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Industrial Engineering and Operations Management

XXVI IJCIEOM (2nd Edition), Rio de Janeiro, Brazil, February 22–24, 2021

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Editors

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Challenge and Trends for Sustainability in the 21st Century

Springer

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Preface

We are pleased to Preface this second volume of the Proceedings to the XXVI International Conference on Industrial Engineering and Operations Management (IJCIEOM). The Conference was initially scheduled to take place on the campus of the Pontifical Catholic University of Rio de Janeiro, Brazil, in the first semester of 2021. Due to the pandemic of COVID-19, the Conference migrated to a virtual edition, held successfully between 22 and 24 February 2021. It resulted equally in the combination of the events of 2020 and 2021, each in a single Conference. The 2020–2021 Conference was jointly organized by ABEPRO (Associação Brasileira de Engenharia de Produção), ADINGOR (Asociación para el Desarrollo de la Ingeniería de Organización), IISE (Institute of Industrial and Systems Engineers), AIM (European Academy for Industrial Management), and ASEM (American Society for Engineering Management). This second volume is a testimony of the persistent and high-quality production of our Operations Management and Industrial Engineering (OM&IE) peers in difficult times.

The Conference's theme was the "Challenge and Trends for Sustainability in the twenty-first Century, looking ahead to bridge theory and practice of economic, social, and environmental sustainability." This volume assembles 48 papers selected through a double-blind review process. The content of the selected papers covers a diversified array of themes and methods in the broad fields of operations and supply chain management, industrial engineering, engineering management, and related disciplines. It is a companion to the first volume of the Proceedings, which assembled 52 papers originally submitted to the 2020 edition of the Conference. Papers submitted for the 2021 edition are now being published in this separate volume.

The topics covered in this volume can be regrouped under the general headings of innovation, sustainability, sector-specific applications and management practices, maintenance engineering, decision-making processes, and education. Innovation appears often in combination with the related areas of Industry 4.0 and the digital transformation of supply chains. This cluster of papers includes open and green innovation ecosystems, contributions of Industry 4.0 technologies to sustainable operations and functional machinery safety management in the automotive industry, and the digital transformation of supply chain management processes. It embraces also the circular economy and recycling. The concept of circular economy is analyzed concerning the digital transformation of eco-innovation, supply chain management, its measurement in companies, with exemplar applications to industrial clusters, to packaging shape models, and the segments of lubricating oils and the packaging recycling chain.

Sustainability is equally represented as a core and diversified theme. It includes papers on cleaner production in aeronautical workshops, sustainable entrepreneurship, use of photovoltaics in electrical vehicles, building construction, the use of sales and operations planning as a driver to sustainability, public transportation in city logistics, and the adaptation of engineering to a sustainable service sector. The analysis of effluents and contaminants is well represented in papers about the critical factors for effluent drainage network projects, biosafety in supermarkets, and CO_2 emissions in the soil-cement industry.

The application of management practices in specific economic sectors appears chiefly under the heading of lean and lean six-sigma applied to a diverse set of industrial engineering projects implementation, improvement of electronic components, and the application of takt-time to the production of coffee powder. Applications to the health sector are also well represented, with papers on simulation models in emergency departments and on the effects of COVID-19 on vaccine supply chains and the planning of intensive care units. Other sector-specific application covers the banking sector, with papers on benchmarking of sustainable banking under COVID-19 pandemic, and bank mergers and acquisitions. A particular application of management practices appears in papers offering system dynamic views of disasters and human migration and a review of deprivation costs in humanitarian logistics and operations. Project management is represented by two articles on dynamic project management and the integration of business process model life cycle analysis in the design thinking process. General supply chain management processes are analyzed for the segment of porcelain export.

Several papers are situated in the area of maintenance engineering. They cover topics about fuzzy criticality assessments of corrosion risks in the petroleum industry, autonomous maintenance in factories, and total preventive maintenance in lean health care. The relationships between the key indicators of the maintenance process, the dimensions of sustainability, and the use of multi-criteria decision-making in maintenance prediction are equally represented.

The decision-making process was the focus of a proposed framework for the development of competencies, an analysis of entrepreneurship resilience and gender, and a broader review of the relations between the decision-making process and sustainability in general, and more specifically in the mining industry. Education in OM&IE covered the use of games and teaching cases, the measurement of universities' commitment to sustainable development goals, and an appraisal of the relevance of the concepts of advanced manufacturing and industry 4.0 to technology development.

Altogether, the papers gathered in this second volume of proceedings of the XXVI IJCIEOM Conference are representatives of the diversity of interests and methods applied to the betterment of the theory and practice of OM&IE. The editors also

acknowledge the support of Fundação de Amparo à Pesquisa do Estado do Rio de Janeiro—FAPERJ (210.368/2020—SEI-260003/002594/2020). As editors, we are proud to offer this companion edition to the first volume of the XXVI IJCIEOM proceedings and we hope you will enjoy the reading.

Rio de Janeiro, Brazil — Antônio Márcio Tavares Thomé
Rio de Janeiro, Brazil — Rafael Garcia Barbastefano
Rio de Janeiro, Brazil — Luiz Felipe Scavarda
Lisbon, Portugal — João Carlos Gonçalves dos Reis
Aveiro, Portugal — Marlene Paula Castro Amorim

Contents

Data Modelling and Validation of An Emergency Department Simulation Model—A Lean Healthcare Approach 1
Alexandre Castanheira-Pinto, Bruno Gonçalves, Rui M. Lima, and José Dinis-Carvalho

Assessing the Influence of Circular Economy Practices in Companies that Orchestrate an Ecosystem of a Brazilian Industrial Cluster 13
Marcia M. C. Bacovis and Miriam Borchardt

Public Transport Systems and its Impact on Sustainable Smart Cities: A Systematic Review 33
Roberto Rivera, Marlene Amorim, and João Reis

Eco-Innovation and Digital Transformation Relationship: Circular Economy as a Focal Point 49
Adriane Cavalieri, Marlene Amorim, and João Reis

Open Innovation and User-Community as Enhancers of Sustainable Innovation Ecosystems 65
Joana Costa, Pedro Freire, and João Reis

Impact of Lean Tools on Companies During Industrial Engineering Projects Implementation: A Correlation Study 79
Ângela Silva and Ana Cristina Ferreira

Mapping of the Porcelain Export Process in Brazil Based on the SCOR Methodology 93
Leonardo Melo Delfim, Caio de Araújo Pereira Gadelha, Jonas Figuerêdo Silva, Gabriella Gambarra Moreira, and Maria Silene Alexandre Leite

Circular Economy for Lubricating Oils in Brazil 103
Marcelo Guimaraes Araújo, Giancarlo Lovón-Canchumani, and Lilian Bechara Elabras Veiga

