic and Migliano (2013), the following techniques can be adopted:

a) repairing: restoration of the conditions of use, with the repair or replacement of some components;

b) remanufacturing: separation into subsets or components, generating a mix of new and used items to be applied in a new product;

c) cannibalization: selective rescue of components, depending on the required application, it can be possible to reuse the material or reuse it for recycling;

d) recycling: the material is applied in the production of new items or disposed of for incineration and safe disposal.

As pointed out by Tachizawa and Andrade (2012), among the main actions of the footwear industry is the concern with water and energy consumption, atmospheric emissions, waste and hazardous materials. They are looking for changes in their products and processes in order to improve aspects related to the environment and human health. In addition, they adopt reverse logistics, invest in recycling programs, energy saving measures and other ecological innovations (Plentz & Tocchetto, 2014).

In addition to the characteristics of the operational process, suggesting the need of actions aiming to avoid or, at least, to reduce the environmental impact, especially through better management of solid waste generated, the aforementioned economic sector is also characterized by fierce competition between agents. In this perspective, institutional theory, according to which social behavior is shaped by standards developed through human interactions and then incorporated into norms, social rules and laws, contributes to explaining the efforts of industries to promote sustainable actions and, thus, ensure its legitimacy (Meyer & Rowan, 1977; Dimaggio & Powell, 1983; Dacin, Goodstein & Scott, 2002; Bender, 2004).

Zeng, Chen, Viao and Zhou (2017) built a theoretical model based on institutional theory following the “institution-conduct-performance” paradigm. Next, the proposed model was tested in an eco-industrial park in China, with the aim of analyzing the relationships between institutional pressures, supply chain management, sustainable supply chain design and the ability to promote the circular economy. The results of the survey, with 363 respondents, showed that institutional pressures exert influence on the sustainable supply chain design, which is relevant to the development of companies’ capacities for the adoption of circular economy practices.

Ding, Wang and Chan (2023) deepened the discussion on circular economy, proposing a theoretical model, through which they suggested reverse logistics steps corresponding to each of the stages of the production process. Kannan, Solanki, Darbari, Govindan and Jha (2023) also emphasized the relevance of the operational process to support reverse logistics, by proposing a mathematical model, with the aim of reducing the environmental impacts of the reverse logistics process and making it more efficient. Mishra, Dutta, Jayasankar, Jain and Mathiyazhagan (2023) carried out a systematic review of the literature on reverse logistics and its relationship with the circular economy, demonstrating the relevance of the contribution of both to promote sustainability and generate social benefits.

For Leite (2017), among the alternatives to consolidate the circular economy model, reverse logistics stands out. With the increasing reduction of the life cycle of products offered on the market, the volume of solid waste also grows. However, the increase in the volume of solid waste in sanitary landfills reduces their operating time, requiring the opening of new deposits. Reverse logistics emerges as an alternative to reduce this problem, as it allows the partial recycling of discarded products, with the reinsertion of parts of these products in operational processes of the same or other economic sectors. The author also emphasizes the relevance of the legal framework that regulated solid waste management, which is the national solid waste policy, in which reverse logistics was established as an obligation for various economic sectors.

The reverse logistics process, considered as one of the alternatives for dealing with solid waste from the shoe manufacturing process, represents a relevant challenge for most organizations. Authors Tibben-Lembke and Rogers (2002) described and analyzed the entire set of variables that make up the reverse logistics process, with the aim of demystifying the idea that reverse logistics only represents inverting the orientation of the logistics system, from retail to factory. They highlighted the difficulties involved such as the wide variety of products, in different formats, as well as the marketing aspects involved, accompanied by costs and expenses that the final consumer is not always willing to pay.

New technologies, with emphasis on Cloud Computing and RFID, can support the organizational effort spent to achieve this goal. In the following topics both will be deepened, to highlight their characteristics, as well as their potential to assist organizations in the implementation and operation of reverse logistics.

2.2 Radio Frequency Identification (RFID)

RFID has applications that can help at different activities and sectors of organizations, such as operations that are made manually, and employing sensors and readers, controlling various activities, at the same time, such as all material logistics. The implementation of the RFID system requires some requirements, but on the other hand, it offers opportunities. According to Ávila (2012, p. 16), Radiofrequency Identification Technology (RFID) is based on the use of wireless radiofrequency electromagnetic waves to identify, track, locate and manage products, documents or people, without the need for contact and a visual field by communicating the identification data.

