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Sviluppo di Innovazione di Prodotto e di Processo tramite l'Integrazione di Metodologie Lean,
Digitalizzazione Avanzata e Sostenibilità

ALICE AIUDI

Development of Product and Process Innovation through the Integration of Lean Methodologies, Advanced Digitalization, and Sustainability

RESEARCH PROPOSAL:

- a) *State of the art*
- b) *Research objectives*
- c) *Theoretical and methodological framework*
- d) *Research design*
- e) *Expected results.*

State of the art

In the current context driven by the globalization phenomenon, manufacturing organizations have increasingly experienced the pressure from climate change, increased awareness of stakeholders on social and environmental responsibility, natural resources scarcity, rising population, stricter government regulations, and huge waste managements to improve their environmental performance.

Moreover, these improvements have resulted to be more than ever crucial for organizations to remain competitive in global markets and to gain advantages for long-term survival (Choudhary et al., 2019). These evolutions have indeed contributed to the development of new concepts that are nowadays central topics: advanced digitalization, lean manufacturing, and sustainable development.

For their numerosness, as one of the most important determinants in global economy, small and medium enterprises (SMEs) are responsible for several environmental degradations and therefore, organizations should embrace sustainability issues as a main priority (Henao et al., 2019).

In this perspective it is crucial to adopt an innovative business model, based on the integration of the Lean – Sustainability paradigm (LS), and the advanced digitalization concept, able to optimize the corporate system by increasing productivity and reducing operating costs thanks to the lean approach, able to facilitate and improve the integration and communication aspects among the different corporate departments as a whole, thanks to the digital competences and instruments, and able to generate long-term positive impact in terms of sustainability and green concepts.

Starting from these assumptions, it is important to provide a definition of these innovative paradigms. Lean manufacturing (LM), or lean production, or more often just “Lean”, is a notion that was originally introduced by manufacturing philosophy of Toyota Production System (TPS) which drives companies to adopt policies able to

guarantee efficient levels of productivity in manufacturing processes (Jum'a et al., 2022). It is aimed at eliminating wasteful activities involved in the value creation system.

Nowadays, many companies still produce wastes from their production cycle, and it is always more important to eliminate them because they are a source of costs and loss of productivity, putting organizations' future sustainability at risk. LM is a model supported by a set of tools used to operationalize its main goals, either at a strategic or at an operational level, aiming to achieve the highest possible profitability, quality, and customer service level at the lowest possible cost, in a timely manner, through continuous elimination of waste (Tasdemir et al., 2018). Among the practices the most common applied to adopt lean practices, Dey et al., (2020) identified: sustainable waste reduction practices; efficient productivity and continuous improvement; production planning and control; inventory management system; resource utilization and exploitation; stakeholder engagement; customer complaint mechanism; employee motivation and organization commitment; green waste management and recycling practices; wastewater treatment practices. Varela et al., (2019) have further identified the centrality of the human factor as a fundamental issue in all the decisions associated to LM practices.

On the other hand, the concept of sustainable development has also become a reference for scientific research. It has been used to define issues related to business, industry, urban development and has become the conceptual foundation of theoretical approaches like green economy and circular economy (Ruggerio, 2021). The concept of sustainability has received increasing global attention from the public, academic, and business sectors soon after the World Commission on Environment Development (WCED) has brought the topic into light in 1987, defining it as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Tomislav, 2018, p.74). In 1969, U.S. Environmental Protection Agency (EPA) also published its own definition of sustainability: "Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony that permits fulfilling the social, economic and other requirements of present and future generations." (Tasdemir et al., 2018b p. 3). The essence of the concept of sustainable development is based on the Triple bottom line model, which implies the balance of three pillars of sustainability – environmental sustainability, focused on maintaining the quality of the environment which is necessary for conducting the economic activities and quality of life of people, social sustainability which operates to ensure human rights and equality, preservation of cultural identity, respect for cultural diversity, race and religion, and economic sustainability, fundamental to maintain the natural, social and human capital required for income and living standards. Complete sustainable development is achieved through a balance between all these pillars (Tomislav, 2018b). To leverage its operational achievement, a company should consider applying an integrated operational enhancement initiative along with the sustainability practices.

