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AI Support for Organizational Agility in Cleantechs for Resource Orchestration

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Abstract:
The business environment approaches the use of technologies to broaden its range of competitiveness in the market. Studies demonstrate through Artificial Intelligence new competitive paths and how these can orchestrate technologically sustainable resources. This paper aims to present a proposition model that identifies how Artificial Intelligence (AI) enhances Organizational Agility (OA) for Resource Orchestration (RO) in the context of clean technology companies and sustainable development goals (SDGs). A qualitative, multiple case study research was conducted with 22 semi-structured interviews from 11 clean technology companies in the areas of renewable energy, energy commercialization, energy efficiency, sanitation, and water treatment. Content analysis was used to analyze the data. Artificial Intelligence encourages Organizational Agility to Resource Orchestration, also pointing out new categories (findings) such as: Technology and Digital Skills, System Dynamics, and Accuracy for developing innovative products and services in Cleantechs. This study contributes to the literature with a new model of Artificial Intelligence and Organizational Agility, Orchestrating Resources through Digital and Technology Competencies, providing Dynamics between Learning Systems and Accuracy for the development of products and services that aim to collaborate with the SDGs. Illustrate the strategic paths that Artificial Intelligence can take from the perspective of Machine Learning to address solutions for the energy and sanitation sectors, providing innovations. The originality of the work lies in the contextual articulation of the work between Artificial Intelligence, Organizational Agility and Orchestrating Resources in the context of clean tech companies and SDGs.
Keywords: Artificial Intelligence; Organizational Agility; Resource Orchestration; Cleantech; Sustainable Development Goals.

O suporte da IA na Agilidade Organizacional em Cleantechs para Orquestração de Recursos

Resumo:
O ambiente de negócios se aproxima do uso de tecnologias para ampliar sua faixa de competitividade no mercado. Estudos demonstram por meio da Inteligência Artificial novos caminhos competitivos e como estes podem orquestrar recursos tecnologicamente sustentáveis. Este artigo tem como objetivo apresentar um modelo de proposição que identifique como a Inteligência Artificial (IA) potencializa a Agilidade Organizacional (AO) para a Orquestração de Recursos (OR) no contexto de empresas de tecnologia limpa e objetivos de desenvolvimento sustentável (ODS). Foi realizada uma pesquisa qualitativa, estudo de caso múltiplo, com 22 entrevistas semiestruturadas de 11 empresas de tecnologia limpa nas áreas de energia renovável, comercialização de energia, eficiência energética, saneamento e tratamento de água. A análise de conteúdo foi utilizada para análise dos dados. A Inteligência Artificial incentiva a Agilidade Organizacional para a Orquestração de Recursos, apontando também novas categorias (achados) como: Tecnologia e Competências Digitais, Dinâmica de Sistemas e Acurácia para o desenvolvimento de produtos e serviços inovadores em Cleantechs. Este estudo contribui para a literatura com um novo modelo de Inteligência Artificial e Agilidade Organizacional, Orquestrando Recursos por meio de Competências Digitais e Tecnológicas, proporcionando Dinâmica entre Sistemas de Aprendizagem e Acurácia para o desenvolvimento de produtos e serviços que visam colaborar com os ODS. Ilustrar os caminhos estratégicos que a Inteligência Artificial pode tomar na perspectiva do Machine Learning para abordar soluções para os setores de energia e saneamento, proporcionando inovações. A originalidade do trabalho reside na articulação contextual do trabalho entre Inteligência Artificial, Agilidade Organizacional e Orquestração de Recursos no contexto de empresas de tecnologia limpa e ODS.
Palavras-chave: Inteligência Artifcial; Agilidade Organizacional; Orquestração de Recursos; Cleantechs; Objetivos de Desenvolvimento Sustentável.

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AI Supports Cleantechs' Organizational Agility and Resource Orchestration

1. Introduction

Research on organizations and resources majorly considers technological contexts and has focused on discussing the different roots of competitive advantage and its sustainability (Carnes et al., 2017; Wang et al., 2019a; Dierickx & Cool, 1989). Organizations have operated Artificial Intelligence technology to propose solutions aimed at innovation and sustainable development (Di vaio et al., 2020), mainly in energy (Ghoddusi et al., 2019), agriculture (Liakos et al., 2018), and water treatment sectors (Breviglieri et al., 2020).

Sustainability and technology studies indicate that organizations that operate clean technologies are known as “Cleantechs” and base their innovations on the allocation of clean and natural resources. This process is guided by the Sustainable Development Goals (SDGs) (Mio, Panfilo, & Blundo, 2020) and adapted in a scalable way in the market to create products and services based on digital and industrial foundations (Di Vaio et al., 2020).

The technological and digital foundations of information technology observe Artificial Intelligence as a device to stimulate Organizational Agility in different types of organizations (Panda & Rath, 2017); (Wang, Huang, & Zhang, 2019b); (Zitkiene & Deksnys, 2018). In this context, the primary strategies are aligned with market contexts and different types of corporations such as family business, multinationals and startups (Shakeel, 2021). In this sense, the present work aims to deepen the context of clean technology companies (Cleantechs), and understand how artificial intelligence and organizational agility can foster resource orchestration. Our study is oriented based on existing gaps in information technology literature, organizational strategies, and sustainability (Ghoddusi et al., 2019; Liakos et al., 2018; Wang et al., 2019a; Carnes et al., 2016).

Studies on clean technology organizations point to the existence of gaps in the literature that understand the association of orchestration and resource allocation and the role of organizational agility (Wang et al., 2019a). These were identified mainly under the theoretical lens articulated in the research of Di Vaio et al., (2020), Mio et al. (2020) and Wang et al. (2019a).

Furthermore, other scholars such as Ghoddusi et al. (2019) and Breviglieri et al. (2020) also indicate that Artificial Intelligence Machine Learning (ML) can provide solutions for water treatment and energy efficiency, promoting the insertion of sustainability in the organization. However, these authors do not stress how resources can be mobilized by technology and how speed can be used to adapt the context of market solutions.