The RFID system consists of a reader, tags/tags/transponder, which can be classified as active (with battery attached) and passive (without battery), antenna and software that allows to manage the information. The working principle is through the emission of the signal to the chip, activating it and sending the signal back if the chip is passive, or transmits its own signal if the chip or tag is active (Ávila, 2012).

One of the characteristics of RFID is versatility. This is because the technology allows applications in various market segments and processes. Examples can be cited in health, the airline sector, internal logistics of materials, cargo control, inventory control, the agricultural sector, residential buildings, control of industries, among others (Pedro, 2012). It is important to note that several of these segments are related to the manufacturing industries.

The system has several benefits and to exemplify them, according to Motorola Solutions (2014) and Souza and Nunes (2020), transport companies are using RFID to maximize their efficiency by approximately 100% in shipping, receiving and order accuracy, 99.5% in inventory and order processing speed is 30% faster, in addition to reducing labor costs by 30%.

RFID technology allows not only the identification of a product with bar code technology, but also recording data about process times on the RFID tag attached to the product, also customers can follow the progress of their product in real time. This is a relevant solution mainly for companies that have complex logistics and long production lines. Evolution will address this same concept in tracking people (Gjeldum, Mladineo, Crnjac, Veza, & Aljinovic, 2018, Schwab, 2017).

According to Souza and Nunes (2020, p. 7), "RFID systems improve visibility throughout the supply chain, as it is an automated way of knowing what you have and where it is. Today, RFID systems are used for asset tracking and warehouse management." In other words, any part of a product, items in process, package, pallet, container, can receive an identification by radio frequency allowing traceability of the item or product, knowing where it is and how it has been handled throughout the production chain, adding the possibility of customer to track their order.

Another important benefit highlighted by Gjeldum et al. (2018) is that this type of tracking, which includes real-time production, can significantly facilitate and improve production planning, especially for the production of small batches and individual items, integrating with the Enterprise Resource Planning (ERP) and Manufacturing execution system (MES); however, the technology may have limitations if the structure is not adequate and professionals do not understand the true concept of RFID.

With the placement of labels and antennae, benefits such as lowering raw materials, production scheduling and supply chain control, among others, occur automatically. The same occurs with logistics/shipping sectors that may include inputs and outputs through the system, eliminating or reducing collectors and, in both examples, the labor of reading or collecting data.

Cheah et al. (2022) conducted a research, whose results showed that RFID technology and wireless communication facilitate the traceability of inputs used in operational processes and thus facilitate the design of methods to promote the circular economy. Jia and Mo (2022) found that RFID technology is preferred by industries because it provides information on the location of inputs and finished products, facilitating both planning and operational management, in an agile and uncomplicated way.

Pacheco, Jung and Azambuja (2021) highlighted the advantages of RFID technology to control the production flow, as well as monitoring its performance through industrial integration, machinery and equipment and industry 4.0 technologies, with emphasis on the RFID. Varriale, Cammarano, Michelino and Caputo (2021) conducted a study on the perishables production line and found that connectivity technologies, in particular RFID, make it possible to reduce losses throughout the entire manufacturing process, by allowing the traceability of inputs used.

2.3 Cloud Computing

All organizations have in their composition data, information, hardware and software. This allows companies to have a memory of the past, manage and execute in the present and plan the execution in the future using resources such as computing or information technology (IT).

According to Cañavate, Monteiro, Freitas and Borges (2017, p. 210), "companies have a duty to safeguard documents and manage organizational memory. The performance of this role depends on the degree of sensitivity and registration of activities". In other words, keeping what is important to companies is vital.

Therefore, storing information, data, software and hardware requires both physical space and computational resources. In this way, costs are generated with servers, maintenance of the structure, physical space, professionals for maintenance and these are allocated whether there is demand or not. These are fixed costs.

With advances in technology, options arise to solve the aforementioned problems. According to Oztemel and Gursev (2020, p. 144), "cloud computing is a storage system for all applications, programs and data on a virtual server". According to the National Institute for Standards in Technology (NIST) (2011), cloud computing is a service model used as required by the customer, which allows broad access to resources such as networks, servers, storage, applications and services and that can be ordered and released quickly with minimal management effort or service provider interaction.

Cloud computing has four options for organizations that share the same challenges or concerns such as security, politics and others. Hybrid, which can be a combination of community, public or private clouds to share specific data between organizations, private clouds that are provided for a specific organization and public clouds that anyone can access (NIST, 2011).