Sustainability in Building Construction: A Comparison Between Certified and Non-certified Companies 115
Gabriel Aires Moreira, Rômulo Soares de Lima Filho, Maria de Lourdes Barreto Gomes, Josilene Aires Moreira, and Ricardo Moreira da Silva

S&OP as Driver for Sustainability 125
Bruno Duarte Azevedo, Christian Kalla, Tobias Kreuter, Luiz Felipe Scavarda, and Bernd Hellingrath

Industry 4.0 Contributions in Sustainable Operations 139
Yasmin Pires Gonçalves and Etienne Cardoso Abdala

Fuzzy Criticality Assessment of Systems External Corrosion Risks in the Petroleum Industry—A Case Study 153
Rodrigo Goyannes Gusmão Caiado, Marina Polonia Rios, Gabrielle Cordeiro Martins, Paulo Ivson Netto, and Fernanda Ramos Elmas

How Much Do the Objectives and KPIS of Maintenance Cover Sustainability Dimensions? 167
João Felipe Fraga Bianchi, Helder Gomes Costa, and Leonardo Antonio Monteiro Pessôa

Circular Economy and Supply Chain Management: Publications and Main Themes 181
Priscilla Cristina Cabral Ribeiro, Luiza Dantas Carpilovsky, and Carlos Francisco Simões Gomes

Framework for Implementation of Autonomous Maintenance with the HTO Approach 193
Paulo Cézar Loures, Luiz Felipe Scavarda, and Andréa Regina Nunes de Carvalho

Definitions of Critical Risk Factors in an Effluent Drainage Network Project Using AHP: A Case of Study 211
J. C. Pereira and Y. Dorino

Decision-Making Process on Sustainability: A Systematic Literature Review 225
Renata Amaral Fonseca, Antônio Márcio Tavares Thomé, and Bruno Milanez

Business Simulation Games: A Comparative Analysis for Teaching of Production Engineering 237
Sofia Emi Maia Pinto Ishihara, Annibal Affonso Neto, and Clóvis Neumann

Descriptive Bibliometric Analysis on Vaccine Supply Chain Management for COVID-19 253
Paulo Henrique Amorim Santos and Roberto Antonio Martins

Disaster Influencing Migratory Movements: A System Dynamics Analysis 265
Luiza Ribeiro Alves Cunha, Joaquim Rocha dos Santos, and Adriana Leiras

The Deprivation Cost in Humanitarian Logistics: A Systematic Review 279
Maria Angélica Silva and Adriana Leiras

Measuring Universities' Strategic Commitment to the Sustainable Development Goals 303
Carolina Grano and Vanderli Correia Prieto

The Adaptation of the Engineer to the Service Sector and the Maintenance of Economic-Social-Environmental Sustainability 317
Cesar B. Z. de Oliveira, Mellany Juhlly Machado, Dayse Mendes, and Kellen Santos

Analysis of Biosafety Actions in Supermarkets: The Customer View 327
Kidja Maria Ramalho Frazão, João Vitor da Costa Santos, Aldaiza Rayssa Santos, Pedro Henrique do Nascimento Silva, and Lucas Ambrósio Bezerra de Oliveira

Framework for the Development of Competencies Using a Matrix for Decision Making: A Case Study 337
Rafaela Plantes Pavloski, Mario Luis Nawcki, Edson Pinheiro de Lima, Fernando Deschamps, and Sergio Eduardo Gouvea da Costa

Advanced Manufacturing or Industry 4.0 Scholarly Works: Are They Relevant to Technology Development? 349
Izaskun Alvarez-Meaza, Jon Borregan-Alvarado, Ernesto Cilleruelo-Carrasco, and Rosa Maria Rio-Belver

Assessment of CO_2 Emission in the Soil–Cement Brick Industry: A Case Study in Southwest Paraná 359
Rogério Expedito Restelli, Atilas Ferreira de Paiva, Diego Audrey de Lima Lamezon, Edson Pinheiro de Lima, and Fernando José Avancini Schenatto

Analysis of the Perceptions on Target Costing Using a Pedagogical Case Study 373
Paulo Afonso, Valdirene Gasparetto, and Cezar Bornia

Bank Mergers and Acquisitions: A Study of Events Regarding the Stock Price in the Hypothesis of Efficient Markets 387
Vinícius Dalla Vecchia and Ana Paula Etges

Cleaner Production with Economic and Environmental Assessment: A Case Study in an Aeronautical Workshop 397
Henrricco Nieves Pujol Tucci, Geraldo Cardoso de Oliveira Neto, Flavio Luiz Rodrigues, Marlene Amorim, and João Reis

The Synergetic Effect of Lean Six Sigma and TRIZ on the Improvement of an Electronic Component 409
Sónia Araújo, João Lopes, Anabela C. Alves, and Helena Navas

The Coordination of Packaging Recycling Chain in Brazil 421
Ticiana Braga De Vincenzi, Roberta Souza Piao, Diego Vazquez-Brust, and Marly M. de Carvalho

Enabling the Use of Shop Floor Information for Multi-criteria Decision Making in Maintenance Prediction 435
Rolando J. Kurscheidt Netto, Eduardo de F. R. Loures, and Eduardo A. P. dos Santos

Exploitative Model for Dynamic Project Management Based on the Project Management Body of Knowledge 449
Luciano Sales and Sanderson Barbalho

Exploratory Analysis of the Impacts of Digital Transformation on Supply Chain Management Processes 463
Lia Denize Piovesan, Daniel Pacheco Lacerda, and Antônio Márcio Tavares Thomé

Industry 4.0 Technologies for Improving Functional Machinery Safety Management from the Interoperability Point of View in the Automotive Industry 475
Marcio Lazai Junior, Álvaro dos Santos Justus, Eduardo de Freitas Rocha Loures, Eduardo Alves Portela Santos, and Anderson Luis Szejka

A Model to Integrate the BPM Life Cycle and the Design Thinking Process 489
Carolina Sierra Vargas, João Francisco da Fontoura Vieira, Marlon Soliman, Érico Marcon, and Arthur Marcon

An Internal Efficiency Benchmarking Investigation for CEF's Sustainable Banking and Response to the COVID-19 Crisis 501
Thyago Celso Cavalcante Nepomuceno, Susane de Farias Gomes, and Túlio Fidel Orrego Rodriguez

Paradox of Firm Theory and Sustainable Development in the Mining Industry: Approximation Through the Managing Leader 513
Ana Paula Braga Garcez, Josilene Aires Moreira, Ricardo Moreira da Silva, Mário Franco, and Fernando Bigares Charrua Santos

