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Research Article

Industry 4.0 technologies and Lean Office: perspectives to Smart Office

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Abstract

Paper aims: Due to the scarcity of research that approaches the Lean Office in conjunction with Industry 4.0 Technologies, this article aims to discuss, understand and analyze the associations between these two concepts, as well as identify gaps to be explored.

Originality: This research contributes with guidelines for applying Industry 4.0 Technologies in administrative areas and possibilities of an association with the Lean for the development of the Smart Office.

Research method: Based on a systematic review of the literature, with a basic purpose, a descriptive objective, and qualitative data, a framework for developing the Smart Office is presented.

Main findings: An association model between Lean Office tools and Industry 4.0 Technologies is provided. It even classifies and addresses the impact and trends in administrative environments so that managers can develop the Smart Office.

Implications for theory and practice: Industry 4.0 technologies have been widely discussed in companies that seek to improve processes, mainly industries; however, there are still few applications in administrative environments. The applicability and association of new technologies for Smart Office can explore future studies and contribute to the growth of these areas in addition to the creation of new articles relating to technologies in this environments.

Keywords

Lean Office. Industry 4.0 technologies. Smart Office. Framework. Literature review.

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1. Introduction

Regardless of the type of company or process, administrative activities, or office work, play a decisive role in the company's overall performance. Therefore, as might be expected, it must be subject to continuous improvement. However, the number of publications on improving office work processes is relatively low compared to the vast body of work published on enhancing production processes. The very definition of the concept of office work and knowledge is not consensual and low (Sousa & Dinis-Carvalho, 2021). In this sense, the Lean office encompasses improving administrative processes and information flows. The concept derives from Lean Thinking and can also be called lean thinking principles in information management (Freitas & Freitas, 2020).

From the implementation of Lean Office, several benefits can be obtained, such as improved communication, use of space, boosted lead time, conscious use of materials, standardization of tasks, objectivity in meetings, and motivation of the work team (McKellen, 2005). Because the Lean concept is a change in the organization's mindset and not just the application of specific tools or modifications to some processes (Melton, 2005; Freitas & Freitas, 2020). Thus, effective communication is achieved through visual management, elimination

of physical file storage areas, lead time reduction through the identification and elimination of delays between departments, as well as the optimization of tasks and standardization of operational procedures for optimizing meetings based on fast and efficient communication (McKellen, 2005; Freitas & Freitas, 2020).

Emerging technologies are increasingly being researched and studied in companies in the current process management requirements. In the same way, industrial and administrative environments tend to improve their controls and metrics (Goecks et al., 2020). Several authors point out that disruptive technologies have excellent adherence to Lean. Kolberg & Zühlke (2015) cite that Industry 4.0 (I4.0) and its technologies must be integrated with Lean to improve the system. At the same time, Wang et al. (2016) propose the term Lean Intelligent Production System to improve production efficiency and reduce waste, considering Lean and Industry 4.0 practices, aiming at waste reduction. Also, Davies et al. (2017) emphasize that Lean Six Sigma can be boosted by Industry 4.0, particularly by Cyber-Physical Systems (CPS) networks, which enable real-time access to operational data.

It is observed that the administrative sector can benefit from Industry 4.0 technologies since applications that can make more accessible the work of employees and smartwatches that have the potential to reveal our mood and interfere with the room environment (changing temperature and lighting, inserting music, among other environments improvements), making it more pleasant. Also, the way employees will work in an office will certainly change, and the variables of administrative functions will be a challenge to be solved with Artificial Intelligence (AI) technologies and Machine Learning (ML) algorithms, for example (Rüttimann, 2019).

Still, other studies that do not directly address the concept of Industry 4.0 already show the positive consequences of digital transformation in the Lean Office. Patria & Mynderse (2017) use a simulation model to integrate lean principles into daily management activities in government agencies or businesses. In addition, other researchers apply Business Intelligence (BI) and Big Data (BD) concepts in coordinating medical center activities Silva et al. (2015), mapping the value stream to identify industrial waste Sabur & Simatupang (2015), in a game development which simulates a series of administrative processes to schedule customers appointments Mirehei et al. (2011). Also, Kuriger et al. (2010) present an Augmented Reality (AR) environment for simulating and training people in administrative scenarios.

Digital transformation in the administrative environment has been gaining increased interest in companies, and it is challenging and necessary for all business units and processes. It is recommended to start with few users and a limited number of activities, acquiring experience to expand the digital transformation project later to the rest of the organization (Abollado et al., 2017). Considering this scenario, integrating Lean and Industry 4.0 concepts are recurring themes in developed countries (Kull et al., 2014).