On the other hand, from an organizational perspective, Wang et al. (2019a) and Zainal et al., (2020) identified that Organizational Agility strengthens the ability to respond and make decisions about business opportunities when operating technologies for sustainability. However, it is still unclear how resources are operationalized in terms of artificial intelligence (Zainal et al., 2020) and Sustainable Development Goals (Di Vaio et al., 2020; Mio et al., 2020), visualizing the innovative solutions in the energy, sanitation, and water treatment market, which are the central scope of this article.

Based on scientific research in management and strategy in parallel with studies on information technology, the specific research gap that this work aims to fill resides in the findings of Ravichandran (2018) and Zainal et al. (2020). The authors evidence the need to investigate OA from different theoretical prisms of information technology (e.g., Artificial

Intelligence), visualizing other organizational formats and how companies operate business resources that can boost competitive advantage.

In addition, another gap that this work aims to address is related to AI studies and sustainable development goals. We have identified a lack of studies that tried to understand the correlation between AI applications and its allocation of resources to generate innovative solutions in new small-scale companies (Divaio et al., 202; Liakos et al., 2018; Ghoddusi et al., 2019)

Considering the scientific gaps found in the literature, the research question is: “How can Artificial Intelligence (AI) support Organizational Agility (OA) for the Resource Orchestration (RO) in the context of cleantech companies to collaborate in the achievement of sustainable development goals?”. Thus, this paper aims to present a proposition model that identifies how AI enhances OA for the RO in the context of cleantech companies and SDGs.

The main theoretical contribution of the article is presenting a novel model of artificial intelligence, and organizational agility. The model proposes orchestrating resources through digital and technology competencies, highlighting the dynamics between the learning systems and accuracy for the development of products and services that aim to collaborate with the objectives of sustainable development. The practical contribution presents the strategic paths for artificial intelligence to strengthen organizational agility in cleantech organizations and their innovative solutions focused on energy (Ghoddusi et al., 2019), sanitation and water treatment (Liakos et al., 2018) sectors.

The text is organized in 6 Sections: Introduction, Theoretical Framework, Methodology, Data Analysis, Results and Discussion, Final Considerations.

2. Theoretical Framework

The foundations of the theoretical framework of the present paper covered the theoretical prisms from the sciences of Information Technology and Business and Management. Theoretical prisms were established to support hypothetical qualitative propositions and deal with the following topics: (a) Artificial Intelligence: Machine Learning Approach; (b) Organizational Agility and the technology context and (c) Resource Orchestration: structuring, bundling, and leveraging. This foundation of theoretical reference aims to study the context of clean technology companies, corresponding to the fulfillment of sustainable development objectives, discussed in depth in Section 3 (Methodology).

2.1. Artificial Intelligence: Machine Learning Approach

Artificial Intelligence (AI) is a broad field that encompasses the study of machines with intelligence that think or act like humans (Dobrev, 2012). Due to the great success of Machine Learning (ML) in applications such as natural language processing and computer vision, this article focuses on ML as an approach to AI.

Machine Learning is a subset of Artificial Intelligence that aims to construct computer programs that automatically improve with experience (Mitchell, 1997; Helm et al., 2020). Barber (2012) relates ML to data-driven methods capable of understanding and aiding human information processing tasks. Considering the history of innovations presented by Isaacson (2014), computers were created to automate laborious and repetitive tasks. Still, programmers had to write programs that model business rules and comply with real-world constraints. It is possible to learn these rules based on large data sets using machine learning algorithms.

If the machine can learn from a large set of known examples, it is possible to apply a Supervised Learning (SL) model (James et al., 2013). This kind of technology can assist humans in projecting systems that can be used by financial institutions to fight monetary fraud and detect criminal/suspicious transactions (Mehrabi et al., 2021).

Another kind of machine learning is Unsupervised Learning (UL). Given a large set of data, Unsupervised Learning is used to discover unknown similarity groups in this data (James et al., 2013). Some big successes are speech recognition and statistical machine translation in the natural language processing field. If a plethora of textual information is available in a specific language, it is possible to apply Unsupervised Learning to learn its rules (Halevy et al., 2009). It is an example of how machine learning can help understand a human information task.

Successful machine learning techniques support use cases such as financial time series forecasting, supply chain management, market predictions, customized marketing in social media, and emotion classification in medicine (Cavalcante et al., 2016; Reis et al., 2020). These examples present that this strand of Artificial Intelligence has real-world commercial applications when applied in specific scenarios.

Machine learning techniques are also popular in many areas of the energy industry to drive optimizations and predictions. Some applications are optimizing reactors, power load forecasting, failure prediction, solar radiation, and wind power forecasting (Ghoddusi et al., 2019). It is worth mentioning that there are also machine learning use cases in agriculture: yield prediction, disease, and weed detection, water and soil management (Liakos et al., 2018).

2.2. Organizational Agility and the technology context

Organizational Agility (OA) had its roots developed by deriving them from studies in Lean Manufacturing, aiming to reduce losses and obtain more quality and efficiency in industrial processes (Harraf et al., 2015). In the mid-1990s, OA was defined as the ability to sense and respond to changes, to gain and maintain competitive advantages in a business environment (Žitkienė & Deksnys, 2018).

OA in the literature is seen as multidimensional and applicable to different organizations (Harraf et al., 2015). In primary studies carried out, according to Dove (1994) proposed, OA is a strategic amalgamation of positioning the balance between four dimensions: cost, time, quality, and structure. Furthermore, Zainal et al., (2020), argue that OA is influenced by the bases of value that interact simultaneously: speed, flexibility, search for innovation, and strategy. Both views observe industrial assumptions of optimization and response to technological contextual changes.

In the digital context of organizations, technology becomes interdisciplinary, and OA works at all organizational layers, expanding its scope for rapid response to macroeconomic changes (Harraf et al., 2015; Žitkienė & Deksnys, 2018). In parallel, according to Panda and Rath (2017) and Ravichandran, (2018), in their studies, they explored the capacity in Information Technology (IT) and Innovation Capacity if it is associated with OA, through the processing, analysis, and compilation of data, bringing an assertive response.