According to Vaquero, Rodero-Merino, Caceres and Lindner (2009), cloud computing does not have a clear definition because it is an evolving technology, but he proposes to conceptualize it as a large deposit of resources such as hardware that becomes digital, software and creation platforms, which can be easily accessed and configured so that adjust to different usage needs and that is paid according to the needs of each customer.

According to Camboim and Alencar (2018), cloud computing provides the use of applications, platforms and infrastructures through remote connections, causing a reformulation in the way companies use computing internally. Also, according to the authors, consumers and suppliers are increasingly interested and preparing for future demands because cloud computing provides flexibility and practicality.

The most conservative organizations interested in cost reduction and that are insecure about making the organization's data available see cloud computing as a way to create their own cloud infrastructure (Camboim & Alencar, 2018). In other words, creating their own network can be advantageous precisely for ensuring confidential information and economically can be justified by the fact that they have a robust IT structure that meets other demands of the organization.

Authors such as Marchisotti, Joia and Carvalho (2019, p. 17) and Vaquero et al. (2009, p. 54) complement by stating that Cloud Computing makes data and information available remotely, it is out of the owner's control, and this inevitably brings up security-related issues and that, therefore, improvement is necessary so that companies can have confidence in allocating its data in the cloud.

Creating cloud storage requires a robust framework, called data centers. They are the ones that store the information and provide the functioning of the clouds. These structures contain electronic equipment used to store, process and transmit data in addition to having a backup. These four operations need to work uninterruptedly and at the same time, and for that, equipment is needed to maintain adequate temperature and humidity. Logically, electricity consumption is high, qualified professionals are needed and it is necessary to compete with major players if the company wanted to enter the market (Sabi, Uzoka, Langmia, & Njeh, 2016).

According to Schwab (2017), storage capacity has evolved a lot to the point that many companies offer storage that can range from 2 to 50 GB for free as a benefit of acquiring other services. He also states that the amount of information produced is a lot, however, there is no longer the need to worry about erasing data to free up space due to the high storage capacity and availability.

Another important data that Schwab (2017) brings is that it is estimated that 90% of the data produced in the world were created between 2015 and 2016 (the book was written in 2016). With the significant increase in data, storage has become a commodity. According to Schwab (2017), the world is moving towards free and unlimited access to storage and by 2025, it is expected that 90% of people will have unlimited and free storage and that storage companies should, for revenue purposes, looking for other alternative, as advertising, instead of storage.

Another consideration to be made is in relation to the IT area that coordinates cloud computing and storage in organizations. It becomes a vital sector in gaining competitive advantage and reducing costs. Mainly, but not only, when it comes to industry 4.0 technologies, it is necessary for IT to know the steps that the organization has been planning so that it can plan its area as well as any other sector of the organization.

A survey carried out in Brazil by Marchisotti, Joia and Carvalho (2019), with IT professionals, on their perception of cloud computing, concluded that professionals have a vision focused more on the operational aspect than on the strategic vision of this technology. According to them, the basis is on security, storage and availability of what is stored and, thus, lacking a perception of strategic value, which can generate new business models and competitive advantage.

In addition, Oztemel and Gursev (2020, p. 144), state that cloud computing "facilitates the operation because customers and employees access the same data and at the same time, it reduces costs, eliminates the complexity of the infrastructure, expands the area of work, protects data and provides access to information at any time". The understanding is that cloud computing is a paradigm shift in relation to hardware and software infrastructure (computers, servers, networks, users) of IT in organizations.

It provides the total integration of organizations, eliminates geographical barriers, uses storage as needed, is scalable as needed, makes the entire operation of the company interconnected where authorized people access information related to their activities from anywhere on the planet, and these possibilities can generate competitive advantage and new business models if contemplated in the company's planning.

3 METHODOLOGY

To achieve the objective of the study, the authors opted for the case study strategy, qualitative approach, collection of empirical data through semi-structured interviews with organizational managers directly involved with the investigated phenomenon, documentary survey, consulting the organization's internal records, and systematic non-participant observation.

The option for the single case study strategy, in one of the largest footwear industries in Brazil, is justified by the large size of the company, with a high degree of complexity of the organizational universe, due to the significant amount of existing and consolidated organizational processes. This strategic option is supported by authors who talk about alternatives to conduct scientific research in applied social sciences, especially Yin (2010), Gil (2002) and Minayo (2002).