Considering the research identified and reviewed, there is a lack of transparent methodologies that aim to promote improvement in administrative sectors by applying disruptive technologies, precisely regarding the association of the Lean Office with the technologies of Industry 4.0 to reduce waste and optimize services. In practice, administrative sectors generate high costs for companies, and applying new technology can increase this area. With the same idea, managers who have demanded improvement may not be prepared to apply technology in an environment with little experience but with many possibilities for continuous improvement. In this context, the research question emerges: "What are the possibilities of aligning Industry 4.0 technologies with the principles of Lean in the administrative area (Lean Office) for structuring and developing a Smart Office?" In response to this gap, this study proposes a model of the association between Industry 4.0 technologies and Lean Office in administrative sectors, optimizing processes and reducing costs.

The rest of this article develops from Section 2, background with literature review, section 3 where the method that guided the review and the structuring Lean Office integration model of Industry 4.0 concepts is presented. Subsequently, in Section 4, the related studies are presented, that is, the reviewed literature used as a basis for developing this integration. Then, in Section 5, the results that effectively demonstrate this integration. Finally, in Section 6, the final considerations about the results obtained, the challenges, and the contributions of this research.

2. Background

In the administrative area, the main difficulty is the great diversity of tasks performed, and to some extent the resistance to change from employees. The use of Lean tools and methodologies to eliminate the variability of processes and wastes within the administrative process is known by the term Lean Office, that consist adapting the Lean practices for administrative areas (Tapping & Shuker, 2018). In the administrative environment, an efficient information management can promote advantages and create significant financial benefits (Bevilacqua et al., 2015). Studies show emerging companies with satisfactory performance levels have implemented Lean methodology and are more willing to carry out the digital transformation and adopt Industry 4.0 technologies (Tortorella & Fettermann, 2018).

With Industry 4.0, several technologies were adopted, increasing worker productivity in industrial contexts. The benefits generated in this type of environment are varied, and some were demonstrated by Sousa & Dinis-Carvalho (2021), who developed a game to train concepts about lean and lean office, respectively, in the area of people management, such as balancing, the unitary flow of parts and process mapping. These authors also highlight that digital transformation can produce satisfactory results once associated with Lean Office elements and system performance improvements.

In the administrative context of the Supply Chain, the article by Dworschak & Zaiser (2014) demonstrates that Industry 4.0 technologies, such as the Internet of Things (IoT) and Big Data (BD), are used to obtain immediate and automatic feedback from suppliers. It includes efforts to overcome bureaucracy and barriers which lead to delays in communication channels between customers and suppliers. According to Shariatzadeh et al. (2016), the implementation of IoT presupposes integrated communication devices, as it allows for managing information about transported goods and tracking them to their destination. It is possible to verify the growing evolution of studies related to industry 4.0; however, by not considering the problems of dynamic environments such as administrative sectors, they can impact the implementation of these technologies. In the article by Tortorella et al. (2020) future research is suggested to identify other potential relationships between I4.0 technologies and guidelines for lean value. Also Macias-Aguayo et al. (2022) cite that developing a clear notion of Industry 4.0 and Lean integration is critical for this field and comment with optimism how researchers have recently published about determining patterns for the successful joint deployment.

As an offshoot of the Lean Manufacturing concept, Lean Office emerges in the culture of managing administrative work, aiming to serve customers with the lowest cost, high quality, and shortest possible time (Tapping & Shuker, 2018). The main difference between Lean Manufacturing and Lean Office is the visualization of work scenarios. In manufacturing processes, these are very visible (physical flows). The value-adding methods depend on information flows and practical knowledge in administrative areas.

The article of Dornelles et al. (2022) studies the contribution of Industry 4.0 technologies to specific worker capabilities, among them smart working, in which it is concluded that they generate positive impacts on workers but also carry some limitations in their use, which still a challenge in many applications in industry and in the applications of cognitive tasks that the author cites cognitive tasks (e.g., planning and design) the paper also identifies a gap and need for contributions to smart working, conduct future research to investigate learning curves during technology adoption.

Cagliano et al. (2019) suggest that future research investigates the integration of smart manufacturing and workers' activities. Meindl et al. (2021) signal a study gap regarding the interconnections between Industry 4.0 and workers, which is not always connected; the author mentions that the smart working dimension is still the least investigated one in the Industry 4.0 domain, representing the main gap for future research to fill in this area, in his study the results also showed limitations of smart working technologies, what is also important for the literature to avoid considering Industry 4.0 technologies as a solution to any manufacturing challenge.

In practical research such as the Rajeshkumar et al. (2023), novel deep learning based Faster R-CNN, which integrates with the Internet of Things (IoT) to overcome the security issues in the office, this type of application shows how much new 4.0 technologies also arrive in the most diverse ways in the workplace. Already the paper by Bogdan et al. (2021) conducts a practical experiment using a voice assistant in the office to create a healthier, more dynamic, and proactive environment; with the help of voice assistants, the result was satisfactory for tasks and dynamics of easy interaction with the available service.

The study of Prim et al. (2022) conducted empirical research on the intangible factors of technology applications in Industry 4.0. The factors that stood out the most refer to the empowerment of employees and leaders based on applying these aspects. These points must be considered as the discussion takes place along with Lean, which are points that this paper explored.