For Wang, Huang and Zhang (2019b), the OA is structured based on Culture of Innovation, Communication and IT, applying to different organizations to strategically position companies in terms of business competitive advantage. The author proposes the AO cycle, composed of: (a) Sensing, (b) Responding, and (c) Decision Making. (a) Sensing is about mapping business opportunities. (b) Responding is the ability to react according to the identified opportunities. On the other hand, (c) Decision Making is related to the entrepreneurs' execution and decision-making ability in search of OA. In this way, Wang et al., (2019b) articulate artificial intelligence and OA demonstrating that organizations can obtain quick responses in a technological context, operating the algorithms on the OA cycle.

In the same perspective, Žitkienė and Deksnys (2018) operates the cycle of OA on a conceptual model that has (i) agility drivers, (ii) agility facilitators, (iii) agility capabilities e (iv) agility practices. This model composes the structures for the agility process considering factors such as processes, technologies, human resources, physical resources and business structure, cooperation practices involving production chains to outsourced contracting to enable and encourage agility in organizations.

On the other hand, Trihn et al. (2012) present OA from the perspective of organizational adaptability and flexibility. The adaptability of the organization focuses on the structure and degree of influence to respond to varied situations in the market. Flexibility is the ability to adjust and adapt to changes in the macroeconomic environment, restructuring the organization's operations according to business opportunities and risks.

Nowadays, data growth makes machine learning an indispensable foundation for achieving OA, analyzing consumer habits and choices, mining, and processing data, and innovating with prediction and speed (Wang, 2019b). Understanding what factors affect this technological movement within the organization is crucial to business growth. (Žitkienė & Deksnys, 2018).

OA is directly associated with AI and is present in driving organizational sustainability. Machine learning associated with OA operates its algorithms exploring issues related to the rationing of energy resources, expansion of electrical distribution, credit risk analysis, analysis of gaseous emissions, rupture of pipelines and dams, among many other applications, continuously authenticating the solidity, speed and originality of the information at all times (Faceli, Lorena, Gama and Carvalho, 2011).

2.3. Resource Orchestration: Structuring, Bundling and Leveraging

Resource Orchestration is rooted in the idea of structuring a firm's resource base and is considered essential to achieve full corporate potential (Peuscher, 2016). It's based on the Resource Based View theory (Sirmon et al., 2007). Sirmon et al. (2007) highlight that there are three major aspects involved in this process: (i) the different stages of a firm's life cycle, (i) the broad scope of different strategies, and (iii) all the aspects that structure a firm's strategic, operational and tactical levels.

The acquisition, diversification, and accumulation of resources may depend on internal and external movements that a firm can articulate to create a successful resource management system (Wang et al., 2019a). Shukla (2015) stated that this management framework is crucial to a firm's performance in the market. Delmestri et al. (2005) highlights the importance of social bonds and social interactions to all the steps involved in the embryonic stage of structuring a firm's set of resources. They argue on a crucial step: the interaction with complementing agents acting in the same industry or scope and attest that the positive outcomes of such interactions may lead to industry-level advancements. Similarly, Dierickx, & Cool (1989) clarify that resources structuring depends on three basic steps: acquiring, accumulating and divesting. All of these must be conducted by a well-connected and well socially articulated manager.

In a fast-paced era, creating strategies that can maximize values and lead to new product and service capabilities is essential for a company's growth. Carnes et al. (2016) highlight the importance of combining novel and pre-existing resources to strengthen the dynamic of a business and create an innovation cycle with a practical resource orchestration arrangement. This arrangement is ideally divided into three major steps explained in detail below.

In this article, we will use the definitions of structuring, bundling, and leveraging, according to Carnes et al. (2016) as a means to effectively frame the technological and digital context of the present study.

- **Structuring:** It is the very first stage of the process and may require some interpersonal skills. Managers and/or owners first need to outline the variations of potential resources before articulating them to their best use. This process may result from social exchanges and require an in-depth evaluation of what can be expanded from the core resource possibilities. Structuring movements strengthen a firm's foundations and give room to the development of new resources that can replace old, inefficient ones.
- **Bundling:** The bundling stage refers to steps necessary to actively integrate the resources to the farm and articulate new capabilities around them. Managers are in charge of launching and investing new resources and stabilizing their use based on diversification strategies. However, it is essential to consider that the ways to conduct this process may vary according to the means of access and the levels of quality of the new resources.
- **Leveraging:** As firms invest and move towards building their resource portfolio, they have to consider types of resources that they can direct to create new capabilities and perform according to their market and institutional goals. At this stage, companies need to pay attention to gaps for minor improvements and possibilities to transform resources to create value.

Zhou et al. (2017) argues that the modern era imposed new conditions for IT firms to lead their resource orchestration process. Considering all the phenomena that unfold for constant upgrades in modern technologies, only by making use of such tools can a firm strengthen its organizational performance, improve its functionality, and become more competitive in the market.

According to Joshi et al. (2010), IT innovation is a process-based phenomenon that results from IT capabilities resources and how they affect a firm's innovation outcomes. In this case, for the orchestration to occur, it is necessary to analyze what inside the company can be used to exploit opportunities and gain an advantage. Particularly in IT companies, there's an order that follows from an unknown scenario that can be explored, leading to the three aforementioned steps, i.e., structuring, bundling, and leveraging. Without these steps, it would be challenging to effectively clarify IT capabilities and resources, impacting firm performance (Ahuja & Chan, 2017).

2.4 Research Propositions

2.3.1. Artificial Intelligence supporting Organizational Agility in Technology Contexts

According to research by Wang et al. (2019b) and Panda & Rath, (2017), Artificial Intelligence is articulated in related studies as a technological source of automation solutions, generating a competitive advantage for companies in the market. This competitive advantage used by AI, following the findings of Wang et al. (2019b) and Žitkienė and Deksnys (2018), can be applied by the bases of organizational agility in information technology articulating the subconcepts (a) Sensing, (b) Responding, and (c) Decision Making.