Implementation of Takt Time in the Development of a New Value Stream Mapping in the Production of Coffee Powder 523
Érik Leonel Luciano, Marcelo Tsuguio Okano, Rosinei Batista Ribeiro, Thulio Cesar Ferreira Rocha, and Wagner Alexandre Dias Chaves

Planning Intensive Care Resources: A Forecast and Simulation Approach Due COVID-19 Pandemic in Rio de Janeiro City 535
Daniel Bouzon Nagem Assad, Javier Cara, Miguel Ortega-Mier, Thaís Spiegel, and Luana Carolina Farias Ramos

Genetic Algorithm Applied to Packaging Shape Models Using Sustainability Criteria 545
Tarcisio Costa Brum, Marcos Martins Borges, Afonso Celso de Castro Lemonge, and Lino Guimarães Marujo

Entrepreneurial Ecosystems and Sustainable Entrepreneurship: Challenges Towards More Social Entrepreneurial Orientation 559
Mariana Pita, Joana Costa, and António Carrizo Moreira

TPM Adaptation as Lean Healthcare Practice to Improve the Logistics Processes of a Pharmaceutical Supply Center—PSC 569
L. S. de Bittencourt, A. C. Gularte, B. A. Leal, I. C. de Paula, and W. P. Bueno

Green Innovation Ecosystems: An Exploratory Study of the Involved Actors 585
Arthur Marcon, José Luis Duarte Ribeiro, Rosa Maria Dangelico, and Luca Fraccascia

Circular Economy and Companies: Understanding the Characteristics and the Challenge of Measurement 597
Marina I. Baumer-Cardoso, Lucila M. S. Campos, and Weslynne Ashton

Reviewing Photovoltaics and Electric Vehicles: Synergy and End of Life Management 609
Rafael Marcuzzo, Lucila M. S. Campos, Mauricio Uriona Maldonado, and Caroline Rodrigues Vaz

Entrepreneurial Resilience and Gender: Are They Connected? Contributions Toward Entrepreneurship Policy-Package 621
Mariana Pita and Joana Costa

Data Modelling and Validation of An Emergency Department Simulation Model—A Lean Healthcare Approach

Alexandre Castanheira-Pinto, Bruno Gonçalves, Rui M. Lima, and José Dinis-Carvalho

Abstract An increasing demand for the public emergency systems has been noticed in the recent past. Since public hospitals capacity, in terms of resources, doesn't followed such increase proportionally, operational problems started to emerge. To pursue better hospital operations management, lean philosophy has been adopted since the its successful cases in the industry. For this purpose, a statistical analysis was made in the hospital database in order to obtain key performance indicators (KPI), such as *Takt Time* as well as the arrival patterns per priority. Such statistical data and KPIs were posteriorly used to validate a discrete simulation model that represents the emergency system of a public hospital in Portugal. Therefore, multiple processes were modeled, like the admission, triage and the arrival of patients to the treatment rooms. Finally, it is presented the validation procedure for the simulation model. After testing it was possible to prove that the simulation model is valid, which means that is capable of representing the real system, achieving realistic results.

Keywords Simulation · Lean healthcare · Discrete event simulation · Simulation model

1 Introduction

In the mid-twentieth century, a new productive ideology was born within Toyota, capable of breaking the productive paradigms rooted at the time. Contrary to the concept of mass production developed by Henry Ford, the Toyota Production System (TPS) intends to achieve the same objective, continuous production flow, with fewer resources [1]. The benefits caused by TPS in the production department, such as the costs reduction and increasing product quality, quickly led to its expansion to different sectors [2]. This expansion process was intensified when several industrial segments, besides the automobile industry, reached prominent results with the adoption of Lean

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principles in their production processes [3]. According to Hines et al. [4] delivering value-added products to customers, passed not only through the application of Lean principles at the operational level, but also at the strategic level, given rise to a new concept known as Lean Enterprise [1]. This philosophy excels in identifying the processes and tasks that truly add value to the service provided to customers. Thus, by implementing Lean Enterprise, it is expected to reduce operating costs, improve the quality of the service provided, as well as the reduction of its lead-time. Such gains provided by adopting a Lean Enterprise philosophy quickly stimulated curiosity in different sectors. There has been an increasing tendency to transport Lean principles to the public sector in order to reduce costs and simultaneously improve the efficiency of government operations [5]. Notwithstanding the above, the health sector, due to its great complexity regarding operations and resources management and entities flow control, is being seen as a very suited sector for the application of lean principles. Thus, the sector is capturing the scientific community attention, given rise to a new concept known as Lean Healthcare [6].

To advocate a management policy based on Lean Healthcare concepts means a constant search to provide more health services using a lower number of resources. It is also important to mention that Lean Healthcare presents an antagonistic perspective to traditional management policies, which is based on workers dismissal or compromising the quality of the service provided [6]. The exact beginning of the application of Lean Healthcare principles is somewhat diffuse, however a pioneering work stands out [7], in which the author transports productive technology to the hospital context in order to reduce inventories. Since then, multiple publications have emerged in the scientific community, addressing several problems from the application of SMED techniques for reducing preparation time in an operating room [8] to the application of 5S techniques [9]. Lean Healthcare has been in the spotlight of the scientific community, with an exponential growth in the number of annual publications [6]. However, the work of Proudlove et al. [10] published in 2008, reinforced in 2015 by the work of D'Andreamatteo et al. [11], show the embryonic stage that Lean Healthcare is currently at, with countless opportunities yet to be explored. Combining this with the constant technological advancement, has enhanced the development of simulation software more robust and capable of numerically translating a real scenario. This fact makes possible to test changes into existing processes without the need to implement them on a real scale. Despite representing a theme that has been cherished in academia since 1950, the use of discrete simulation as a tool to analyze issues related to production only proliferated in 1986 [12]. Since then, the adoption of simulation as an analysis technique has gained notoriety, having been published several studies in different contexts [13–15]. Just as Lean has expanded to different sectors, so has simulation. The application of this technique as a problem analysis technique that aid to the decision-making process quickly spread in the health sector, highlighting the adoption of themes such as the study of surgical procedures, intensive care unit design, among others [16].

Both the discrete event simulation technique and the Lean Healthcare principles share the goal of improving the process under analysis, but represent two isolated approaches. The first attempt at integrating these two concepts was proposed in 2012 by Stewart Robinson [17]. Thus, testing the various scenarios resulting from the adoption of measures based on Lean Healthcare concepts became possible with the use of discrete event simulation [18, 19].