The choice of approach is, in this case, qualitative, which is in line with the strategic option, insofar as the aforementioned approach makes it possible to highlight the details of the analyzed organizational environment, by allowing it to be explored in depth, which is the specific characteristic of this choice, as highlight by Gerhardt and Silveira (2009) and Minayo (2002). To achieve the objective of the study, it was necessary to understand the organizational context, the internal infrastructure, the way of arranging organizational resources, as well as the set of criteria that guided the decision making.

With the similar purpose, adhering to methodological procedures of empirical data collection, to the objective of the study, the three collection techniques were selected, namely, (i) semi-structured interviews, with the managers of the investigated organization; (ii) documentary survey, based on consultation of internal records of the company's operational areas and (iii) systematic non-participant observation, by one of the research authors. These empirical data collection techniques are the most cited in the scientific literature consulted, which deals with scientific methodology (Fonseca, 2002; Gil, 2002; Deslandes, Cruz, & Gomes, 2002; Gerhardt & Silveira, 2009; Minayo, 2010).

The empirical data obtained were submitted to content analysis, following the recommendations and guidelines of Bardin (2011). Content analysis is a set of methodological instruments, which are applied to the analysis of extremely diversified discourses, seeking to classify them through a thematic categorization. Content analysis, according to Bardin (2011), allows the joining of a significant number of organized information, starting with the data inventory, where the common elements are isolated, and then with the classification, the elements are divided and its organization is structured, enabling the last phase of the research, which is the interpretation of the data.

The company participating in this case study operates in the footwear sector in the state of Rio Grande do Sul, with eleven branches and eight brands, which deliver quality, comfort and fashion for all styles. With innovation and effective management, it is a leader in the footwear segment, being one of the largest Brazilian manufacturers, delivering its products to more than 95 countries in the world and throughout the national territory. For the purposes of this study, it will be named as Alfa company.

Three of the eleven branches of the Alfa company were randomly chosen to contribute to the study, each of which produces a certain brand:

a) subsidiary 1, which manufactures women’s sandals;

b) branch 30, which manufactures men’s tennis shoes;

c) branch 16, which manufactures injected women’s shoes.

Between March 11 and April 25, 2022, interviews were carried out with employees of these branches and with the legal manager of the Alfa company. Also, the CEO of the recycling company, which carries out the waste recycling processes of the Alfa company, participated in the interviews. Nine interviews had their audio recorded and transcribed in full, carried out via telephone call, using the Whatsapp application; two were answered in the form of a questionnaire, that is, two respondents chose to type their answers. The interview with the CEO of the recycling company, on the other hand, was carried out in person and also had its audio recorded and transcribed.

Among the eleven respondents, five women and six men participated, aged between 25 and 54 years. Respondents will be identified by the acronyms E1, E2, E3, E4, E5, E6, E7, E8, E9, E10 and E11. Respondents E2, E5 and E6 belong to Branch 1, where women's sandals are manufactured; respondents E3, E4 and E8 belong to Branch 3, where men's and children's shoes are manufactured, while respondents E1 and E7 belong to Branch 16, where injected women's shoes are manufactured, all the chosen interviewees are related to the topic addressed, based on previous experience and professional trajectory.

Respondents E9 and E10 are, respectively, the legal manager of Process and Quality of the Alfa company and his intern. Respondent E11 is the CEO of the outsourced company that supplies raw materials, and the unit where he works is a recycling company and business partner of the company Alfa.

The academic background and current position of the interviewees are shown in Table 1.

Table 1 – Academic background and current position of interviewers

Respondents	**Academic level**	**Current position in the company**
E1	Financial Management	Administrative Supervisor
E2	Management Processes	Administrative Supervisor
E3	Production Engineering	Industrial Manager
E4	Administration	Administrative Supervisor
E5	Publicity and Advertising	Footwear Designer
E6	Administration	Administrative Supervisor
E7	Product Design	Designer
E8	Designer of Footwear	Designer
E9	Process and Quality Management	Process and Quality Manager
E10	Mechanical Engineer and Master in Generalist Engineering	Intern
E11	Economics with Emphasis on Projects and Business Psychology	Entrepreneur and CEO of the company

Source: prepared by the author (2022)

Regarding the total working experience time of employees, only one of them has less than one year, four employees have up to ten years of work and the others have more time, reaching 20, 35 and up to 42 years of total work time.

As for the time they have worked at Alfa, two interviewees have been working for less than a year, six have been working for ten years, while the others have an average of fourteen years of experience in the company.

