

Combining Lean principles with information tools for optimizing enterprise management

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Abstract: - The business environment in our region is facing multifaceted changes. Globalization, coupled with the opportunities provided by information technology, is pushing companies to adopt new management models that have already proven successful across different countries and industries. Despite the efforts made during the last decades, enterprises in Albania and Kosovo have a road ahead to enhance their competitiveness and long-term sustainability. A comprehensive approach that integrates modern managerial practices with digital tools would contribute to the optimization of processes, elimination of inefficiencies, and achievement of higher operational performance.

This study introduces the Lean management concept and explores effective strategies for applying its principles in both manufacturing and service firms in our region, where the approach remains relatively underutilized. It identifies common types of waste within organizations, examines their root causes, and proposes methods for reducing or eliminating them as part of an ongoing improvement process. The study adopts a qualitative approach to build its theoretical foundation and to provide guidance for practical application in the businesses of developing economies, where the economic, social, and cultural contexts differ from those of Lean's origins. Based on real cases observed in manufacturing firms in both countries, the paper highlights how combining Lean management principles with information technology solutions can significantly improve efficiency, enhance quality, and reduce costs, thereby strengthening business performance and sustainability.

The paper provides theoretical and practical contributions to both scholars and practitioners in the region by introducing knowledge about the Lean approach and its implementation in connection with information systems available. The case study method used for the investigation has permitted the exposure of small and medium-sized enterprises to new managerial approaches and provided them with recommendations for better resource utilization while simultaneously advancing the integration of technology and digital systems into their operations.

Key-Words: - Lean management, continuous improvement, digital technologies, performance, waste, Albanian and Kosovo SMEs.

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1 Introduction

Managing businesses nowadays is becoming complex due to increased competition, easy spread of information, and changing costs of inputs. At the same time, information technology provides helpful instruments to digitalize production and management processes, facilitating the best use of all assets and supplies. Moreover, the optimal utilization of available resources in the short and long term is capturing the interest of both public and private establishments. This is encouraged by the international institutions [1], [2] to achieve

sustainable development objectives (especially SDG 9, related to production and transport). Meanwhile, at the national level, strong driving factors for Albania and Kosovo are the initiatives to join the European Union and the trend towards green transition within the framework of the Green Agenda for the Western Balkans [3], [4]. At the business level, in addition to these political and regulatory forces, a driving factor remains market competition, which is now taking on global proportions. Consequently, businesses are making efforts to effectively use all their input,

relying on technological developments and best managerial approaches from the world practice [5].

Large companies are generally more inclined to adopt these methods as they have the financial and managerial capacity to recognize, adapt, and implement them. On the other side small and medium-sized enterprises (SMEs) have to struggle between the hurdles they face due to external factors and internal shortcomings, and lack of resources. Carrying out activity in a competitive market forces them to keep trying improvement efforts and performance. This is evident in the business environment in Albania and Kosovo [6], [7], where the SMEs are dominant in manufacturing and services, while their managerial and digital capabilities are somewhat limited. This situation highlights the necessity to support enterprises in strengthening their knowledge of methods, approaches, and tools that can enhance performance. Following best managerial practices combined with digital instruments, SMEs can achieve higher productivity in production and services, improve quality, and enhance overall competitiveness. Every contribution at the theoretical or practical level can help them advance individually and bring a dissemination effect on the economy.

The aim of this work is to present Lean management [8] as a managerial approach that contributes to minimizing waste and optimizing costs by combining it with the increased use of information technology in company processes. In this way, improvements can be achieved in the value chain, which lead to expected benefits for the consumer, the company, and the country's economy [9], [10]. The paper develops a theoretical framework for this approach, illustrated with practical examples and recommendations drawn from Albanian and Kosovo business cases. It is organized, including this introduction and the four following sections that enable a presentation of the key principles of Lean management and its implementation strategies, a display of the research method and the primary and secondary sources used, and afterwards the discussion of findings. The paper offers new insights into the company's opportunities to reduce waste and optimize resource utilization, followed by key takeaways and recommendations, as well as some avenues for future research.

2 Research Framework

Lean management is one of the management initiatives that large organizations are constantly trying to implement with the aim of increasing their

competitiveness [11], [12] and sustainability in the global market [13].

2.1 Origin and content of lean management

The origin of Lean management stems from the Toyota Production System (TPS) by the middle of 20th century [11], [14], but the term 'Lean Production' was popularized after the publication of book "The machine that changed the world" [8] in 1990, which extended the philosophy and the guiding principles of lean at the company level [14].