In this study, we assumed that AI, from the perspective of Machine Learning, is operated by organizations for the generation of Organizational Agility (Rangel-Martinez et al., 2021; Wang et al., 2019b), speeding up market responses in the technological context of an

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organization. Furthermore, according to the Rangel-Martinez et al. (2021), organizational agility, when operated by technologies such as Artificial Intelligence, shines a light on automation solutions that give the organization a competitive advantage by solving digital bottlenecks in the energy, sanitation (Faceli et al., 2011) and agriculture (Liakos et al., 2018) and promoting sustainability and collaboration to meet SDGs (Di Vaio et al., 2020).

Based on the evidence presented on the gaps in the literature between Artificial Intelligence and Organizational Agility (Ravichandran, 2018; Zainal et al., 2020), Proposition 1 of this research is:

Proposition 1: Artificial intelligence operated by organizations supports the generation of organizational agility

2.3.2. Artificial Intelligence and the Resource Orchestration through Organizational Agility

Organizational Agility studies present that the allocation of resources is essential for companies to adapt to a technological context (Trinh et al., 2012; Zainal et al., 2020). In this sense, companies use the sensitivity of opportunities and their ability to respond to decision making, thus boosting the axes of (a) structuring, (b) bundling, and (c) leveraging (Trinh et al., 2012). Previous studies (Ravichandran, 2018; Harraf, 2015) demonstrate, based on its limitations and suggestions for future research, the need to understand the orchestration of resources and organizational agility from the perspective of companies at different scales (Di Vaio et al., 2020) and that use technologies to orchestrate their resources and allow solutions to be addressed in contexts of fast technological change. Based on these premises, **Proposition 2** of the work is:

Proposition 2: Organizational agility supported by artificial intelligence allows organizations to orchestrate their resources in contexts of rapid technological change.

3. Methodology

3.1. Method Approach

The qualitative methodology was adopted as an approach, in parallel with an exploratory feature, aiming after a multiple case study that can achieve its research objectives. The multiple case study method enables the empirical examination of real-life phenomena (e.g. organizations and institutions), in differences and similarities, through data collected in the field and analytically detailed (Gustafsson, 2017). Furthermore, the multiple case study methodology allows us to analyze the data within each situation and in different contexts, as well as generate evidence to answer the "How" question addressed in the "research question" of this study (Yin, 2009).

3.2 Context of the Research: Sustainable Development Goals and the Cleantech Companies

The present study aims to analyze the technological AI solutions proposed by Cleantech companies to boost the OA (Organizational Agility) and meet the Sustainable Development Goals (SDG) (the SDGs are presented in Section 3.2.2). This research focuses on a scope that is directed to meet three primary objectives related to three SDGs: (i) 6º - Clean Water and

Sanitation, (ii) 7º - Affordable and Clean Energy, and (iii) 9º - Industry, Innovation, and Infrastructure. This primary focus dialogues with the research sample, since the participating Cleantechs act in the field of sanitation and energy, with a particular inclination to innovative solutions.

3.2.1 Cleantech Companies and the market context for sustainability

Cleantech firms are organizations that provide technology services and products aligned with the idea of minimizing or causing a minimum impact on the environment. This is done by encouraging the use of renewable sources e.g., wind power, photovoltaic energy, and biofuels (Shakeel, 2021; Noronha et al., 2022b; Noronha et al., 2022c). Following the same perspective, Pernick & Wilder (2007) define Cleantechs as organizations that hold any product, service, or process that can deliver value to the market utilizing low or zero non-renewable resources or creating fewer residues than the average industry.

Cleantechs can act in different industry sectors: energy, transportation, raw materials, and construction (Shakeel, 2021; Noronha et al., 2022b; Noronha et al., 2022a). Furthermore, the implementation of new technologies such as Artificial Intelligence collaborates with the advancement of sustainability, where the prediction characterized in the field of Machine Learning evidences the performance, control, and monitoring based on data quality and quantity (Rangel-Martinez et al., 2021). According to Rangel-Martinez et al. (2021), promoting these topics and combining them with renewable energy and industry sanitation are crucial points to achieving satisfactory levels of sustainability in society.

3.2.2. Sustainable Development Goals: Affordable and Clean Energy, Sanitation, and Innovation

Considering the social and environmental needs, the United Nations (UN) published in 2015 an official agenda formally containing 17 goals that must be achieved by 2030 (Mio, Panfilo, & Blundo, 2020). These are:

(SDG1) No Poverty;
(SDG2) Zero Hunger and Sustainable Agriculture;
(SDG3) Good Health and Well-being;
(SDG4) Quality Education;
(SDG5) Gender Equality;
(SDG6) Clean Water and Sanitation;
(SDG7) Affordable and Clean Energy;
(SDG8) Decent Work and Economic Growth;
(SDG9) Industry, Innovation and Infrastructure;
(SDG10) Reduced Inequalities;
(SDG11) Sustainable Cities and Communities;
(SDG12) Responsible Consumption and Production;
(SDG13) Climate Action;
(SDG14) Life below water;
(SDG15) Life on land;
(SDG16) Peace, Justice, and Strong Institutions;
(SDG17) Partnership for the goals.

In the present study, we focus on three goals that directly dialogue with the solutions found in the samples. The final objectives of these SDGs are presented in detail below:

- **Clean Water and Sanitation (SDG6)** - Ensure availability and sustainable management of water and sanitation for all;
- **Affordable and Clean Energy (SDG7)** - Ensure access to affordable, reliable, sustainable, and modern energy for all;
- **Industry, Innovation and Infrastructure (SDG9)** - Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.