Based on the succinct historical framework presented, it is clear the importance and the innovative and avant-garde nature of the theme presented for this article. Both the application of the Lean philosophy to the health sector, as well as the use of the simulation technique as an aid to the improvement of hospital services represent a recent theme in the scientific community. This work is being developed in a public hospital which is undergoing an expansion and complete remodeling of its emergency service physical plant. So, it is intended to develop studies to evaluate the capacity, use of resources and the operating mode of the hospital new emergency service, through the association of the simulation technique with the Lean Healthcare philosophy. In this way, several variant scenarios developed according to Lean Healthcare principles can be studied without the need for scale tests. As easily understood the investigation methodology is based on a case-study approach, being identified the system operation in order to develop a simulation model.

2 System Description and Parameterization

Since modern societies develop new standards of living, some public sectors started to observe an increased demand and consequently an inefficiency in the operation processes. Solving such problem, and respond more efficiently to the increasing demand, can generally be solved by adopting new management principles, as the ones preconized by Lean philosophy. This work presents an ongoing study of an emergency department in a Portuguese hospital located in the north of Portugal. In order to better understand the patient flow, as well as the tasks and phases from which the patient undergoes in the system, an illustrative scheme is presented in Fig. 1. It is important to emphasize that only the flows analyzed are outlined in the figure, with a multiplicity of flows ignored due to their weak relevance to the study.

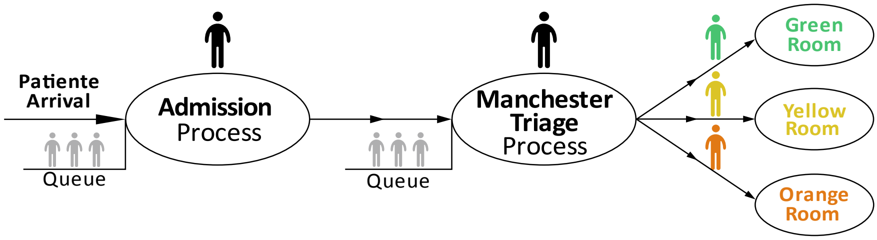


Fig. 1 Illustrative scheme of the emergency department *modus operandi*

2.1 Patient Arrival

Starting by analyzing the demand of the emergency service to identify demand patterns (very important for applying to the simulation model), the authors had access to the hospital 2018 database. Since every emergency episode (patient emergency request) is registered, the database had 92978 entries, which represents a very good sample for statistical purposes. Thus, all episodes were separated by hour for each day of week, being posteriorly determined the average of arrivals per hour. Using such information was possible to draw the emergency arrivals pattern, as it is expressed in Fig. 2. In spite of being presented only four days, the demand pattern was assessed for all weekdays. Since the patients with priority between green and orange color (Manchester Triage System) represent 98.75% of the sample, the statistical analysis only focused on these patient's groups. Therefore, some conclusions can be drawn by scrutinizing Fig. 2. Firstly, there are two periods of the day with an arrival peak, between 8–10 and 14–16 h. Another interesting aspect is the fact that in night shift, between 0 and 7 h, the arrival rate is almost the same independently of the weekday considered. Finally, Monday express itself as the more demanding day having an average arrival rate of almost 30 patients in the peak hour.

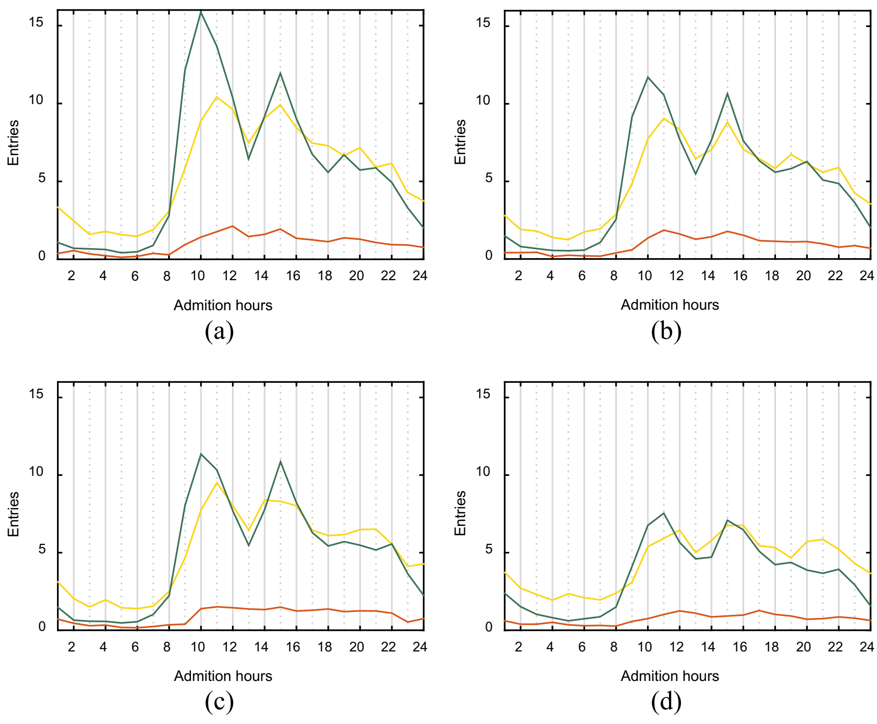
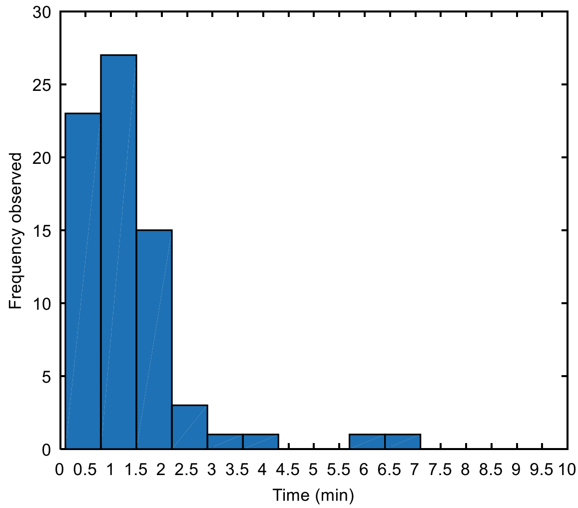


Fig. 2 Patient arrival rate per hour: **a** Monday, **b** wednesday; **c** friday; **d** sunday; (green dots—green priority; yellow dots—yellow priority; orange dots—orange priority)

Fig. 3 Histogram of recorded admission time



2.2 Admission Process

The admission generically represents the emergency registration, which is the first task that a patient will experience in an emergency episode. The hospital monitors the patients flow during their stay in the emergency service by registering a set of process times, event times and waiting times. However, the hospital can only start monitoring the patients after their registration in the emergency service. So, in order to obtain the process times of the registration task, an observation action was conducted in the field to collect the registration task process time (Fig. 3). With the purpose of using such information in the simulation model, the collected data was treated and fitted, conservatively, to a uniform distribution, with a minimum and maximum of 3 and 5 min respectively.