Essentially, the goal of Lean management is to identify and eliminate any activity in business processes that does not add value to the customer [15], [16]. The Japanese company Toyota has developed the Lean management method with the aim of eliminating waste and reducing inefficiency in its production environments [11], [14], [16]. This management approach was successful during its implementation because of the positive impact on several performance indicators, especially those reflected in financial terms in businesses [9]. Originating from the manufacturing industry and initially applied in the context of a specific (Japanese) culture, the Lean method has undergone changes. Although it started at the production factories, the concept of Lean became known and applicable successfully to services and other sectors as well [17], [18]. Despite the evolution of the concept and changes in implementation frameworks, the main pillars of lean management remain those of the Toyota way, namely, "Continuous Improvement" and "Respect for People" [14], [16], [18]. The implementation of the Lean approach is supported by a whole set of managerial tools, the Lean Toolbox, each of which represents an important, specific, and useful means in the organizations of all types [16], [19]. Theoretical elaboration [18] and practical overview [14], [20] point out that continuous improvement is required in three dimensions: waste reduction, value enhancement, and people involvement.

Although the Lean concept 'to maximize customer value while minimizing waste' [18] seems easy, its holistic nature requires a substantial engagement to understand and learn it [21]. Introducing the Lean approach in the company facilitates the management to focus on improvement as a key goal. Daily managerial experience is a prerequisite for realizing the lean management requirements and for creating a culture of improvement in the company. Beyond discrepancies, authors [12], [14], [22], [23] accept Lean as a lifelong journey to 'continuous improvement', which in itself is not possible without 'respect for people' [14]. The

increasing amount of literature about Lean in recent years has revealed that for the adoption and implementation of Lean management, changes are required in the entire management system of an enterprise [11], [14], [20]. According to [21], most senior managers seeking to adopt Lean management fail to understand it, as they have for decades been engaged in daily routines and habits that are non-Lean and very difficult to break. Therefore, it is necessary to influence the system, culture, and people of an enterprise using Lean management tools. This becomes even more important and requires creativity when applied to SMEs, whose strategic focus is mostly on the here and now [24].

2.2 Lean principles and benefits

The lean approach can be seen from different perspectives, and it is more advantageous to consider it as a multidimensional concept for understanding its different aspects and benefit from them [14]. However, there are five principles that constitute its basis, according to [16]. They are considered a five-step process for guiding the implementation of lean techniques (Table 1) through engagement of most functional units of the company, as expounded below.

Table 1. Lean principles

Step	Description
1	Identify value
2	Map the value stream
3	Create flow
4	Establish pull
5	Seek perfection

Source: [8]

The process starts with the identification of the value for the customer, understanding what truly adds value from the customer's perspective. As [25] phrases it, "Lean thinking defines value as providing benefit to the customer; anything else is waste". The key role here belongs to product design and marketing functions, complemented by other functional departments [26]. Then all the steps needed to make a product, or service can be ranked so displaying the value stream. During this ranking or mapping process, it is important to point out every action that does not create value, in order to eliminate wasteful ones. The third one is the creation of a flow that runs smoothly, without interruptions, delays, or bottlenecks. Engineering and production/ operations management functions direct the actions for these two steps, closely collaborating with other company units [26], [27]. Both steps contribute to making "Lean" the design and production process.

Despite the well-known advantages of push systems [23] and mass production, the fourth principle of lean is to establish a pull system, which ensures the product is produced and delivered when there is a demand from the customer [5]. Last but not least, seeking perfection implies repeating the steps for reducing waste and enhancing value, while making lean thinking and process improvement part of the company culture, as strongly advised by previous and recent literature about lean [16], [18], [21], [14], [24].

In general, this managerial approach enables businesses to eliminate unproductive processes and actions by providing an appropriate environment for monitoring, analysis, and a continuous approach to improvement and productivity growth.

The main benefits of implementing these principles for companies have been pointed out by various research [12], [16], [17] and include:

- efficiency improvement due to reduced downtime, increased productivity, faster response to customer demand, and better adaptation to market changes.
- cost reduction, coming from the elimination of waste of different forms (materials, labor work, transport, defective goods), minimizing the expenses. This leads to improved profitability for the companies.
- increased customer satisfaction, due to better understanding and fulfilling of customer needs, faster delivery, and lower cost.
- quality improvement, as the careful monitoring and analysis of the processes enables the visible, smooth flow, elimination of unnecessary parts, and focus on what generates value for the customer.
- positive corporate culture, due to the promotion of employee empowerment, collaborative spirit, and problem-solving orientation.