3.3 Case Selection Criteria

Understanding what constitutes a cleantech company and which technologies can be included or excluded explores how business models are tied to technological contexts from an innovative base (Shakeel, 2021; Pernick and Wilder, 2007). Through this, quick and agile responses will result in a level of sustainability to maintain or create a competitive advantage, visualizing the orchestration of resources and the reconfiguration of business models (Shakeel, 2021). Based on this pretext, we use the case study method to understand organizations in the context of Cleantechs. The selection criteria for selecting the cases were:

(i) The company must be a cleantech from the fields of Energy and Sanitation;

(ii) It must use AI for its organizational solutions;

(iii) These solutions must address SDGs 6, 7 and 9;

To supplement the validity of these three criteria, the firms included in this study were selected based on the “Mapping of the Brazilian Cleantech Startup Ecosystem” report (FGV, 2019). This document helped us visualize the actuation sectors of these cleantech firms and their sustainable solutions.

3.4 Data Collection

The data included in this research were collected via a series of semi-structured interviews based on a research outline. The outline contained 16 questions related to the theoretical framework and categories of analysis of this study. Each interview was conducted in Portuguese to match the native language of the participants. The data collection and production timeline of the study started in December 2020, and ended in November 2021.

We have conducted 22 interviews with 11 cleantech firms acting in the renewable energy, energy commercialization, energetic efficiency, sanitation and water treatment fields. Additionally, the core characteristic of the sample is represented by founding managers, co-founders, and CEOs of the companies interviewed, aiming to understand the strategic positioning of the organization in relation to the SDGs and the clean technologies operated by the organization.

The interviews were carried out with the support of conversation and video software (e.g., Zoom, Google Meet, and Whereby). Based on the participants' authorization and request for anonymity, the material was recorded and transcribed for data analysis with the support of research software.

4. Data Analysis: Content Analysis

The analysis technique for this study is Content Analysis, supported by the use of MAXQDA software. The procedure adopted for the Content Analysis process was based on studies by Bardin (2016) and include the following steps: (i) organization and exploration of data, (ii) categorization (deductive and inductive), (iii) creating analysis standards, (iv) creation of graphics, tables and visual models to illustrate data and results.

Table 1 represents part of the transcripts of the categories identified from repetitions observed by the MAXQDA software. Repetition represents the number of times the category was present in the interviews, while the percentage of repetition is related to the percentual value of the total repetitions. In addition, the Data Analysis column presents the association between the deductive and inductive categories and their fulfillment of the propositions listed in the research.

The deductive categories were composed based on the literature review, coming from the theoretical framework of AI, OA, and RO. On the other hand, the inductive categories emerged from the analysis of data and their incidence of repetition were indicated by the software.

According to Nascimento et al., (2018), the theoretical saturation point is reached in a maximum of 15 interviews, and it is suggested to add a third to validate the sample. The saturation point of the interview was determined by the MAXQDA software, applied to 15 interviews. A total of 22 interviews were carried out to validate the categories. The validation of the interviews beyond the saturation point took place to confirm the deductive categories used throughout the analysis process, confirming the methodological direction of the research.

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Table 1. Table of Reports by Category, Distribution of Repetition, Transcription, and Data Analysis

Category	**Repetition (n)**	**Distribution of Repetition [%]**	**Transcription**	**Data Analysis**	**Propositions Match**
AI (**Deductive Category**)	n = **31**	19 %	[...] "Our solution is a digital electrician friend, an AI that reads your account data and guides you on the best savings paths, considering both the economic and environmental indicators, since all the savings paths we suggest are sustainable" [...]	AI employability provides a quick, effective, and innovative response to a company's sustainable aspects and its energy-saving and water waste initiatives. Furthermore, the automation employed by Machine Learning supports the mobilization of resources so that companies can structure their business models in an agile way and thus respond to externalities of society and the environment, visualizing the context of technological innovation of Cleantechs.	Proposition 1
OA (**Deductive Category**)	n =**25**	15 %	[...] "We use AI to predict the consumption of a residence and thus make more assertive suggestions for energy savings, and also analyze the best pricing plan based on the understanding of the consumption profile. For each savings tip, you can simulate the potential consumption for a specific home. By understanding the seasonality and consumption profile, it is also possible to use AI to reduce risk by suggesting a pricing plan with variable pricing during the time of day, based on the greater predictability provided" [...]	In the organizational context, (a) Sensing and (b) Responding are linked to the use of AI to predict (sense) energy consumption and provide information (respond), driving organizational agility and creating competitive advantage in the market. This facilitates the orchestration of resources to internally restructure its processes and operations, impacting society and sustainability.	Proposition 1 Proposition 2
OR (**Deductive Category**)	n =**39**	24 %	[...] "Our system acts in the water management. The mission is to improve the efficiency of water distributors by combating losses. The mobile solution is a system that scans the city and neighborhoods, looking for potential leak points. We have a specialist team that, with a specialized ear, which goes from hydrometer to hydrometer to check for leaking noise there, and this mobile solution is a kind of bionic ear in which we capture the audio, we send it to our artificial intelligence that classifies that point as a potential leak or not, and with that it	The use of AI in capturing water leakage points can make managers more agile in deciding the possibilities of acquiring new resources (Structuring). It can also positively impact measurement processes, enabling the company to transcribe its enrichment in the method adopted (Bundling) and subsequent implementation, generating value to society and upgrading the level of efficiency in water treatment and distribution	Proposition 2

			is possible to use the AI solution to assist this operation in the field, in order to optimize the work of the specialists. For example, it is possible to use a non-expert team to use the automated solution to do the initial scan, and then send specialists only at suspicious points" [...]	(Leveraging).	
Technology and Digital Competencies (**Inductive Category**)	n=**19**	12%	[...]"The sensors for monitoring consumption and energy efficiency equalize the devices and self-learned consumption behavior [...]. Everything is digital, and the company has this support so the customer can access and understand their expenses. Our application is managed by our product development and IT teams, and the algorithms indicate on the internal dashboards the different consumption and energy peaks of a customer. For us, automation is an innovation that depends on the ability of the development team to make it happen" [...]	The challenge of delivering an innovative and sustainable result is linked to the organization's value base of Technological and Digital Competencies. The use of automation to monitor consumption and energy efficiency is likely to result in agile and effective upgrades for the organization. In parallel, the orchestration of resources is directly affected by the flexible and adaptable structure permeated by managers and other teams within a company. This configuration allows the company to enter the scope of Cleantechs by offering fast and sustainable technologies.	Proposition 1
System Dynamics (**Inductive category**)	n=**22**	13%	[...] "We have a solar tracker that is traditionally controlled via satellite with equal movement throughout the year. With AI, instead of making the same movement every time, the follower tests some movements, collects the angle data and how much solar energy he managed to generate, and thus discovers the best strategy automatically, improving year by year" [...]	The changes in System Dynamics caused in business processes by the use of AI is a consequence caused in the process of technological adaptability in Cleantechs. In parallel, managers' focus can be reused to orchestrate new business resources and improve the strategy to achieve greater levels of sustainability.	Proposition 2