2.3 Triage System

After concluding the admission process, the patients will wait for the Manchester triage system where they are assigned with a priority level (represented by a color), and a medical specialty is specified to attend the patients based on their symptoms. Since the processing time for the triage task is monitored by the hospital, a probabilistic fit to the database provided was performed, using the maximum likelihood method [20], being expressed in Fig. 4 the cumulative frequencies for the real data, as well as for the theoretical distribution.

A Lognormal distribution was found to be the random distribution which better describes the triage process, with an average of 113.836 s and 4667.12 of variance.

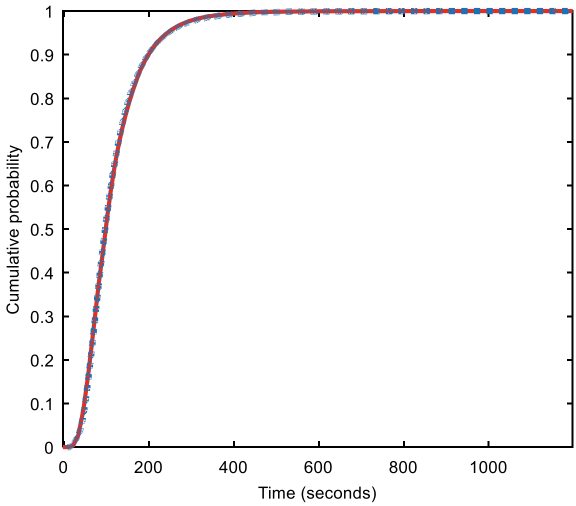


Fig. 4 Cumulative frequencies of triage data (blue circles—real data, red line—theoretical distribution)

After the triage task the patient is allocated to a designated area in accordance to the priority received in the Manchester triage system.

2.4 Treatment Room Arrivals

Lack of efficiency is commonly associated to the emergency services worldwide, being characterized by long waiting queues and consequently by huge waiting times. Low medical resources as well as empirical design of the space per treatment area influence directly the unproductive behavior of an emergency system. Thus, to pursue a better performance, and properly design the requirement resources is imperative to known the exact demand of the treatments rooms, which may be assessed by measuring its *Takt Time*. *Takt Time* measure, in average, how often a patient arrives at the treatment room. Since the hospital monitors at which time the patient begins the triage system and also the triage duration, it is possible to determine at which time the patient arrives at the treatment room. *Takt Time* will be the average time between arrivals, being expressed in Table 1.

Analyzing the data of Table 1, it is possible to observe that green and yellow patients arrive almost at the same rate, which is related to the fact that they represent a similar percentage of the emergency episodes. Orange episodes, as it makes reference to more serious health diagnosis are not so common as the green and yellow, being

Table 1 *Takt Time* obtained by the hospital database

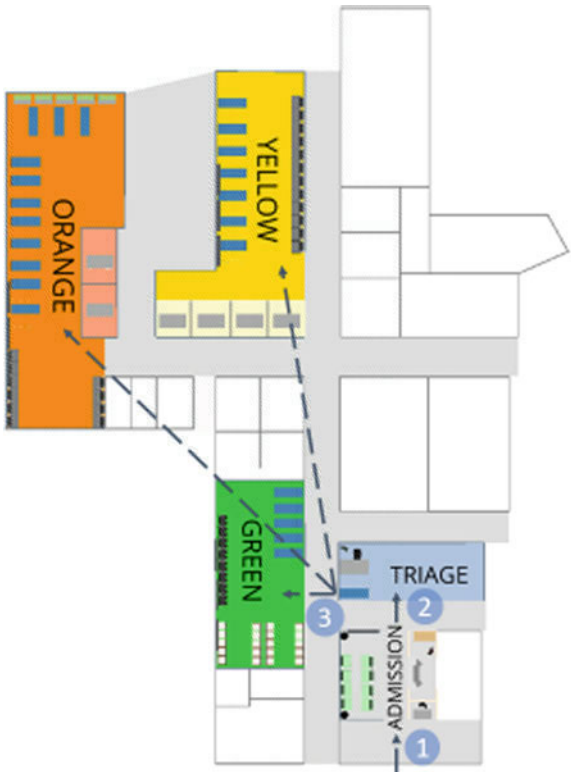
Green room (min)	Yellow room (min)	Orange room (min)
13	12	69

the *Takt Time* considerable higher. For the purpose of stablishing an efficient service, the *Takt Time* represents the needed treatment rate at which there will be no queue in the treatment rooms. Therefore, *Takt Time* can be used to design the medical staff capacity required to respond to a specific demand.

3 Simulation Model

As an attempt to predict how the new emergency department will behave, a discrete simulation software (simio) was used to model the system. In Fig. 5 it can be seen an overview of the model being superimposed all the available flows that a patient can follow. To better understand how the model was developed a stage-by-stage explanation will be followed.

Fig. 5 Overview of the simulation model with the patient flows available



3.1 Entities Arrival

In the simulation an entity represents the object that will cross a designated process. As can easily be perceived, in this context an entity will represent a patient in the emergency system. Thus, the arrival rates, obtained in the system's parametrization, were considered in the simulation model to generate the patient's arrivals. Considering the patient arrival as an arrival rate, makes the model flexible to study the impact of an increasing demand expected to occur in the future.

3.2 Admission Process

As it was said previously, the admission process is the beginning of an emergency episode. Such task was modeled in the simulation model (processing time) using the uniform distribution expressed in the system parametrization, making the model dynamic and representative of the real scenario. When the arrival rate is less than the operations time, achieved by resources considered, queue will be experienced, being the simulation modeled able to count for such particularity. As observed *in loco* the admission process can be done by more than one person, being implemented the same feature in the simulation model.

3.3 Triage Process

Concluding the admission process the entities follows to the triage process. In a real-life event, after a patient is admitted to the emergency system, needs to wait for the triage process (which might be full or without available triage resources). Similarly, in the simulation model when the entity exits the admission process checks for available space in the triage process. If there is no available space in the triage process, then the entity waits in a queue. For triage's processing time, the lognormal distribution presented in the previous chapter was assumed. The simulation model is also flexible to considered any scenario of triage workplaces.

3.4 Treatment Rooms Arrival

Finally, the entities are forwarded for a designated room, in accordance to the priority received in the triage system. To posterior validation, the arrival time is recorded per entity at the room entrance.