3. Method

The nature of this study can be classified as exploratory, as it seeks information on the criteria used to select studies during a research study. It aims to build an association model of the findings during the Systematic Literature Review. In the article that Gundogan et al. (2020) evaluates the compliance of journals that used the PRISMA, a gap is signaled in this study not only being used by the health segments but also by other areas of study, also in the article it is demonstrated that general compliance with the PRISMA statement has improved the quality of publications. The PRISMA contains comprises the well-define stages of a systematic review such as developing eligibility criteria and describing information sources, search strategies, study selection processes, outcomes and data synthesis (Moher et al., 2015).

Still, it presents a qualitative character to assist in developing a model of the association between Industry 4.0 technologies and Lean tools. Thus, this research method can be divided into three essential phases: research definitions, data collection method, and analysis of results, according to Figure 1.

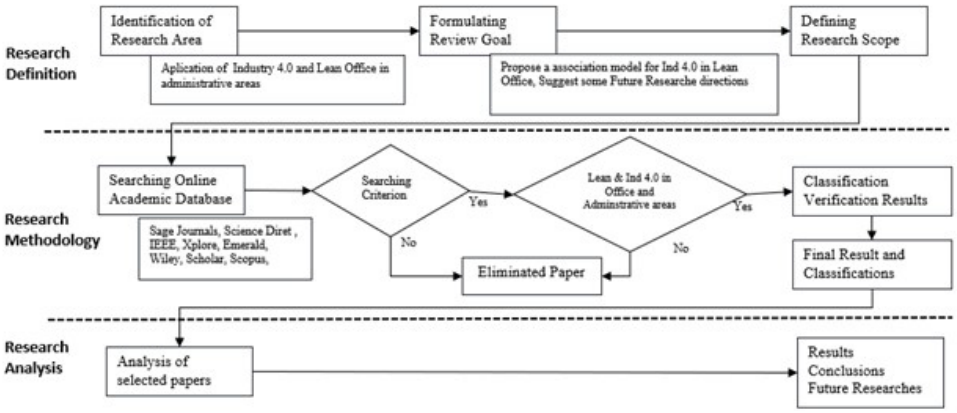

Figure 1. A methodological framework for research.

The first phase determines the research area, objective, and scope. The research area is a systematic review of Industry 4.0 (Ind 4.0) and Lean in business environments. The research objective identified the need to understand how office environments perform when faced with Industry 4.0 technologies and Lean tools. As research on the subject is relatively recent, the scope of this investigation was not limited to the period, considering that the concepts of Industry 4.0 were introduced in 2011.

The search rules for article selection were defined in the second phase, including creating the association table for classifying these articles. The databases searched were SCOPUS and Web of Science, the broader ones. Then, other more specific databases were included to check if the number of results could be higher: SAGE Journals, Science Direct, IEEE Xplore, Emerald, Wiley, Scholar, and Taylor & Francis. This literature search was based on the search term "ALL (("Lean" AND "industr* 4.0") AND ("Office" OR "Administrative Areas"))", resulting in Figure 2 (regarding the research method).

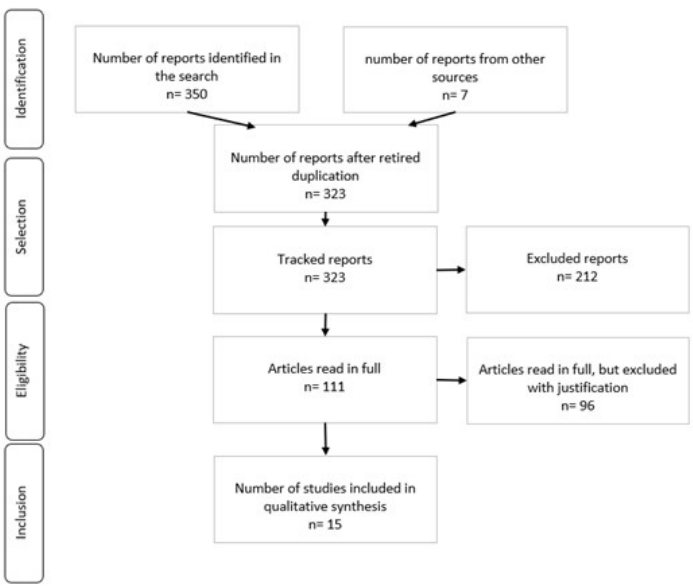

Figure 2. PRISMA.

We used the terms (shown in Figure 1, second phase) to search in the online databases, which resulted in "350" articles.The selection of articles must first be published in academic journals for which full-text versions are available. Conference papers, master's or doctoral dissertations, textbooks, and unpublished working papers are excluded. Finally, read the titles, abstracts, and keywords (in the seletion to the eligibility phase), resulting in 111 papers. The authors performed the review and ranking process jointly, selecting only articles related to Lean/Industry 4.0 and Office/Administrative, excluding 96 articles in the eligibility phase – so, the 16 articles were highlighted due to their alignment with the study. Thus, variations and combinations were used to expand the possibilities of finding significant results in the theme. As selection criteria to compose the basis of this research, articles published in journals were considered. Each article was carefully examined to meet the selection criteria cited above.