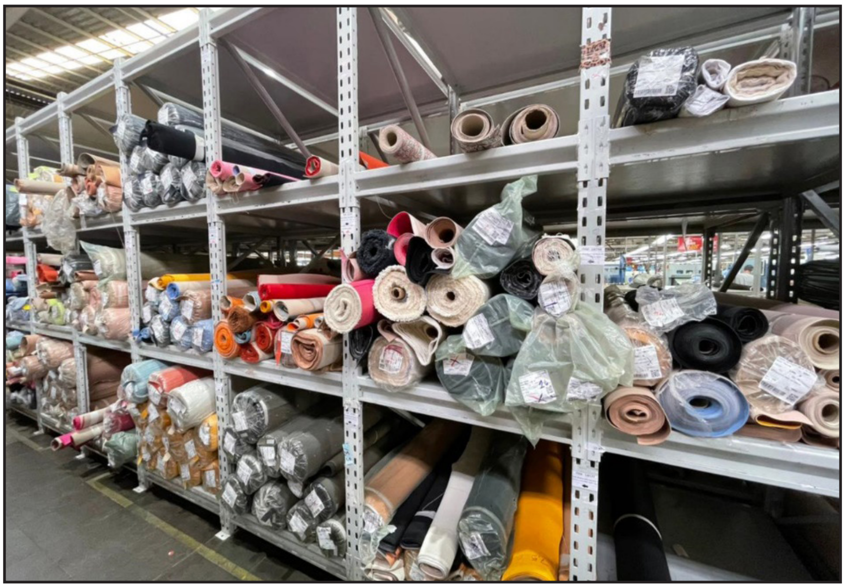
4 ANALYSIS AND DISCUSSION OF RESULTS

The set of Industry 4.0 technologies enable the organization of production processes based on technologies and equipment that communicate autonomously along the value chain; an intelligent model in which computerized control systems monitor physical processes, create virtual copies of the real processes (Pedro, 2012; Zhou, Liu, & Zhou, 2015). One of the technologies that stands out, within the scope of Industry 4.0, is the radio frequency identification technology (RFID), which is based on the use of radio frequency electromagnetic waves, wirelessly, to identify, track, locate and manage products, documents or people, without the need for contact and a visual field through the communication of identification data (Gjeldum et al. 2018; Varriale et al., 2021).

The RFID system is composed of a reader, tags/tags/transponder, which can be classified as active (with battery attached) and passive (without battery) antenna and the software that allows the management of information. The working principle is through the emission of the signal to the chip, activating it and this sending the signal back, if the chip is passive, or transmits its own signal if the chip or tag is active (Ávila, 2012; Pacheco, Jung & Azambuja, 2021).

But how could RFID technology contribute to the reverse logistics process at the company, one of the largest footwear industry in Brazil? E3 stated that RFID technology, among the set of technologies of industry 4.0, would be the one that could contribute most to reverse logistics, stating that the Alfa company already uses it in the central warehouse, to structure the process of intelligent supply of raw materials, put it in all operational units of the organization, located in in the state, in Brazil or abroad. Figure 1 demonstrates the company's central warehouse, where the different types of materials used in the production of shoes cataloged with an RFID tag are stored.

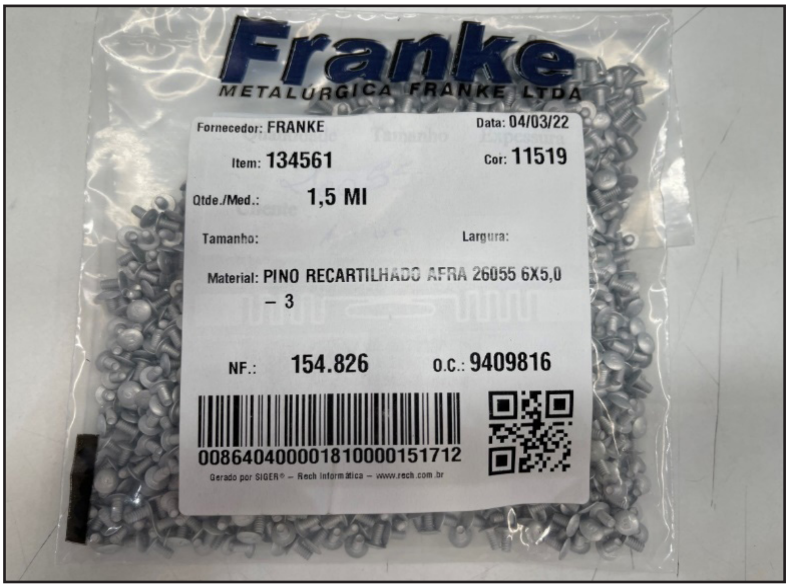
Figure 1 – Warehouse of branch 16 of the company Alfa



Source: prepared by the author (2022)

Figure 2 shows a detailed image of the RFID tag, currently in use by the company Alfa.