As the experience shows [12], "the effectiveness of Lean lies in the simple but powerful message that success could be achieved through the removal of waste".

2.3 Removing waste

The concept "waste" is primary in Lean management. Waste [16] is any step or action that is not required to transform input into a product or service that has value for the customer and which he/ she is willing to pay for. Such unnecessary steps or actions, called 'non-value-adding' ones in Lean management, are classified in eight categories. According to the original (Japanese) approach announced thirty years before by [16], there are seven types of wastes that are part of work processes. The eighth one is associated with the managerial capability to utilize the professional and creative potential of personnel, and it is added to the list when lean methodology was

adopted within the Western world [15], [28]. The detailed description of waste, after [12], [15], [16], [29] presented in Table 2 helps in their detection within the company.

Table 2. Lean Waste Categories

Waste category and meaning
W1 – Overproduction: Producing more than customers require, or producing earlier than needed
W2 – Overprocessing: Performing additional steps or activities in a process that do not create customer value
W3 – Waiting: Idle time when people, materials, or equipment remain unused until the next process step
W4 – Transport: Moving products, materials, or resources unnecessarily, without adding value
W5 – Inventory: Accumulating raw materials, work-in-progress, or finished goods beyond what is necessary
W6 – Defects: Delivering products or services that do not meet quality standards, requiring rework or replacement
W7 – Motion: Excessive or unnecessary movement of employees, tools, or equipment that does not contribute to value creation
W8 – Underutilized Talent: Missing the opportunities to fully use the employees' skills, knowledge, and creativity

Source: created by the authors

Detecting the eight wastes through Lean techniques implementation is much easier when the process is fully visible. Organizations need to understand and map the value stream; then Lean tools, combined with the digital ones, can be deployed to systematically eliminate the waste within an organization's processes in order to maximize profitability.

2.4 Digital tools to support the lean management

Digitalization and Lean management individually contribute to improving operational performance in businesses. For a long time, they have been seen as complementary or independent options [30], not compatible with each other. Lean manufacturing uses decentralized control by giving autonomy to local workers and emphasizes simplicity and transparency. In a Lean manufacturing system, any problem should be addressed immediately, taking care to find the root cause of the problem [8], [16], [20]. While IT, on the other hand, focuses on creating a centralized database and a "single correct version", which creates a disconnect between what happens on the production

process (shop floor) and the virtual information generated by the IT system. It is generally accepted that digital technologies may lead to processes' complexity, extra tasks, resource consumption, high investment required, etc., [30], [31]. However, evidence suggests that various digital tools can serve as enablers of improvements in lean industrial environments, especially when Lean-based practices are implemented prior to the application of IT infrastructures [13], [22], [30]. In such cases, information technologies and systems can be effectively incorporated into Lean manufacturing, provided that they align with Lean principles and contribute tangible value to the process. This is currently made easier because the introduction of cyber-physical systems (CPS) and the Internet of Things (IoT) enable elements of autonomy not typically found in traditional centralized IT systems [13], [24]. Also, the information systems available to support separately every functional area like Accounting Information Systems (AIS), Customer Relations Management (CRM), Supply Chain Management (SCM), Human Resource Management Systems (HRM), Manufacturing Resource Planning (MRP), or the integrated systems for the whole company (Enterprise Resource Planning - ERP) can greatly facilitate the company's efforts to minimize waste, enhance value and empower people.

This display is the impetus for our interest in exploring how digital tools and systems can be used for the proper application of Lean management, emphasizing that simultaneous use brings complementary or synergistic effects on businesses. The ability of companies to put the latest digital technologies into use and combine them with proven lean management principles becomes a factor with high impact on operational performance and hopefully on sustainable economic development.

3 Methodology

The above theoretical framework has enabled the formulation of the research question: What specific digital tools and technologies can be used to implement Lean management principles in businesses of our region?

3.1 Research Objectives

The objectives of the research are:

- To identify in which processes or links of the value chain and functional areas there are losses and waste,
- To what extent are advanced production/ service and information technologies used in these processes and in the company as a whole,

-How the waste identified for each group of resources can be avoided or minimized by using digital tools and systems in companies.