Table 2 *Takt Times* (min) comparison

Triage		Green room		Yellow room		Orange room	
Real	Simulated	Real	Simulated	Real	Simulated	Real	Simulated
5.5	[5.2; 5.8]	**13**	[10.9; 12.4]	**12**	[10.1; 14.1]	**69**	[54.8; 83.1]

3.5 Model Validation

The validation procedure consisted in the direct comparison between the *Takt Time* registered in the simulation model and the real *Takt Time* obtained by the hospital database (Table 1). Since admission and triage times are dictated by probabilistic distributions several replications of the model were ran for the results to achieve statistical meaning. In the present study, and for this preliminary stage, it was assessed that 40 replications are enough for a robust statistical analysis. As the results of the simulation model are in fact a multiplicity of results, as many as the replications considered, the software expresses them as a confident interval with a confidence level of 95% (probability of being inside the interval). A comparison of both results, real and simulated are presented in Table 2 being expressed in minutes. As can be seen, all the simulated *Takt Times* are reasonable in terms of results magnitude. Another interesting aspect is the capacity of the model to simulate properly the emergency behavior since the results achieved contained, for almost every process, the real *Takt Time*, being the simulated model validated.

Despite of the green ‘s *Takt Time* does not contain the real value, it can be perceived that is very close, which. can be justified by the fact that the calculation of the database’s *Takt Time* is merely an arithmetic average and the simulation model have the consideration of randomness in the arrivals process.

4 Conclusions

An overview of the emergency system from the studied public hospital was presented with the correspondent process parameterization, being found that the triage process time can be described by a lognormal distribution and the admission as a uniform distribution. Demand pattern assessment allowed the identification firstly of two major peaks which occurs between 8–10 and 14–16 h, and concomitantly that Monday is the most requested day. In the pursue to preview how the emergency system will behave in the future, a simulation model capable of representing the real system was developed. To properly simulate the emergency system until the treatment room’s arrivals, several features needed to be considered. The dynamic behavior of the operations was one of them, with the adoption of probabilistic distribution for the processing times. The simulation model is also capable of considering the desired scenario in terms of workplaces on all the operations modeled. A direct comparison between the real *Takt Time*, obtained by treating the hospital database, with the result achieved using the simulation model was followed as a validation strategy. To achieve statistical meaning, the simulation model ran 40 replications, being the results expressed as confident intervals. It was seen that for all the priorities considered the real *Takt Time* is achieved by the simulation model. Such fact proves the validation of the model in producing accurate results, and therefore as a powerful tool to predict outcomes to a desired scenario.

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References

1. T. Melton, "The benefits of lean manufacturing: what lean thinking has to offer the process industries," *Chemical engineering research and design,* vol. 83, no. 6, pp. 662–673, 2005.
2. M. Ballé, G. Beauvallet, A. Smalley, and D. K. Sobek, "The thinking production system," *Reflections,* vol. 7, no. 2, pp. 1–12, 2006.
3. J. P. Womack and D. T. Jones, "Lean thinking: Banish waste and create wealth in your organisation," *Simon and Shuster, New York, NY,* vol. 397, 1996.
4. P. Hines, M. Holweg, and N. Rich, "Learning to evolve: a review of contemporary lean thinking," *International journal of operations & production management,* vol. 24, no. 10, pp. 994–1011, 2004.
5. E. A. Scorsone, "New development: what are the challenges in transferring Lean thinking to government?," *Public Money and Management,* vol. 28, no. 1, pp. 61–64, 2008.
6. D. Weinstock, "Lean healthcare," *The Journal of medical practice management: MPM,* vol. 23, no. 6, p. 339, 2008.
7. S. E. Heinbuch, "A case of successful technology transfer to health care: total quality materials management and just-in-time," *Journal of Management in Medicine,* vol. 9, no. 2, pp. 48–56, 1995.
8. M. Leslie, C. Hagood, A. Royer, C. P. Reece, and S. Maloney, "Using lean methods to improve OR turnover times," *AORN journal,* vol. 84, no. 5, pp. 849–855, 2006.
9. S. Kanamori, S. Sow, M. C. Castro, R. Matsuno, A. Tsuru, and M. Jimba, "Implementation of 5S management method for lean healthcare at a health center in Senegal: a qualitative study of staff perception," *Global health action,* vol. 8, no. 1, p. 27256, 2015.
10. N. Proudlove, C. Moxham, and R. Boaden, "Lessons for lean in healthcare from using six sigma in the NHS," *Public Money and Management,* vol. 28, no. 1, pp. 27–34, 2008.
11. A. D'Andreamatteo, L. Ianni, F. Lega, and M. Sargiacomo, "Lean in healthcare: A comprehensive review," *Health policy,* vol. 119, no. 9, pp. 1197–1209, 2015.
12. L. F. McGinnis and O. Rose, "History and perspective of simulation in manufacturing," in *Simulation Conference (WSC), 2017 Winter*, 2017, pp. 385–397: IEEE.
13. B. Dengiz and O. Belgin, "Simulation optimization of a multi-stage multi-product paint shop line with Response Surface Methodology," *Simulation,* vol. 90, no. 3, pp. 265–274, 2014.
14. S. A. M. Hashim, "Simulation for reducing energy consumption of multi core low voltage power cable manufacturing system," *Journal on Technical and Vocational Education,* vol. 1, no. 2, pp. 1–10, 2017.
15. W. Terkaj, T. Tolio, and M. Urgo, "A virtual factory approach for in situ simulation to support production and maintenance planning," *CIRP Annals,* vol. 64, no. 1, pp. 451–454, 2015.
16. M. Thorwarth and A. Arisha, "Application of discrete-event simulation in health care: a review," 2009.

17. S. Robinson, Z. J. Radnor, N. Burgess, and C. Worthington, "SimLean: Utilising simulation in the implementation of lean in healthcare," *European Journal of Operational Research,* vol. 219, no. 1, pp. 188–197, 2012.
18. N. Ö. Doğan and O. Unutulmaz, "Lean production in healthcare: a simulation-based value stream mapping in the physical therapy and rehabilitation department of a public hospital," *Total Quality Management & Business Excellence,* vol. 27, no. 1–2, pp. 64-80, 2016.
19. F. Rocha, J. Queiroz, J. Montevechi, and J. Gomes, "Aplicação de value stream mapping e simulação a eventos discretos para melhoria de processo de um hospital," *Anais do XLVI Simpósio Brasileiro de Pesquisa Operacional, Salvador,* 2014.
20. G. N. Murshudov, A. A. Vagin, and E. J. Dodson, "Refinement of macromolecular structures by the maximum-likelihood method," *Acta Crystallographica Section D: Biological Crystallography,* vol. 53, no. 3, pp. 240–255, 1997.