The number of studies about the concepts of lean and sustainable manufacturing is increasing over time. Furthermore, the literature review that investigates the integrated relationship between lean manufacturing and sustainable practices is also growing and it allowed the creation of the management paradigm Lean-Sustainability. Varela et al., (2019b) discussed the relations between lean manufacturing (LM) and the 3 dimensions of sustainability, summarizing some recent contributions about these dynamics:

- Influence of Lean Manufacturing on the Economic Dimension: they provided examples of initiatives leading to cost savings (decrease of operational costs) and cases of increased process performance.
- Influence of Lean Manufacturing on the Environmental Dimension: when companies adopt LM practices, those experiences are positively related to environmental management practices and performances that lead to these results: decrease of industrial waste, decrease of energy consumption of non-renewal energy sources, and increase in the practice of circular economy.
- Influence of Lean Manufacturing on the Social Dimension proved its effects on: increase of the quality of work conditions of employees and increase in the participation of its employees in the decision-making process.

Overall, lean positive effects on economic performance of sustainable development, as well as on operational one, were already detected and underlined several times in multiple cases (Henao et al., 2019b), namely in terms of cost savings and quality improvement (Sá et al., 2022; Murmura et al., 2021). According to Solaimani and Sedighi (2020), lean techniques can have positive effects on all sustainability pillars, namely through standardized work, that can lead to lower production expenses (economic effect) and greater workers' safety (social effect), and error-proofing, which can lead to less rework (economic effect), less waste of resources (environmental effect) and to fewer hazardous activities (social effect). This suggests that lean is being sought as potential contributor to sustainable development and that the two models can easily work together to shape the paradigm Lean-Sustainability, able to help organizations in improving their performances.

The other crucial element that represents a challenging point, especially for SMEs, is the concept of digitalization. Indeed, the digital revolution increasingly calls SMEs to pursue technological innovation, as well as to adhere to environmental sustainability goals. As value chains become global and digital, readiness to implement digital processes will be indeed crucial for smaller firms to join global digitalized value chains of suppliers, to connect in integrated business networks and to target global customers with personalized offers (Denicolai et al., 2021). Digital technologies are changing market environments, opening up new challenges and at the same time new opportunities for these firms (Quinton et al., 2018). They are disrupting across the economy and society, bringing novel cultural, holistic, and multidimensional phenomena, and driving a complex and highly interconnected network profitable for organizations (Letouzé and Pentland, 2018). Brennen and Kreiss (2019) understood digitalization as "the way in which

many domains of social life are restructured around digital communication and media infrastructures". Starting from this definition, the association of the notion with the social implications of increased computer-assistance, with new media and communication platforms for economy, society and culture is made clear (Schumacher et al., 2016). It has been largely demonstrated that digitalization now represents a key element as it brings numerous benefits in terms of improved efficiency, enhanced productivity, greater work safety, and sustainability. Indeed, rapid technological advancements are redefining the pace and scope of change in processes, capabilities, and offerings, creating innovation opportunities (Parida et al., 2019). Many manufacturing companies involved in various sectors throughout the last century have started to adopt different methodologies to improve the management of their operations in terms of "digital". More recently, advanced IT solutions, typically under the broader concept of Industry 4.0, have gained popularity among consultants and academicians since they are currently considered as important enablers of competitive advantage.

In the contemporary economy, digitalization, environmental sustainability, and the adoption of lean practices are thus key for growth. Firms are increasingly driven to implement these innovative processes and practices. Moreover, digitalization is seen as one of the most promising transformations for guaranteeing sustainability (Gouvea et al., 2018). The strong connection between digitalization and sustainability is thus more and more perceived as a winning convergence, offering opportunities within and across organizational boundaries especially for overcoming informational void (Atos, 2018).

However, the implementation of these innovative systems in manufacturing companies seems to be slower. Most manufacturing companies are still in the early stages of implementing such technologies. Moreover, the potential of digitalization is not limited to large enterprises (LEs), and it can also offer significant opportunities for SMEs. SMEs have motives for exploring Industry 4.0, as its general benefits of profitable growth through new products, new services and innovative business models, and increased efficiency and reduced costs through digitalization are important advantages independent of company size (Buer et al., 2020).

Digital transformation and lean-sustainability paradigm are increasingly intertwined challenges for SMEs. Furthermore, while products may significantly vary between organizations, the typical wastes in any organization are relatively similar, represented by transportation, excess inventory, unnecessary motion (of operators, machines/equipment, materials), waiting (of operators, machines/equipment, materials), over-processing, overproduction, defects, and underutilized skills (Farias et al., 2019).

Therefore, each of these dimensions must be addressed and aligned with the overall business logic of the company to ensure development of an effective business model strategy. Lean and Sustainability Development both enhance competitiveness of small and medium enterprises (SMEs) in a sustainable way, where lean is focused on the efficiency element, whereas Sustainability Development emphasizes the responsiveness of firms and finally, also digital opportunities represent a key path for growth.