They are dealt with as auxiliary questions and are answered through qualitative research based on a combination of primary on-site and secondary on-desk research. Literature review and secondary research in databases have brought the findings identified by researchers on lean management. Further on, it has highlighted the trend of recent years to combine the simplicity of this approach with the opportunities that IT currently offers for rapid data processing, finding improvement ways, and making fast decisions to eliminate waste. The whole work intends to empirically contribute to the main hypothesis of a broader study undertaken by the authors that Lean-IT integration optimizes enterprise management.

3.2 Research Design and Data Collection

The study model was designed based on the above theoretical groundwork and was applied through primary research into companies in Albania and Kosovo.

The specific nature of the issue does not allow the extension of research to a large number of companies, as this (Lean) management approach is little known (except for the courses of Operations Management and Quality Management in several universities) and even less used in SMEs or institutions in our region [32], [33]. Consequently, the primary research was based on the multiple case study methodology [34], [35], conducting an exploratory analysis of some SMEs in different manufacturing sectors, where it was most probable to find the due conditions for investigating such an issue.

The sample of this study included 12 enterprises in Albania and 2 in Kosovo, all of them small and medium ones (according to “number of employees” and “annual turnover” criteria). This choice derives from the main aim of the study, which is to encourage the recognition and use of effective managerial approaches and digital tools, especially in SMEs that constitute the main part of businesses in our countries [6], [7], [36].

The sample is made of SMEs from the manufacturing sector due to its established history with Lean, its measurable processes for waste identification, and the need to promote this sector as a boost to the country’s economy. The manufacturing sector is an enabler towards the utilization of local natural and processed inputs for sustainable development, while countries strive to integrate into the global supply chains and into the EU [2], [3], [6].

3.3 Data Collection Instrument

The interview instrument is used to collect primary data on (1) the processes or functions where waste is identified in the value chain of observed SMEs, and (2) the areas of application of digital tools. During on-site trips to company facilities, guided interviews were carried out with top managers. The questions aimed to reveal and identify in which production and managerial processes there were waste and losses, and what their main causes were. At the same time, they aimed to investigate whether the use of digital tools and information systems allowed for the minimization of waste and how such improvements could be achieved.

The qualitative analysis of collected data leads to some results and findings described in Section 4.

3.4 Quantitative Validation

To statistically validate the qualitative findings, a Chi-Square Test of Independence was conducted to examine the relationship between the implementation of Lean principles and the use of information technology (IT) tools within the analyzed enterprises. The Chi-Square test is a non-parametric statistical method suitable for categorical data and used to determine whether two variables are associated or independent [37].

In this study, it was tested whether the level of Lean implementation (low, medium, high) was related to the degree of IT integration (limited, integrated, advanced) and to the perceived level of management optimization (low, medium, high).

Categorical data were organized into a contingency table, enabling the evaluation of whether Lean adoption and IT tool use were statistically independent or systematically related in influencing managerial performance.

The analysis was performed using SPSS v.29 at a 95% confidence level ($\alpha = 0.05$) [38].

The Chi-Square Analysis proved particularly effective in confirming that the combination of Lean principles and IT tools is not random but systematically related to management efficiency improvement.

4 Discussion

4.1 Operational Findings and Process Observations

Lean manufacturing, as defined by [8], aims to reduce waste and non-value-added activities. This can be achieved in manufacturing through standardized, consistent, and optimized processes, enabling uninterrupted product flow. It also requires

production to be based on current market demand, keeping minimal inventories. Applying the Lean principle of mapping the value stream brings the visualization of the entire process and facilitates evidence waste. The short setup times and employee involvement in continuous improvement efforts proved to be essential for effective waste reductions. According to research [9], [10], [12], these means can support improvements in different dimensions of operational performance, such as cost, speed, quality, dependability, and flexibility.

Starting from this approach and based on observations in several manufacturing companies in Albania and Kosovo, we have analyzed their situation regarding the utilization of resources, the processes or departments where waste is identified, and what are their causes. The analysis has considered the key areas of operations management [23], [26], [27], going through product and process design, unit layout, capacity and automation, scheduling, and the interconnections among the activities and sub-activities at the company level.

In most companies, investments in production technology have been made at different times and fragmented by adding machinery and equipment of different generations. This has made it difficult to integrate the machines added to the production line into a single chain, which can be monitored or commanded from a single center. This causes waste of several categories, like time waste (waiting/ W3), unnecessary transportation (W4), increased inventory of product in process between machines or processes (W5), and waste in workforce time and efforts (W8).