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Accuracy **(Inductive Category)**	n=**27**	17%	[...] " Water waste in Brazil is immeasurable. Our technology is the leading resource that makes it possible to identify ruptures or leaks in the hydraulic systems and call third parties to solve national sanitation bottlenecks. These are innovations programmed for the automation of systems and knowledge that help in infrastructure and move towards sustainable goals, especially regarding saving and wasting water. [...] We gained scalability with the monitoring solutions, but we still have several points to improve to reach new heights with a consistent customer base" [...]	Accuracy emerged as the final output to achieve sustainability through innovation. By using technological resources, companies can effectively reduce water and potentially solve the bottlenecks in the system, improving the agility in activating outsourced teams. Furthermore, automation contributes to the result of waste management and the speed of decision-making related to the allocation of resources by managers.	Proposition 1 Proposition 2

Source: Authors.

In addition to the analysis of the interviews presented by Table 1, Table 2 below presents each Cleantech interviewed, with their technologies employed (i.e. Big Data & Analytics, IoT, 5G, Artificial Intelligence, Data Cloud and Blockchain) and how the fulfillment of the proposals of SDGs 6, 7 and 9 is achieved with these technologies and their business models impact at Environment, Economy and Society.

Table 2. Technologies and Digital Solutions of Cleantechs to reach the SDG 6, 7, 9.

Cleantechs	Technologies employed	Impacts	Cleantech Solution and how they address the SDG
1	Big Data & Analytics and IoT	Economic and Environmental	Development solar electricity systems shared through credit packages, facilitates the access for renewable energy (SDG 7).
2	Big Data & Analytics, 5G and Artificial Intelligence	Environmental and Economic	Development of renewable energy projects, commercialization, civil construction and asset management and structured products, fomenting and increasing industry innovation (SDG 9).
3	IoT, Big Data & Analytics and 5G	Economic and Social	Management of solar plants and energy supply aimed at retail networks, industries, homes, and the public distribution electrical system. Those Cleantechs, can impact in renewable energy access, being diffusors of clean energy (SDG 7).
4	IoT, Artificial Intelligence & 5G	Environmental, Economic and Social	Digital management of energy bills through tariff studies and consumption monitoring. These solutions increase access to renewable energy through digital format and provision of new information (SDG 7 and 9).
5	IoT, Big Data & Analytics	Social and Environmental	Supply of photovoltaic panels to capture solar energy and chargers for electric vehicles. They can contribute to this sector fomenting industry innovation (SDG 7 and 9).
6	Big Data & Analytics, IoT and 5G	Environmental and Economic	Monitoring of water distribution focused on automatic leak detection in the distribution grid. An important way to reduce leaks and losses of water, being more accessible and more quality delivered (SDG 6)
7	Big Data & Analytics, IoT and Artificial Intelligence	Environmental and Economic	Installation of photovoltaic solar panels and resale of solar energy equipment's (SDG 7).
8	Big Data & Analytics, IoT, Data Cloud, and Blockchain	Environmental and Economic	Smart meters for energy efficiency management (SDG 9).
9	IoT	Environmental, Economic and Social	Technological platform for financing solar energy uniting investors, integrators, and customers (SDG 7 and 9).
10	Big Data & Analytics, IoT and Data Cloud	Environmental and Social	Digital platform to subscription solar energy for residential consumers (SDG 7).
11	Big Data & Analytics, IoT and 5G	Economic	Through the electricity grid, they shared generation of renewable energy, being more accessible (SDG 7).

Source: Authors.

5. Results and Discussion

Table 1 illustrated the core results of the categorical association of AI, OA, and RO references. This section will present the main results that dialogue with the data presented above, subdividing the paragraphs and their evaluation according to the study categories (deductive and inductive), thus illustrating a model built based on the measurement of the previously collected data (Figure 1).

Initially, the results support that for the orchestration of resources to happen through organizational agility supported by artificial intelligence, it is necessary to have technological and digital competence on the part of organizations that envision a dynamic of systems, thus providing the required accuracy to targeting products and services that aim to address bottlenecks related to SDGs linked to sanitation, innovation, and clean energy.

5.1. Deductive Categories: Artificial Intelligence. Organizational Agility. Resource Orchestration.

The interviews and incidence analysis revealed that the Artificial Intelligence category (n=31) represented 19% of the total repetition of the survey. According to the interviewees, it appears as a driving mechanism to provide innovations and a digital structure that subsidizes agility for the organization to mobilize its resources using Machine learning monitoring and automation systems. These resources must be applied to solve challenges in the energy and sanitation sectors in an agile and accurate way and with the existing resources of an organization as pointed out by related studies (Wang et al., 2019a; Ghoddusi et al., 2019). These evidences associated with results presented by other scholars in the field such as Zainal et al., (2020) and Ravichandran (2018) validate **Proposition 1** of this work

Organizational Agility (n= 25) conferred by Artificial Intelligence accounts for 15% of the representative total, which paves the way for opportunities to be foreseen, provides information for monitoring and automation systems, and responds quickly to the everyday demands of the market and society (Proposition 1). Respondents report that organizational agility is essential for a rapid technological response to the challenges of sustainable development, as indicated by Ravichandran, (2018) and Shakeel, (2021). (Proposition 2).