Assessing the Influence of Circular Economy Practices in Companies that Orchestrate an Ecosystem of a Brazilian Industrial Cluster

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Abstract The purpose of this study is to verify the presence of principles, strategies, and practices of the circular economy in a group of companies installed in an industrial cluster in the Brazilian Amazon region. The research is exploratory, using multiple case studies. Using as constructs, the eight Schools of Thought, precursors of the circular economy. Which guided the identification of 37 sustainable circular strategies and practices that guide the transition to the circular economy. The practices identified were transformed into a questionnaire, used in the interview with managers of three large companies (orchestrators of an ecosystem). As a result, it was found that the practices of schools of thought Natural Capitalism and Supply Chain in Closed Loop (CLSC) are the most influential and present in the sample companies; and the practices with less influence refer to the School of Biomimicry. The study found that companies have focused on minimizing the generation of waste, reducing the consumption of water, energy, reducing unnecessary resources, recycling packaging; but there are few efforts and strategies to keep components, materials, and products in the loop for longer. New partners are needed to collaborate in the value chain and reconsider creating value, extending the product's useful life, or looking for ways to regenerate and recover its waste.

Keywords Circular economy · School of thinking · Natural capitalism · Closed-loop supply chains · Biomimicry · Industrial cluster

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1 Introduction

Sustainable development has been a challenge for business organizations, which are called upon to balance their rate of exploitation of natural resources without compromising future generations [1]. In the context of sustainable development, Circular Economy (CE) emerges as a strategy that aims to improve the efficiency of materials and energy use [2]. CE is an approach to the management of restorative and regenerative industrial production systems [3–5], in which products, components, and materials that remain valuable in the greatest usefulness and for the longest possible time [2–4]. The CE theme has gained considerable attention from researchers and professionals in recent years because of its potential economic, social, and environmental benefits [3]. Research on CE acceptance by the industry remains limited [6], as there are several challenges in the transition to CE to be faced by manufacturing companies [7]. CE is not an easy concept to implement [3], and empirical evidence on CE adoption at the organizational level has been particularly critical in emerging economies, in addition to China [1, 6], where much research has been carried out on the topic. The same does not happen in Brazil [8, 9].

For the authors [10–12], there are little empirical evidences on the implementation of CE practices at the micro-level, deserving greater attention, especially in the context of companies manufacturing facilities installed in emerging countries, such as Brazil [1, 8]. For [9], the CE in Brazil still faces institutional gaps and sustainability paradoxes. The dissemination of CE in emerging economies has been hampered because the field of CE research is filled with divergent approaches, with little research on the benefits of adopting CE strategies and practices having been developed [12, 13], pointing to the need for more research on innovative practices and strategies for CE [14].

De Oliveira et al. [15] state that, in Brazil, research on the application of Circular Economy practices is still incipient and requires the identification and articulation of actions coordinated by companies. In this context, despite the literature pointing to a growing interest in CE practices, there are still few studies analyzing the adoption of circular business practices and models in emerging countries, especially in Brazil [8, 16]. Thus, this research was carried out in three companies located in the Brazilian Amazon region; a region that has an enormous amount of available natural resources, but that cannot be fully utilized without the mechanisms that promote sustainable development, such as the principles of the circular economy, being properly applied; since in underdeveloped regions, economic success is almost always achieved with the depletion of natural resources, generating a loss of biodiversity and climate change, in addition to impacts on the health of the local population. Given this context, the research questions that guided this study were: (Q1) What are the strategies and practices of CE implemented in the researched manufacturing companies? (Q2) How CE strategies and practices are adopted by companies located in emerging countries, subsidiaries of large manufacturing companies, in order to minimize the impacts of their activities in the region?

The paper is organized as follows. The Introduction in the first section. In the second section, we have a review of the literature on strategies and practices of CE Schools of Thought. The third section describes the methodology used to conduct the research and case studies. The fourth session presents the results and discussions. The fifth section summarizes the contributions, makes a conclusion, and suggests future research.

2 The CE Practices from the Circular Economy Schools of Thought

The CE is based on established concepts and theories that defend the transformation of linear economic systems into circular systems, in which there are no losses. Linear systems rely on extraction, production, consumption, and disposal processes. The general concept underlying the circular economy has been developed by many Schools of Thought (ST) [2, 17, 18], such as Industrial Ecology [19, 20], Cradle to Cradle (C2C) [21], Performance Economics [22, 23], Biomimicry [24], Blue Economics [25], Regenerative Design [26], Closed-loop supply chain [27], and Natural Capitalism [28].

Industrial Ecology (IE) is a well-established area of research, considering a systemic perspective, complex patterns of material and energy flows within and outside the industrial system and technological dynamics, which requires a systemic view [29]. An important strategy of IE is Eco-efficiency, by which the company can create value and reduce the environmental impact [12, 30]. Resource-efficient production saves them for other purposes or for use in future generations. The Industrial Symbiosis strategy involves industries traditionally separated in a collective approach of competitive advantage and the physical exchange of materials, energy, water and/or by-products, through cooperation between companies [12, 19]. In both IE and CE, there must be cooperation between actors within and between the technical and biological cycles. The CE model is systemic, focused on effectiveness in terms of systems (the entire product life cycle and its relationships with other cycles, with the environment and society) [5]. Another strategy identified in IE is investment in new technologies. For Agyemang et al. [1] technology is important for the company to achieve sustainability in advanced manufacturing; it also allows for radical transitions during the manufacturing process, allowing for reduced energy, material consumption and toxic emissions. The **Cradle to Cradle (C2C)** is based on the proposal that products can be designed so that their constituent materials circulate indefinitely in biological or technical systems when using energy from renewable sources, with a circular design and considering waste as food [2, 12, 21]. The design of the product is crucial in the design of sustainable circular systems. Efforts to close the material cycle by C2C design approaches have been researched since 1990 [29, 31]. The expansion of the return on products used, through the reverse logistics strategy, is explicitly related to companies' sustainability efforts [2, 32]. The C2C is a holistic framework with the objective of creating efficient, sustainable and waste-free systems, as the concept goes beyond the design and manufacturing processes [32].

Performance Economics emphasizes the design of durable products, guaranteeing strategies for extending the product's useful life and defending the sale of the service of a product and not the physical product itself [22]. The "design for durability" and "design for reliability" will allow you to extend the life of the products; promoting the adoption of new business models based on use-oriented services (PSS), in addition to options for reusing products and components [2, 33]. Recent thinking about CE focuses on "dematerializing" the economy, reducing material flows in production and consumption; create products and services that provide consumers with the same level of performance, but with an inherently lower environmental burden [22]. Dematerialization has promoted new forms of business models such as the economy of sharing and collaborative consumption, which are an integral part of CE [22, 31].