Finally, in the third phase of Figure 1, the selected articles were analyzed to structure an association model that aims to guide managers and researchers in combining Lean tools with Industry 4.0 technologies for administrative areas and offices.

4. Industry 4.0 and lean principles for Smart Office

One of the main characteristics of Lean Manufacturing is to combat waste or loss, as it consumes resources and does not deliver value to the customer. These losses can be classified into seven categories: overproduction, transportation, movement, waiting, inventory, unnecessary processing, and defect (Roehl, 2000). Consequently, applying this philosophy in the administrative sector allows for increasing the transparency of processes, making it easier to visualize the flow of information. Thus, some lean manufacturing practices are easily applied in offices, while others require considerable effort and adaptation to gain the organization (Rüttimann, 2019). Including on this topic and to reinforce the article, we seek to fill the gap the authors like Yokoyama et al. (2019) that leaves suggestion for future research indicate researches that detail how implementations were conducted; that make comparisons between the implementations in offices of different areas; that check if there is an indication of what lean office tool to start implementation according to the office sector; and that present possible solutions to the difficulties encountered.

As far as Lean Office is concerned, according to Tapping & Shuker (2018), losses can be classified into ten categories, where the first seven are similar to Lean Manufacturing but with an emphasis on three new types these being people skills, office policies, and process imbalance/unequal. As for Lean Manufacturing losses, Satoglu et al. (2017) show practices and methods that can help reduce the seven wastes (Table 1).

Table 1. Lean Manufacturing wastes and practices to solve Lean Office challenges.

Waste	Lean practices					
	Jidoka	TPM*	Kanban	WIP**	CIM***	Heijunka
Overproduction			X	X		
Transport						
Motion	X		X		X	X
Waiting	X	X	X	X	X	X
Inventory						X
Over-processing					X	X
Defects	X	X			X	X

*Total Production Maintenance;
**Work in Process Reduction;
***Computer Integrated Manufacturing.

Waste	Industry 4.0 technologies					
	3D Printing	VR°	RPA°°	IoT°°°	Data Analysis	Cloud
Overproduction		X	X		X	
Transport		X	X			X
Motion			X	X	X	X
Waiting	X			X	X	
Inventory	X		X			X
Over-processing	X		X	X	X	
Defects	X	X	X	X	X	

°Virtual Reality;
°°Robotic Process Automation;
°°°Internet of Things.

Production leveling, Heijunka, can be an essential practice in helping to eliminate or reduce waste related to waiting, unnecessary processing, defect, and motion. According to Tapping et al. (2010), they point out that the leveling of the process (Heijunka) can help in the wastes related to waiting, unnecessary processing, defect, and movement, the main ones to be attacked in the administrative processes. Also, according to Satoglu et al. (2017), Table 1 shows the relationship between waste and technologies that can assist in its mitigation, demonstrating adherence with administrative support sectors.

The proposed term Industry 4.0 is a "Smart Factory" with agile, flexible, and dynamic technologies (Shahin et al., 2020). They are changing traditional ways of working and incorporating emerging technological advances to improve manufacturing processes in the face of global challenges (Moeuf et al., 2018). However, technologies do not show significant gains. It is suggested to associate several technologies and integrate them into other tools, as in Lean Satoglu et al. (2017). In this way, Industry 4.0 can be divided into different patterns and layers. Figure 3 presents the steps of Smart Supply Chain, Smart Working, Smart Manufacturing, and Smart Product (Frank et al., 2019b).

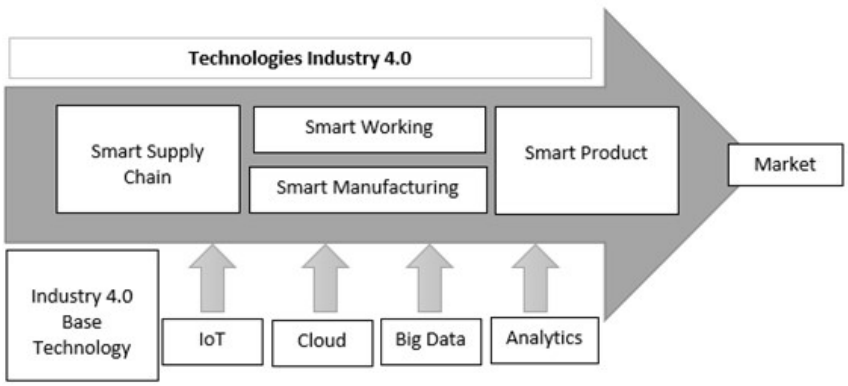

Figure 3. Theoretical Framework of Industry 4.0 Technologies.