Resource Orchestration (n=39) was the most representative category (24%) in the analysis process, as it was a determinant for the association. According to the interviewees, for orchestration to occur, it is necessary to dynamically operate technologies based on the knowledge and interpersonal resources of the development teams, aiming at the acquisition of (Structuring). When working through OA, it drives the dynamics of software and management systems that articulate technological resources (e.g. digital solutions as software and internal applications), providing strategic diversification (Bundling). In this way, merging AI and OA gives the orchestration process capabilities to feel, identify and respond in an innovative way to the macroeconomic challenges of sustainability linked to the context of this research: clean water and sanitation (SDG6), energy (SDG7), and innovation (SDG9). These results are congruent with the research findings of Zainal et al., (2020) and Ravichandran (2018) concerning the orchestration process, hence evidencing the fulfillment of **Proposition 2**.

5.2. Inductive Categories - Findings: Technology and Digital Competencies System Dynamics, Accuracy

The inductive categories appear as a block of findings of the work as they emerged during the analysis and the data measurement processes. The inductive categories that surfaced as findings in this study are: (i) Technology and Digital Competencies, System Dynamics, and Accuracy.

Technology and Digital Competencies (n=19) was the category that had the lowest repetition rate, representing 13% of the total. Referring to the responses of respondents, it could be verified that this category is presented with the need to position itself in the current market and have competitive advantages through automation or other technological resources. In this perspective, the link established between Technology and Digital Competencies and Artificial Intelligence gives the orchestration of new resources the possibility to innovatively invest in the market of Cleantechs. If using AI as a resource brings improvements and agility in the process, OA comes as a consequence and forces operational changes within the organization. These results are in agreement with Ravichandran, (2018) and Panda and Rath, (2017), when emphasizing the use of IT resources and performing the level of sustainability in society to the detriment of SDGs.

System Dynamics (n=22) appears with a performance equivalent to 13% of the total of the categories. According to Ravichandran (2018), System Dynamics is the impact forcedly caused by OA and technologies in managing business processes and operations. In parallel, with the union between AI and OA, System Dynamics favors decision-making by managers in Structuring in Resources Orchestration, to the detriment of the agile response generated in the transformation of information by AI. These conclusions follow the same perspective as Ravichandran, (2018); Zainal el al., 2020), when dealing with OA and its impact on organizations by transcribing changes in the system for allocating new resources.

Accuracy (n=27) has a better performance than the other inductive categories, with a representation of 17% of the total, and is considered decisive in the model's output, that is, the delivery of the result to draw the levels of sustainability and develop solutions that collaborate with the fulfillment of SDGs 6, 7 and 9. The interviewees associate Accuracy with the effective reduction of water waste and energy efficiency of Cleantech companies by the AI-related resources. In comparison with the literature panorama, the results are congruent with the views of Wang et al. (2019b), by demonstrating the ability of AI to transcribe greater accessibility to operational data.

5.3. Artificial Intelligence Model for Resource Orchestration through Organizational Agility

The categorical repetition and analysis of the qualitative data obtained from the interviews allowed us to present the association between the theoretical lenses, reinforcing the fulfillment of propositions as illustrated in the previous section and in Table 1. To illustrate this association between the categories, we have used our core results to create a model that demonstrates how Artificial Intelligence can support Organizational Agility for Resource Orchestration, thus answering the research question of this study (Figure 1).

The model below (Figure 1) illustrates the research results in the context of Cleantechs and Sustainable Development Goals. However, it is worth clarifying that, since this research accommodates the theoretical approaches of the fields of study on organizational strategy and information technology, the model was developed targeting its application to other research areas. It is not restricted only to the phenomenon investigated and enables the deepening of new perspectives and theoretical lenses particularly linked to the research findings.

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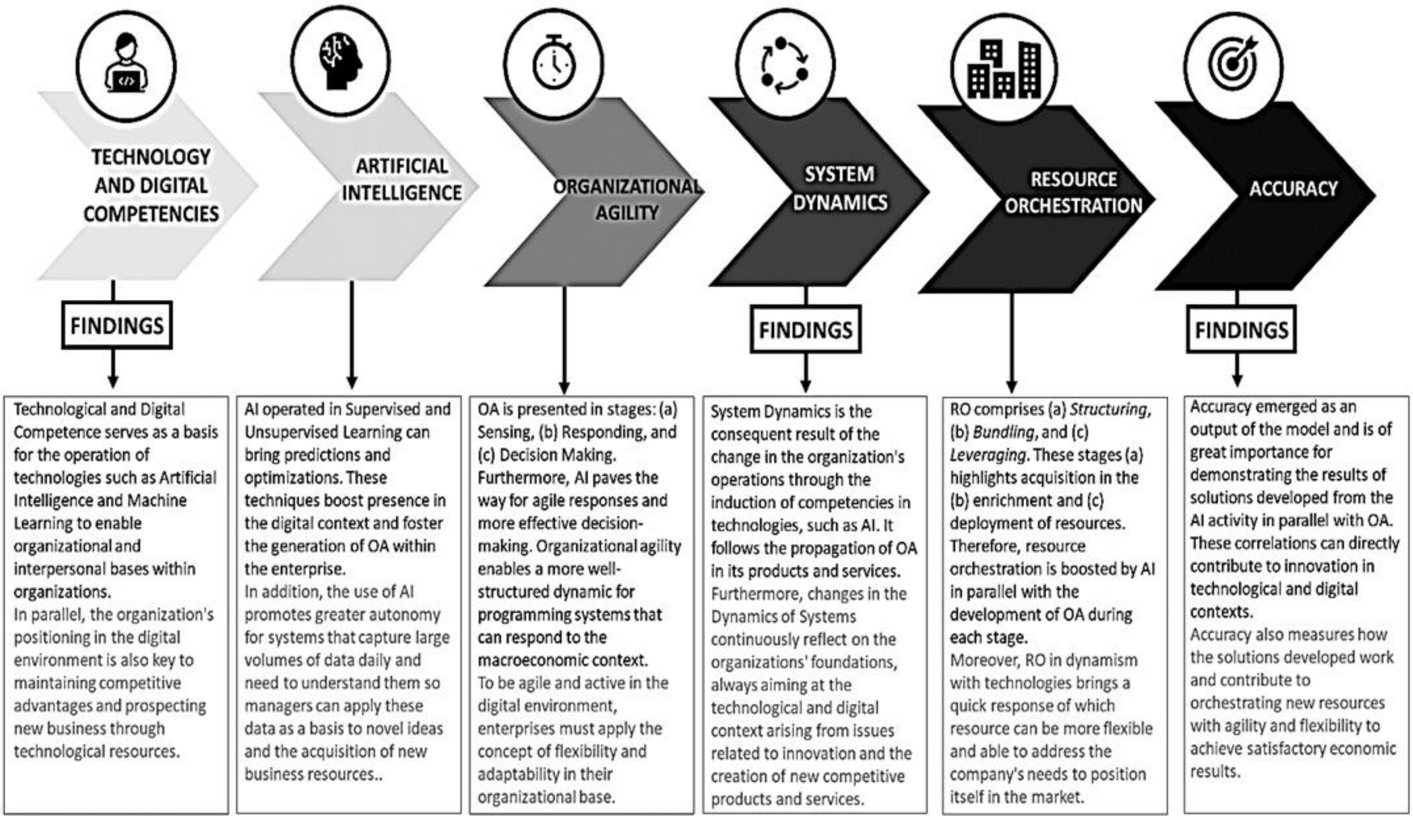
Figure 1. Artificial Intelligence Model for Resource Orchestration through Organizational Agility