In **Biomimicry**, nature is the great source of inspiration for innovation [24]. It is inspired by natural ecosystems where the waste of one organism is the food or shelter of another being. In this sense, the CE can be seen as an application of biomimicry at the level of an ecosystem, as the perfect source of examples and successful models of materials and energy flow is in ecosystems [12, 24]. Eco-innovation, present in Biomimicry, is becoming a theoretical reference for strategic development, which can lead to an increase in productivity and an improvement in competitive advantage at the company level [34]. The **Blue Economy** highlights that waste does not exist: nutrients, matter and energy have a ripple effect; by-products can be used for the development of new products [25]. The use of resources from renewable sources provides compliance with the first principle of CE: preserving and improving natural capital, controlling finite stocks and balancing the flow of renewable resources. Thus, natural capital must be valued by reducing its use for the minimum necessary [35]. Circular Economy is inspired by this school, based on a model that optimizes the flow of goods, maximizing the use of natural resources and minimizing the production of waste. Competitiveness are two characteristics of the Blue Economy that serve as a motivation for CE [25, 32]. **Regenerative Design** is based on systems theory and has as premises that the recovery of materials and products should not be treated at the end of its useful life, but be contemplated from the design, through the choice of renewable materials or design for disassembly [2, 26, 29]. The **Regenerative Design**, in the context of CE, requires central skills in circular design to facilitate the disassembly of products and which allows the reconditioning, remanufacturing, reuse and recycling of each one, that is, to guarantee its use in cascade [2, 26, 31, 32]. For Moreno et al. [31], designers are responsible for defining how products and services are designed and built and that the design of most products is far from circular, as it follows the linear pattern of resource use. It is worth pointing out that the design of circular products needs to consider the chosen business model [17, 36, 37] and the selection of material [17].

The **Closed loop supply chain (CLSC)** proposes the "closing of the loops" through the retention of value promoted by the "R" frameworks and Reverse logistics. The literature points to several "R" frameworks that make it possible to retain the value of products and resources: such as the 3Rs (reduce, reuse and recycle) [12, 38], the 4R (reduce, reuse, recycle and recover), 6R (reduce, redesign, reuse, remanufacture, recycle, recover), and 9R are proposed by [39] (refuse, reduce, redesign, reuse, repair, remanufacture, recondition, recycle, recover). **Natural Capitalism** refers to the world's natural assets, such as air, water use and land use. The model argues that the interests of the environment and companies are not mutually exclusive, but overlapping [2, 28, 32]. Natural capital must be valued by reducing its use to the minimum necessary. For Bradley et al. [35] the energy and resources used must be primarily from renewable sources. Moving to CE requires organizations to innovate in their business models [2, 17, 30]. The reformulation of the business model allows traditional companies to more easily integrate sustainability into their businesses [17, 30]. The table in the Appendix, present the characteristics of the schools and the main practices and strategies recommended by the ST, as well as the main references that empirically base each body of knowledge.

3 Methodology

This research is classified as follows: as for the objectives, it is exploratory; as for nature, it is quantitative, as for the object of study it is a study of multiple cases. The analysis of the literature provided a theoretical basis for the study of multiple cases performed here. The case studies are suitable for investigating contemporary phenomena [40]. This research method was chosen due to the exploratory nature of the research. In addition to the study of multiple cases, a content analysis [41] of the selected articles was carried out to codify strategies and practices and analyze the interviews; using the NVIVO version 11 software. The strategies and practices were submitted to three Brazilian experts on the CE theme for validation. The specialists act as consultants on the subject and have publications in the area of life cycle management and circular economics.

After reviewing the literature, providing the main bibliographic reference, the next step was to choose the companies that would be part of the research. The main criteria for selecting companies was to disclose in the Sustainability Report, published on its website, that they are applying the CE principles and practices (energy efficiency, emissions reduction, reuse of materials, redistribution, remanufacturing, recycling), diversifying their models business models to close loops, delay resource loops and reduce resource flows [17] or regeneration and recovery processes [2]. The multiple case study will be conducted at three companies located in an industrial cluster in northern Brazil that are subsidiaries of global corporations. The companies included in the sample are orchestrators of the cluster's ecosystems, with environmental certification according to the ISO 14.001 family or equivalent, with environmental, social and economic sustainability objectives.

Alpha is a large manufacturer of home appliances, with more than 15 thousand employees and three manufacturing units in Brazil. The company is certified in ISO 9001, ISO 14001, OHSA 18.001 and considers aspects of environmental and social sustainability in its Mission and values, demonstrating that the environmental dimension is of great importance for its business. The company diversified its business model to offer a line of water purifiers in the subscription model (Product Service System). Beta is a supplier of metal packaging for beverages, food and household products. It is the largest manufacture of aluminum beverage cans in Brazil, with a high content of recycled material (97%). Gama, in turn, is a world leader in technology and materials for welding and offers services for the purchase and industrialization of welding residues (Blot/Oxides/Pastes) from the welding process of electronic components, with Environmental Responsibility in the welding process recovery and final destination of this Solder Waste, closing the production cycle. The three companies are corporations, headquartered outside Brazil, so many sustainability strategies are defined at the corporate level. Despite the different sectors and business models, each company chosen as a case study represents a starting point to characterize elements and functions that contribute to the CE.

Data collection was carried out mainly based on structured interviews, using the practices and strategies identified in the literature as a protocol. All visits and interviews were carried out between May and August 2019 and were carried out with key informants from the companies. In Alpha, the interviews were conducted with the Environmental Analyst and EHS Manager (Environment, Health, and Safety). At Beta and Gama companies, there is a manager and/or coordinator responsible for quality (ISO 9001) and environmental (Environmental Management System, ISO 14.001) issues. Thus, the Quality and Environment Manager and Environmental Analysts participated in the interviews. During the research, the content of the questions and the purpose of the study were clarified. Respondents confirmed that they understood the concepts. The interviews lasted more than 90 min and the researcher recorded and transcribed the content for content analysis in the NVIVO11 software. To ensure consistency between the responses and the empirical situation of the companies, the interviewees also manually filled out a spreadsheet summarizing information about each practice, to synthesize the discussion with a categorical question, evaluated on a scale that indicated the importance of that practice/strategy for the company, 1 = very high; 0.75 = high; 0.5 = intermediates; 0.25 = low; 0 = very low]. The question that the study poses is: How does the company evaluate the contribution or the importance of such CE practice/strategy in the company's environmental management strategy? In this context, each practice listed in Table 1, guided a discussion on the motivation to adopt the practice/strategy, as well as the current situation of the company regarding this practice.

Biases in the interviews and reports were considered during data analysis, as pointed out by previous qualitative research on corporate sustainability. To mitigate this research limitation, the interview data were supplemented by published documents and research sites. companies. Besides, during the interviews, concrete examples were asked to illustrate generic statements. The results, transcripts, and final information were presented at a final meeting (which lasted, on average, 90 min), in which the interviewees corrected the results found.

A case study research strategy must guarantee the internal validity and reliability of the results. The main procedures for avoiding interference are extensive review