Smart Manufacturing is the first objective of Industry 4.0, while Smart Product is its extension (Yin et al., 2018). Further, Frank et al. (2019b) point out that these add value to product manufacturing, while the Smart Supply Chain and Smart Working dimensions aim to provide efficiency to complementary operational activities. Where Smart Working represents the methods by which workers perform their activities, based on the support of technologies (Stock et al., 2018), and Smart Supply Chain is the means of information exchange and supply chain integration, synchronizing production with suppliers to reduce delivery times and information distortions that produce whiplash effects (Ivanov et al., 2016). In this way, technological solutions in IoT, Big Data, Cloud, and Analytics support the dimensions classified as core technologies of Industry 4.0 (Wagner et al., 2017). This concept can be enhanced by using Industry 4.0 technologies in various industrial value streams, including production support environments.

As an example, Tay & Low (2017) report the case of a digital transformation in a Higher Education Institution, which evolved from traditional printed materials to digital formats, simplifying its internal operations and creating value for the teaching and learning community. While in the research of Monteiro et al. (2017), from the application of Lean tools associated with Industry 4.0 technologies, a reduction of 84% in lead time was obtained and the organization of electronic space in the administrative sector. In a similar context, Tortorella & Fettermann (2018) propose a new approach between Lean and Industry 4.0, based on this association, to improve operational performance in a broader context than the manufacturing process itself.

From these theoretical assumptions, the phase of definitions of the research helped in the absorption of concepts and alternatives around the theme addressed. It was possible to identify gaps and bring answers to the research question. Next, the systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology.

Consequently, this systematic review was necessary for the research question. Including the lack of studies integrating Lean tools with Industry 4.0 technologies for the administrative support sectors of companies. Thus, the final stratum in Figure 2 is presented in Table 2.

Table 2. SLR Main Findings (PRISMA).

References	Lean tools	Industry 4.0 technologies	Application
Meudt et al. (2017)	VSM	IoT and BD	The VSM of the Company in the administrative sector was developed using IoT and BD.
Mayr et al. (2018)	TPM	Cloud and AI	Identify in the Management Room (Office) the prediction of the machine stop and preventive action.
Xu & Chen (2018)	Just In Time	BD, Analytics, and AI	Integrated AI analysis with large volumes of data to study the unit flow of administrative documents
Zaker & Coloma (2018)	Continuous Flow	VR	Used VR technology to demonstrate to the employees the continuous flow in administrative environments
Trappey et al. (2017)	Standardization	IoT	IoT is used to identify an error in the patent verification process.
Powell et al. (2018)	Heijunka	BD	Use the massive data generated in the administrative environment to level the most recurrent activities of employees.
Jayaram (2016)	Six Sigma	IoT	The application was made using the resources generated by the IoT and presented to the User of the administrative sector if the process is within the established Six Sigma standard.
Sastre et al. (2018)	VSM; Visual Management	BI and BD	The company's VSM in the administrative environment, with inputs and outputs coming from the Company's database, and made it updated online.
Silva et al. (2015)	VSM	BI and BD	VSM of the company in the administrative environment, with inputs and outputs from the Company's database, and this monitoring was made available to the business area.
Belayutham et al. (2016)	VSM	BD, Cloud and RPA	Integrated administrative VSM with BD and Cloud techniques for online interaction with administrative workers, this interaction also used RPA to automate the process.
Demeter & Losonci (2019)	Employee; 5S Empowerment; Standardization	Cloud, RPA, Analytics, and AI	They made available and programmed a game to integrate the administrative environment into the 5S programs and generate greater employee engagement.
Villarreal et al. (2016)	VSM	BD and Cloud	It was integrated with the Administrative Flow Mapping DB and Cloud techniques for online interaction with administrative employees.
Chiarini & Kumar (2021)	VSM and Continuous Flow	BD, Cloud, and Analytics	They made available and programmed a game in the Cloud using BD and Analytics to integrate the administrative environment in the 5S programs and, consequently, generate greater engagement for the Employee.
Hofmann & Rüsch (2017)	JIT and Kanban	Cloud, CPS and RFID	It aims to evaluate how Industry 4.0 affects logistics management by consulting experts, which includes Kanban and JIT, since large applications in this field are expected.
Mirehei et al. (2011)	Employee empowerment, Continuous Flow	BI, BD	It proposes a lean office simulation game to demonstrate the effect of lean implementation on office processes. Various performance metrics are recorded during gameplay to capture the impact of these tools

Among the main findings, one can cite the article by Demeter & Losonci (2019), where the results indicate a good adherence between companies (in different regions/countries) regarding the transfer of lean knowledge (explicit and implicit), enabling the development of dynamic environments in rapidly changing scenarios.

Emerging technologies can help support administrative improvements, as highlighted by Belayutham et al. (2016) and Villarreal et al. (2016). Both works use real-time monitoring of administrative processes, referring to accurate and immediate decision-making in case of divergences in daily activities. These applications in companies that need to be attentive to the dynamism of the market, including where the support sectors have a high cost, help them be competitive against the competition, positioning them strategically in the market.