In this perspective, Choudhary et al., (2019b) revealed that there is little research that deals with the lean approach analyzing its gains in terms of sustainability, especially within the scope of SMEs in manufacturing sector. The manufacturing sector has significantly contributed to the economic growth of many countries and strengthens the ideas and practices underlying inclusive and sustainable development. Overall, the relationship between sustainability-related manufacturing practices and organizations' performance has received limited attention, reality even more evident and reinforced in the case of SMEs (Martins et al., 2022). SMEs have indeed limited resources and face numerous competition (De et al., 2020). Siegel et al., (2019) too found and discussed after a study about Lean-sustainability and SMEs around the world that due to their limited access to resources and to their restricted size, SMEs struggle to effectively integrate lean management within their business operativity.

Moreover, few evidence is shown in the sector regarding the influence of the LS paradigm on the social component of the sustainability concept, as also demonstrated by Teixeira et al., 2021.

Furthermore, many scholars have focused their attention on the digitalization phenomenon that involves many organizations, but little is known about the impact of these technologies on SMEs (Mittal et al., 2018).

Research objectives

In this sense, the purpose of this research project is to investigate the connection between lean manufacturing practices in SMEs and their sustainability performances and to develop an innovative business model able to integrate the lean-sustainability paradigm and digital solutions which could support the analyzed enterprise in the development of a strong strategic approach, capable of combining the operational efficiency of lean practices with all pillars of sustainable development and with the solutions offered by technological advancements.

The research objectives can be thus summarized as follows:

- i) Enrichment of the reference literature on the integrated LS approach, which clearly shows gaps about the lean advantages and effects in terms of sustainability especially considering the manufacturing sector and the social component, and on the impact of digitalization within SMEs organizations. The promotion of research on SMEs' sustainability is thus a central point of this project, to help them to be an active contributor to sustainable development in view of the lack of resources they usually have.

- ii) Emphasis on the correlation between the lean criteria and the pillars of sustainable development with focus on the mechanical sector.
- iii) Development of an innovative and sustainable business model in terms of production and processes easily applicable to the business reality analyzed that integrates lean practices, sustainable concepts, and digital instruments with the aim to positively impact the context examined in terms of competitiveness of the firm in both national and international markets and of promotion of sustainable aspects. The development of sustainable and innovative processes is thus inspired to the LS approach and the model designed has also to be aligned with the technological and digital advancements defined by the national development plan.
- iv) Development and implementation of models capable of ensuring better and more streamlined warehouse management with a view to decreasing or even eliminating production wastes and research of a model for guaranteeing logistics optimization, and finally, implementation of technologies capable of making communication among company departments and with external entities more effective and efficient.
- v) Verification of the business model developed and applied to the business reality studied and verification of the exportability of its principles to foreign markets in a global perspective.

Theoretical and methodological framework/Research design

The research methodology will be based on the use of both qualitative and quantitative approaches, subdividing the analysis into four different phases:

PHASE 1: In-depth examination of the academic background related to Lean and Sustainable Development and digitalization processes and subsequent focus on the approach of these themes in the specific mechanical sector in which IMAR s.r.l. operates.

PHASE 2: Research and individuation of case studies of companies in the mechanical sector that are particularly active and that apply LS models and technological instruments. Subsequent definition and application of an analysis methodology capable of quantifying the impact of an integrated LS approach with respect to the operational processes of IMAR s.r.l. reality, through the identification of a specific set of indicators able to show both LS elements and digital issues connected to the manufacturing system.

PHASE 3: Analysis of data and information previously collected, and formulation of a business model based on the integration between the principles underlying LS approaches and digital tools to make it applicable to the organization investigated and, more generally, to the manufacturing sector. The development of the model will be supported by the collaboration with the managers of IMAR company, who are directly responsible of the application of activities in the Lean-Sustainability system and thanks to the data collected and available in the company profile. Moreover, research will be developed thanks to a stay at a foreign university to deeply understand and explore the exportability of the model and its applicability in non-Italian territory.

PHASE 4: Application of the model developed and verification of the results in terms of competitive advantages, environmental, economic, and social sustainable effects, of more streamlined activities and less wasteful work on the entire company's supply chain and in terms of more efficient and easier information flow among all the company's functions.

Expected Results

The expected impact is reflected in the following areas:

- Dissemination of new knowledge related to the theme of integration between the Lean Manufacturing concept and the definition of Sustainability
- Development of a solution able to reduce production costs, to reduce production-related wastes and to optimize the logistics system, making more efficient the company core business as a whole
- Identification, experimentation, and evaluation of appropriate digital solutions able to support business models characterized by the Lean-Sustainability combination paradigm and to favor the integration among the company's functions and departments.

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