Figure 2 – RFID tag, inserted in a component used by the company Alfa



Source: Alfa company (2022)

In E3's opinion, RFID could contribute to promoting reverse logistics, as it stores all product information in RFID, such as: when it was produced, when it left the company, when it arrived at the retailer, when it left the store, for how much time has been used, etc. According to E3, this could contribute to reverse logistics, because the aforementioned product history would help in the creation of action plans within the industry to see how long that product would take to be returned at the end of its useful life. This type of information is considered the basis of the reverse logistics management process, according to Demajorovic and Migliano (2013), Tibben-Lembke and Rogers (2002).

E6 believes that the use of RFID in the components would help to identify the material from its exit, thus enabling reverse logistics planning and subsidizing the shoe design and modeling stage, characterizing it as eco-design (Plentz & Tocchetto, 2014). E5 believes it is important to inform the composition of the shoes, so that the retailer could use the technology in his store as well, knowing what materials it is made of and identifying the raw material that is reused in manufacturing. In this way, the retailer could share information with consumers, encouraging the return of the product to the point of sale, initiating the reverse logistics process (Shaharudin, Zailani, & Tan, 2015; Ding, Wang, & Chan, 2023). E7 and E8 claim it to be important, as it could contribute to the information base of each product, from its origin, contributing to production planning and control activities (Liu & Gao, 2014).

The E9 and E10 believe that the RFID system could be used as an integral part of the return logistics chain, to be implemented for recycling. For example, tags could be added to each new product sold, making it much simpler to identify the model, composition and year of manufacture at the time of return. As it is not possible to add it to all footwear, it would still be feasible to implement it in the chain after a first filtering. This way of product tracking, with the purpose of providing maintenance and repair, as well as reuse and reverse logistics, has already been successfully adopted in several economic sectors, as evidenced by Gjeldum et al. (2018), Leite (2017) and Abdulrahman, Gunasekaran and Subramanian (2014).

E4 believes that the adoption of RFID is interesting, because through this technology, it would be possible to identify the date of shipment of the order, the time that it was stored in the store, the time that the product is with the final customer, because if the storage has been long, automatically, the footwear will be used few times and will already have a defect, as a result of the expiration date of certain inputs. This type of concern was also evidenced in studies conducted by Demajorovic and Migliano (2013), recommending studies on ways to track products, made up of inputs with a short shelf life.

E2 states that using the radio frequency incorporated into the information on the composition of the components used in the manufacture of shoes would facilitate recycling. The E1 and E11 agree that RFID technology provide accuracy and agility of information. The relevance of generating data to support the decision-making process of sustainable actions and practices was also addressed by McAfee and Brynjolfsson (2012) and Bouzon, Govindan and Rodriguez (2015), due to the importance of adequate management techniques to support the design of organizational processes aimed at sustainability.

According to Abdulrahman, Gunasekaran and Subramanian (2014), Bouzon, Govindan and Rodriguez (2015), Liu and Gao (2014), Perera, Member, Jayawardena and Chen (2015) and Shaharudin, Zailani and Tan (2015), the use of GPS and radio frequency identification (RFID) technology helps to make product tracking more efficient. Thus, the information obtained allows companies to continuously improve quality control and product delivery mechanisms.

Table 2 – Reverse Logistics and Radio Frequency Identification (RFID)

Continue...

Source	Empirical evidences	Theoretical background
Interview E3 + Production sector records	Among the 4.0 technologies, RFID would be one that could contribute most to reverse logistics, because it would store a product history, which could be used as a source of information for decision-making on the issue of post-consumer footwear return.	Abdulrahman, Gunasekaran e Subramanian (2014); Bouzon, Govindan e Rodriguez (2015); Liu e Gao (2014); Perera et al. (2015);

Table 2 – Reverse Logistics and Radio Frequency Identification (RFID)