The integration between Lean and Industry 4.0 implies new tools for process mapping, focusing on horizontal and vertical integration from end to end, i.e. the need for a Smart Office (Chiarini & Kumar, 2021). In addition, other areas involved in the context of transformation processes must also be analyzed, seeking to improve occupational health and safety. These are essential to ensure and preserve the safety and health of workers in a continuously changing and technologically updated work environment (Maida et al., 2018). Integrating products and services for improving product quality is essential, and emerging Big Data, and Cloud technologies for this change are leveraging factors (Frank et al., 2019b). Thus, Frank et al. (2019a) reinforces the optimization of office environments, using emerging technologies such as Cloud, IoT, Analytics, and BD, assisting in optimizing sectors that present high operating costs for companies.

A detailed analysis of these findings is presented in the following section, showing the possibilities of alignment between Lean and Industry 4.0 for the development of the Smart Office Conceptual Model.

5. Smart Office conceptual model

Based on the results obtained from related studies, the association between Lean Office practices and Industry 4.0 technologies was structured, resulting in Table 3. The first column presents Lean Office practices addressed in the mapped literature. While the first line represents Industry 4.0 technologies, resulting in the flag with an 'X' when there was the association.

Table 3. Lean Office and Technologies of Industry 4.0.

	IoT	BD & BDA	Cloud	RPA	VR	AI	BI	CPS	RFID
Standardization	X			X		X			
VSM	X	X	X	X					
Six Sigma	X								
TPM			X			X			
5S			X			X			
Kanban			X					X	X
Visual Management							X		
Employee Empowerment			X	X		X	X	X	
Heijunka		X					X		
Just-In-Time		X	X			X		X	X
Continuous Flow		X	X	X	X		X		

The gaps were filled based on studies that integrated the two themes. For example, Meudt et al. (2017) addressed value stream mapping (VSM), helping to understand the opportunities emerging with the IoT, Big Data, real-time analytics, storage, and use of information with the generation of KPIs via BI. Mayr et al. (2018) used Cloud and Machine Learning to improve TPM. According to these researchers, Industry 4.0 technologies improve production, reduce machine downtime, scrap and rework, and increase quality. Furthermore, they allow office workers to schedule maintenance activities dynamically.

In their study, Xu & Chen (2018) carried out a technological structure with Big Data and Analytics to support planning and scheduling dynamically in a JIT system. This structure can react to dynamic changes in orders, production, and available resources, allowing users to adjust schedules during production to maximize productivity. In the article by Müller et al. (2018), the author implemented a CPS along the value chain, information online sharing between the shop floor and business departments, thus obtaining optimized and leaner processes. This solution supports employees with recording and reporting changes to components and technical drawings. Hofmann & Rüsch (2017) point out some examples of companies that also implemented a CPS to improve JIT systems, but associated with a cloud-based ERP, to enable actors to exchange and act upon real-time information across their whole supply chain. In this case, an RFID system precisely enables the tracking of material consumption and material flows, providing automatization and accurate demand planning and forecasting in JIT systems, which will consequently increase Kanban cycles' efficiency. It was concluded that changes occur in all areas of the process, such as the administrative sector of purchases and sales. Zaker & Coloma (2018) built a virtual reality (VR) model for monitoring and continuous flow actions in a project company. The results of the experiment's feedback confirmed the benefits of such collaboration. The method provided for online integration and adapting to the current workflows of the participants' companies.

IoT is helping companies improve their relationship with customers, delivering products faster and reducing costs. In this sense, standardization is essential for the adaptation of technology. In the article of Trappey et al. (2017), IoT was used to standardize the patent process in administrative activity. By Powell et al. (2018), adopting disruptive big data analytics and automation technologies makes the Heijunka (service leveling) easy to perform, enabling better scheduling optimization capabilities. Tasks are now supported in real-time for monitoring task execution.

Already Jayaram (2016) combined the IoT approach in the supply chain, building a fully autonomous process with an optimized flow and periodic analysis/assessments to maintain a Six Sigma standard. Since these assessments are done online, any deviation can be corrected almost instantly, empowering the employee with immediate decision-making information.

Using VSM in conjunction with BI and DB tools enabled the identification of waste and its elimination. Order processing time is reduced based on a new future state map (Sastre et al., 2018). To this end, the involvement of the team and directors in the VSM is suggested, considering that Silva et al. (2015) demonstrate the application of the Lean Office concept in a medical center, using BI and DB tools in addition to VSM, eliminating activities that do not add value.

Including the programming and creation of simulation games, with a series of activities or processes, from the Lean office, assist in employee training. In addition to providing greater engagement in the process and the company, the interaction in simulated scenarios of activities will be developed. The phases created for users enable the application in other projects and the proposition of improvements due to the understanding of philosophy in a simulated scenario (Mirehei et al., 2011).