Source: Authors.

6. Final Considerations

The research results here presented could confirm the two research propositions and evidence how Artificial Intelligence stimulates and supports the Organizational Agility for Resource Orchestration. Our outcomes also highlighted the existence of new categories (findings) such as Digital and Technological Competencies, System Dynamics, and Accuracy in the form of outputs to understand their complementary roles from the proposed research lens. Our findings are drivers for the development of innovative services and products in the context of Cleantechs. In addition, the research objective and question were answered using the model presented in Figure 1.

Our model presents the theoretical contribution of the article, presenting that for artificial intelligence to stimulate organizational agility, organizations must have digital and technological skills that outline the conditions for the orchestration of resources via the dynamics of systems. These can then be applied for the creation of innovative solutions, hence improving the accuracy in the development of products and services that collaborate towards the goals of sustainable development and filling gaps in the work of Ravichandran (2018), Zainal et al. (2020), and Divaio et al. (2020). The originality of our study resides in the contextual articulation of the correlation between AI, OA, RO applied to the context of cleantech companies and SDGs.

Still bringing the originality of the study, it visualized how clean technologies can boost and achieve the SDGs proposed by the United Nation. The achievement of the SDGs is visualized in the organization's agility in understanding and improving the inclusion of strategic themes that are addressed in the SDGs.

The analysis of each Cleantech and its data provided in the interviews was an important tool to conclude the fulfillment of the SDGs propositions, considering that the company's attitude in building a sustainable business model is beyond placing renewable energy and accessibility to clean water, but reflects its social and economic impact on disadvantaged populations.

The practical contribution lies in illustrating the strategic paths that Artificial Intelligence can take from the perspective of Machine Learning to address solutions for the energy and sanitation sectors, providing sustainable innovations. Our study successfully addressed the potential of Artificial Intelligence applications to address and reach Sustainable Development Goals, specially in corporate contexts involving companies that aim to generate innovation and smart solutions to improve sustainability. In this sense, organizations, especially Cleantechs, can guide their strategies to meet Sustainable Development Goals in an agile way and adapt to digital and technological contexts, considering their available resources (Trinh et al., 2012; Ravichandran, 2018).

6.1. Research Limitations and Future Avenues

The limitation of this study is drawn from the research sample, selected theoretical lenses, and the context used to identify market solutions that collaborate to meet SDG 6, 7, and 9. We have observed from the sample reports that artificial intelligence within the energy and sanitation context can boost social and economic inclusion, taking related research into a prism outside organizational studies. It is suggested that future researchers explore theoretical prisms that visualize the organization from a socio-environmental aspect, deepening the impact of the findings of this study. (e.g., Technological and Digital Competencies, Systems Dynamics, and Accuracy) to diagnose other corporate formats and cases of success regarding the collaboration towards the Sustainable Development Goals and their benefits to society.

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Annex

Qualitative Questionnaire			
Block	**Organizational Agility (OA)**		
Subcategories	Sensing	Responding	Decision Making
Questions	How can the sense of detection in the organization promote a strategic repositioning in the environment through technologies?	How can the adoption of fast strategies combined with the use of AI reverberate in a new market position? Could you mention an example?	How do you see the improvement in decision making from the adoption of current technologies, such as AI for example?
References	Žitkienė e Deksnys (2018); Wang (2019b); Faceli, Lorena, Gama, and Carvalho (2011)	Žitkienė e Deksnys (2018); Wang (2019b)	Žitkienė e Deksnys (2018); Wang (2019b)
Block	**Resource Orchestration**		
Subcategories	Structuring	Bundling	Leveraging
Questions	How can the structuring of resources promote changes from the use of Artificial Intelligence in your organization?	How can the integration of existing resources in the organization promote new strategies and the use of new capabilities?	How can leveraging new resources add value to your Cleantech innovation solutions? Could you cite an example?
References	Carnes et al. (2016); Joshi et al. (2010)	Carnes et al. (2016); Joshi et al. (2010)	Carnes et al. (2016); Joshi et al. (2010)
Block	**Artificial Intelligence (IA)**		
Subcategories	Unsupervised Learning (UL)	Supervised Learning (SL)	
Questions	How can data processing and programming language collaborate with the restructuring of resources and promote innovation in your organization? Cite examples.	How do you believe that Machine Learning can collaborate to restructure resources, making the organization more agile? Cite examples	
References	Mehrabi et al. (2021); James et al. (2013)	Mehrabi et al. (2021); James et al. (2013)	