Conclusion

Source	Empirical evidences	Theoretical background
Interviews E2, E5, E6, E7 + Production sector records	The use of RFID would help identify the composition of footwear from its origin.	Abdulrahman, Gunasekaran e Subramanian (2014); Bouzon, Govindan e Rodriguez (2015); Liu e Gao (2014); Shaharudin, Zailani e Tan (2015)
Interviews E4, E9, E10 + Production sector records	The RFID system could be used as an integral part of the return logistics chain, contributing information for recycling, tags could be added to each new product sold, making it much simpler to identify the model at the time of its return, composition and year of manufacture.	Abdulrahman, Gunasekaran e Subramanian (2014); Liu e Gao (2014); Perera et al. (2015); Shaharudin, Zailani e Tan (2015)
Interviews E1, E11 + Production sector records	They highlight the accuracy and agility of the information that RFID technology provides.	Bouzon, Govindan e Rodriguez (2015); Liu e Gao (2014); Perera et al. (2015); Shaharudin, Zailani e Tan (2015)

Source: prepared by the author (2022)

RFID technology presents aspects of convergence with cloud computing. For Oztemel and Gursev (2020, p. 144), “cloud computing is a storage system for all applications, programs and data on a virtual server”. Cloud computing has four options:

a) community: which are for organizations that share the same challenges or concerns, such as security, politics, among others;

b) hybrid: which can be the junction of community clouds, public or private, to share specific data between organizations;

c) private: provided to a specific organization;

d) public: those that anyone can access (NIST, 2011).

Due to this convergence, it was also decided to evaluate how cloud computing could contribute to the reverse logistics process. E3 has already started by answering that the Alfa company currently already has a database of return flows, work rates, among other information, in cloud computing. It ensures that the cloud database could make this information available to all company units, to be worked on the issue of the product that returns to the company at the main points of return, to reduce the product volumereturned to the company. The product that the customer received with a quality problem is registered in a database for analysis and adoption of actions to manage these cases, enabling their mitigation and reverse logistics. The importance of cloud computing for systematic organizational records, related to the company's operation, was also mentioned by Perera et al. (2015).

E6 stated that cloud computing has many purposes, such as: (i) better understanding the relationship between sustainability strategies and information technology initiatives, (ii) framing the intersections formed by the three dimensions of sustainability – environmental, social, economic and the legal, and (iii) the sustainable economic and legal dimensions. Still, behavioral factors of the population in relation to recycling can be considered. Therefore, all these dimensions influence the adoption of practices that justify the adoption of cloud computing technology for data control and product return structure, focusing on cost reduction (Souza & Nunes, 2020).

Respondent E5 believes he could help with the creation of a community environment, where consumers could know which companies or brands have the reverse logistics process. The E7 and E8, on the other hand, claim that this technology can contribute to storing data, recording and organizing the information on a platform or in a software with product information, explaining the return process and sustainable origin. Similar data emerged in research carried out by Vaquero et al. (2009) in other economic sectors, which allows the perception of the feasibility of its adoption.

The E9 and E10 summarize that cloud computing is an infrastructure technology for Information Technology (IT) services, being commercially the outsourcing of these infrastructure services in a contracted company, through SaaS (software as a service), PaaS (platform as a service) or IaaS (infrastructure as a service). In this way, it could be used as a replacement or in collaboration with the existing physical infrastructure, corroborating the empirical findings of Wang, Wan, Zhang, Li and Zhang (2016). Its implementation would depend on issues such as cost, software technologies employed and the need for scalability of the company's services. In a context where the new chain was highly integrated, it would be up to the company to define whether it would maintain the administration of its infrastructure internally or if part, or if its entirety would be in the cloud. Each of these situations has particularities aligned with the operational specificities of certain organizations (Zhou, Liu, & Zhou, 2015).

E4 claims to have confidence in the information recorded in the cloud to generate a record of the past and, thus, develop process improvements and avoid product returns. This position is aligned with that expressed by E1, E2 and E11, that highlighted the importance of storing information, clarifying doubts about the components and their recycling methods, as well as their correct destination, thus having knowledge in a faster way, in addition to protection data (Oztemel & Gursev, 2020).

According to a report by the Center for Management and Strategic Studies (CGEE), cloud computing consists of services that use computers, servers and the entire infrastructure necessary to process and store databases, which can be shared and accessed through the internet, from devices, such as computers, tablets and cell phones (CGEE, 2020).

Table 3 – Reverse logistics and cloud computing

Continue...

Source	Empirical evidences	Theoretical background
Interview E3 + Production sector records	The Alfa company already uses cloud computing technology, but could expand to all units of the company by interconnecting and automating the databases.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020); Vaquero et al. (2009)
Interview E6 + Production sector records	Cloud computing can help to better understand the relationship between sustainability strategies in relation to data control and in relation to the return structure of products, focusing on cost reduction.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020); Sabi et al. (2016)
Interview E5 + Production sector records	It could help with the creation of a community environment, where consumers could know which companies or brands have the reverse logistics process.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020); Cheah et al. (2022)

Table 3 – Reverse logistics and cloud computing

Continue...