From these literature reviews, Figure 4 summarizes a compilation of the main Lean Office tools and the most common Industry 4.0 technologies. The boxes marked in blue are a concept already addressed in the literature. However, those without colors demonstrate gaps to be explored in this integration to develop a Smart Office. It is observed that there are several opportunities given the reduced number of studies in this area and the current context of digital transformation.

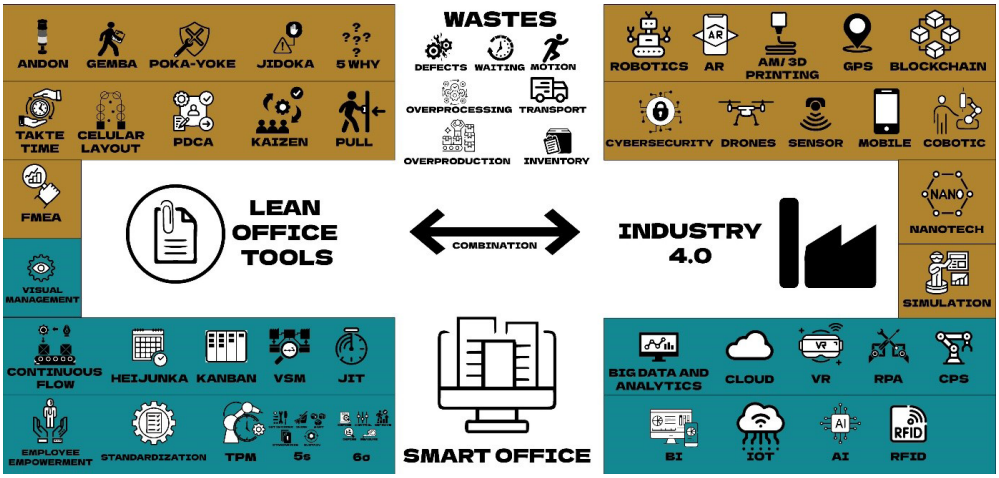

Figure 4. Conceptual model of synergy between Lean Office tools and Industry 4.0 Technologies.

Figure 4 is structured from Table 2 and Table 3, where the relationships between Lean tools and Industry 4.0 technologies are explained. Thus, from the tables mentioned, it is evident how these concepts were integrated, enabling the exploration of new associations regarding Lean losses. Therefore, we decided to present at the beginning of the conceptual model the main inputs that make companies look for solutions, in these cases wastes, that were presented and studied in this paper. In the middle of the Figure 4 we show two other major topics covered in this article, the administrative environment, which in need of improvement is represented by Lean office, and the technologies that come from I4.0. Below this combination, based on the research carried out, we found another term that unites these fields of study, Smart Office, which, as presented in this paper, brings in its concept the search for an intelligent and effective way of managing the office. The technologies represented by icons around the figure are those found by the authors in the research, and as previously mentioned, with some research found, they were colored in one color (blue), and if not another (orange).

There appears to be a lot of space in the literature to be explored, as there is no integration between different topics, such as Andon and GPS. Even some items highlighted in blue can also be explored, as there is still room for new associations, such as TPM with CPS.

The conceptual model presented seeks to clarify the possibilities within work environments, as the model was built, and crossing the literature it was possible to note that not only the industry can benefit from adaptations of technologies, it was demonstrated in the paper, several studies with technologies such as IOT, cloud, big data, which are the gateway to new applications. Figure 4 is the result of the literature review that can be used by academics and companies, to guide towards advancements in administrative environments, this has several associated costs, and in the lean concept, a lot of waste that occurs due to the lack of standardization, often a routine that is not always linear.

Aiming to stimulate the Smart Office application, this research suggests a series of research gaps in administrative processes and technologies to support this area. We trust that a research agenda can help develop and advance the Smart Office, including in emerging issues in organizations and emerging countries. In this way, Table 4 presents potential tool gaps to be explored, strengthening the concept of Smart Office, guiding new applications, and assisting Continuous Improvement to improve administrative processes.

Table 4. Potential Future Research in Smart Office.

Lean Tools	Context	Technologies	Reference
FMEA	Consider the complement using FMEA allows exponentially increasing the reliability of processes showing in the administrative environment.	Cloud and AI	Mayr et al. (2018)
Jidoka	Could better optimize administrative processes to reduce lead time.	BD, Cloud, AI, Analytics, and RPA	Belayutham et al. (2016); Demeter and Losonci (2019),
Poka-Yoke	In the use of VR, a process demonstration with errors would be complemented, in the standardization process also create a mistake-proofing mechanism.	IoT and VR	Zaker & Coloma (2018); Trappey et al. (2017)
Andon	In VR, a demo and color indicators could be created to indicate the process done wrong.	VR	Zaker and Coloma (2018)
Gemba	In all mapping processes, after creating the flow, the operation could be verified in person for validation.	IoT, BD, Cloud, and Analytics	Mayr et al. (2018); Sastre et al. (2018); Silva et al. (2015); Belayutham et al. (2016); Chiarini & Kumar (2021); Villarreal et al. (2016)

The human factor is recognized in association with using the respective technologies. One of the points that can be incorporated into the administrative area is not only the work itself but also the control of other parts of the industry, as in cases of adopting 'Remote production process management' technologies could facilitate pitch control, enabling the reduction of eventual time-consuming activities from leadership and allowing others (besides frontline leaders) to verify the current status of the value stream (Tortorella et al., 2020).

Given the various gaps, the results reinforce the need for further research in this field, as shown in Figure 4. New studies can help managers of administrative areas regarding new methodologies for this sector. These areas generate costs for companies, especially if the segment in which the company operates has these characteristics. Even from Table 3, it is possible to visualize the actions that have already been taken regarding combining Lean tools with Industry 4.0 Technologies in the Office context. In this sense, the company can visualize already implemented practices and evaluate investment possibilities in new technologies. Thus, the association model helps decide technologies to strengthen Lean Office practices. Also, from the moment the first improvement is developed from this association. With this technology, with Lean support for waste reduction, other parts of the company can also enjoy making sequential applications across departments. The fundamental principle behind Lean is minimizing process variation and waste to maximize the value added for customers. This philosophy searches for tools and hard and soft practices to achieve excellence in quality, cost, and lead time (Mrugalska & Wyrwicka, 2017). Technologies 4.0 can help this goal, and It Has already reported performance benefits of implementing Industry 4.0 technologies, ranging from increased flexibility to improved productivity and Other indicators.

Some studies have investigated the benefits of incorporating technology within Lean manufacturing tools and methods, indicating a positive impact on the relationship between I4.0 and Lean. (Rossini et al., 2019). These Technologies should be applied to Lean activities performed successfully before automatization. They also emphasize the importance of an adequate information flow before and after implementation (Satoglu et al. 2017). In this way, considering the flow of information and data circulating through the administrative areas, the importance of automating this sector based on Industry 4.0 technologies and together with Lean tools is evident. Consequently, the conceptual model presented in this research guides this integration of concepts and optimization of the activities of the administrative areas.

In this context, this study has practical and theoretical limitations, contributing to developing new studies. In a realistic environment, the application and validation of some already-exposed models can be reinforced. They were testing new associations, such as the exploration of blockchain technology, which is used in some service contracts, and smart contracts could connect with the context presented in process improvements (Ali et al., 2020; Li et al., 2021). In the same aspect, AR has been gaining ground in companies to generate engagement among employees, which could help in the knowledge of new applications. Another association in Lean tools, ANDON, could be leveraged with AR, Simulation, and Mobile for systems understanding and information.

The same logic for teaching employees can use VR to explain the pull system and how the factory/logistics works if the manager works remotely, for example. So despite the focus being on the administrative process, it may be that some flow in the administrative sector impacts the factory. In the theoretical view, further studies may explore other associations by searching for articles that use Lean tools with the respective Industry 4.0 technologies. These are before the period in which this term was created.

6. Conclusion

Although most studies on Industry 4.0 focus on gains in industry and production and manufacturing processes, this study seeks to expand the application of this Industrial Revolution. They combine Industry 4.0 Technologies with Lean Office tools to minimize waste. With search, this research provides new insights from the Smart Office perspective, reviewing the literature on applications and evaluating synergies between Lean Office and Industry 4.0 Technologies and the gaps to be explored in administrative environments.

The literature was reviewed based on the PRISMA model to select articles in which gaps were identified regarding an association model between Industry 4.0 Technologies and Lean Office tools. Also, when the literature was mapped integrating these themes, the literature is still with few findings. Thus, this study proposed an association model focusing on administrative support sectors, contributing with a model that presents the central practices of the Lean Office against the aspects and Technologies of Industry 4.0. For research, the study opens up new ways of using technologies in administrative improvements, which are currently highly focused on the industry.

With I4.0 in administrative environments, knowledge of information and communication technologies and extensive data analysis becomes essential for professionals and companies seeking constant growth. For this, it will be necessary to be prepared to take charge of improvement projects in this new technological environment. Discusses and brings some insights into the application of Industry 4.0 to support Lean manufacturing improvements, demonstrating the connection between the two subjects. The segmentation made in this paper is for treating the administrative environments that are also impacted by these technologies (Shahin et al., 2020). However, the adoption of I4.0 technologies is still incipient in most industries, and even more so in the eventual confusion that the application can generate for the entire supply chain (for example, in administrative environments, which are indirectly impacted, enabling controls and actions with customers online, without the need for communication from the factory) such practical verifications must be validated from applied studies to verify the real challenges and benefits of their adoption.

In addition to the suggested future work on the limitations and new associations, the quantitative evaluation of gain and payback is also offered because some companies still need to be convinced that applying new technology can bring performance. Studies with methods that can help choose the most viable alternative are needed, trying to understand that hiring technology can help not only waste in one area of the company but several. Another suggestion is to complement the model with the association of new technologies that may emerge or with the Industry 5.0 association.

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