Source	Empirical evidences	Theoretical background
Interviews E7, E8 + Production sector records	This technology can contribute to data storage, recording and organizing information on a platform or software with product information, explaining the return process and sustainable origin.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020); Marchisotti et al. (2012)
Interviews E9, E10 + Production sector records	Cloud computing comprises SaaS, PaaS or IaaS (Software, Platform and Infrastructure as a Service) technologies that can be outsourced, leaving the company to decide how to manage its infrastructure internally or in the cloud.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020); Jia and Mo (2022)
Interview E4 + Production sector records	This technology would increase the reliability of the information, by generating a history, in order to develop improvements in the process and avoid returns.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020)
Interviews E1, E2, E11 + Production sector records	It would help in the storage of information, clarifying doubts about the components and their recycling methods, as well as their correct destination, thus having knowledge in a faster way, in addition to data protection.	CGEE (2020); Liu et al. (2011); Oztemel and Gursev (2020); Pacheco, Jung and Azambuja (2021)

Source: prepared by the author (2022)

Table 3 summarizes the set of empirical evidence that emerged during the research regarding the feasibility of adopting cloud computing to promote reverse logistics in footwear production. For each type of application/use of the aforementioned industry 4.0 technology to provide reverse logistics, authors of reviewed works, who carried out similar research, even in different economic sectors, were referred.

5 FINAL REMARKS

Sustainability and sustainable development currently represent a social need and a priority in most countries at a global level. The urgency in adopting measures to prevent environmental risk stems from the observation of ongoing climate change, which damages environmental quality and require changes, including in the operation of economic actors who work not only in primary activities, directly related to agribusiness, but also, the entire production matrix, retail chain and service provision.

The generation and disposal of solid waste, in ever-increasing volumes, has stood out in recent decades as one of the environmental risk factors. The growth rate of solid waste volume is above the world population growth rate, being driven by the consumption pattern of developed and developing countries at an unsustainable level in the long term.

The desirable solution for this phenomenon would be to change society's consumption behavior, which, however, is cultural in nature and, therefore, long-term. For this reason, legal measures have been formalized to mitigate the negative environmental impact resulting from the disposal of an increasing volume of solid waste, mainly products made of non-renewable inputs. One of these measures is reverse logistics, which, in Brazil, was formalized within the scope of the National Solid Waste Policy, in 2010.

At approximately the same time as the promulgation of the PNRS, a group of German researchers conceptualized a set of technologies, based on connectivity, as Industry 4.0. The purpose was to boost the process of adopting the aforementioned I4.0 technologies in production systems, with the aim of obtaining gains in productivity and cost reduction. Gradually this expectation is materializing, supported by the potential of I4.0 technologies to generate benefits in different spaces, both organizational and social ones.

In this research, conducted in one of the largest footwear industries in Brazil, with a qualitative approach, empirical data collection through semi-structured interviews, non-participant systematic observation and documental research, submitted to content analysis, we sought to analyze the feasibility of adoption of radio frequency technology (RFID) and cloud computing, to operationalize reverse logistics.

The empirical results showed that the two technologies of I4.0 are technically feasible to be adopted and offer favorable conditions to operationalize reverse logistics. The highlight, in the case of RFID technology, is its ability to track products and identify inputs used in the assembly of footwear, enabling the design of operational processes, with the use of adequate infrastructure (people and machines) to carry out reverse logistics. Cloud computing, on the other hand, contributes mainly through the availability of information, recorded in the cloud, in databases, which can be processed and filtered to determine operational, consumption, scripts, product and input stock patterns, for support the operationalization of the reverse logistics process.

The main limitation of the research is in its methodological design, of a single case study, which may make it difficult to generalize the results of the study due to the operational specificities of the organization studied. Despite the aforementioned limitation, it is understood that the results obtained are relevant and contribute to the advancement of knowledge in the area of management and sustainability.

As a suggestion for new studies, it is understood that it would be important to carry out more case studies in footwear industries, allowing the comparison of the results obtained, as well as the quantitative approach with more organizations.

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1. Definition of research problem	√		√
2. Development of hypotheses or research questions (empirical studies)	√		√
3. Development of theoretical propositions (theoretical work)		√	
4. Theoretical foundation / Literature review	√	√	√
5. Definition of methodological procedures	√	√	√
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