Similarly, companies have expanded production by adding lines and sectors over the years, making it difficult to connect them into an integrated system of production. Despite the intention of company managers to employ robotic equipment, the existing layout of the production line hinders their use. Based on the site watch and the expert's opinion in the companies visited, robots can perform different tasks in the surrounding environment, assisted by safety sensors and video cameras, if the layout fulfills the technical requirements. This would lead to increased productivity (reducing the production unit/cost), avoiding errors or defects in work processes (W6), facilitating the work of workers and making better use of their skills and talents, so avoiding or minimizing the eighth (W8). From the technical point of view, in the cases surveyed, it is possible to manage the production line by interconnecting machines and using information systems (available software) to monitor or command them from a center,

which allows for optimization of decision-making and corrective actions in the process.

Despite improvements, the mechanization or automation of processes in these companies is far from what the recent advanced technology allows in these industries, according to evidence from countries having a higher level of technological development, especially in Western Europe. Again, due to the expansion of the production line and departments at different times, conveyor systems were difficult to adapt to production and storage environments. This deficiency has led to the use of a larger workforce in transport processes, with an effect on costs, production lead time, quality, and work safety. They are obviously a waste of categories W4, W6, W8, which need to be minimized for better customer service, higher productivity, and financial results. On the other hand, providing data manually for these processes requires time and commitment from functional managers, impacting the logistics and operations functions.

The lack of connection of supply chain activities in an integrated system also affects sales management and customer order fulfillment. The cases of discrepancy between raw material supply, both in terms of quantity and delivery time, and production scheduling in the production process can be avoided by using new technologies that enable monitoring of the entire supply network and the delivery time of goods according to orders. Companies can use Supply Chain Management (SCM) systems to enable the management of goods, services, and information flow throughout the supply chain. Their use would lead to the reduction of losses from overproduction (W1 - production not balanced with demand), overprocessing (W2 - excessive/unnecessary production costs), and from excess stocks of inputs and/or outputs (W5) [26], [27].

Quality management is one of the functions where deficiencies are observed, due to the hindering factors/ challenges of SME development. Some of them include lack of digital knowledge, high dependence on traditional management methods, and resistance to structural and cultural change. They make the adoption of a comprehensive approach regarding quality (Total Quality Management - TQM) difficult for the manufacturing companies. If these companies have in place integrated production and information systems that offer opportunities for continuous quality control in the production process and real-time process intervention, they could improve product quality, minimizing defective products (W6), avoiding unnecessary losses and low-quality costs. We found out that the observed SMEs generally were not informed about these

opportunities, a fact that surely has hindered their potential efforts for following best practices.

Demand forecasting and planning production orders in accordance with customer demand leads to avoiding waste from overproduction (W1), optimizing inventory (by minimizing respective costs - W5), reducing the quantities of products that may exceed their expiration dates (in the case of food or other perishable products) and to the optimal use of labor (not neglecting their diverse capabilities - W8).

Companies can use Customer Relationship Management Systems (CRM) to help with customer relations and to ensure the most accurate forecasts for future time periods. Such systems are recommended for sales tracking, customer service management, and marketing campaign management, while contributing to avoiding waste of time, resources, and overproduction and optimizing marketing expenses.

In the conditions of companies with higher technological, human, and financial capacities, especially the medium ones, more comprehensive systems can be installed, such as:

- Management Information Systems (MIS) that involve the use of information technologies and digital tools to collect, analyze, and manage information in order to support decision-making and operational efficiency in organizations [39], [40]. They provide managers with tools to organize, evaluate, and manage departments efficiently by generating regular reports and providing data to support decision-making.

- Enterprise Resource Planning (ERP) systems constitute comprehensive platforms that integrate key business processes between different departments into a unified system. They generally include modules such as finance, human resources, supply chain, inventory management, and production [26], [27], [31].

Moreover, the fiscalization process imposed in both countries [41], [42] pushes all companies toward increased digitalization of managerial and financial activities, which facilitates the integration of information systems even in SMEs.

4.2 Chi-Square Analysis: Relationship Between Lean Principles, IT Tools, and Management Optimization

To examine whether a statistically significant relationship exists between the application of Lean principles and the use of IT tools in optimizing enterprise management, a Chi-Square Test of Independence was conducted. Data from the survey at the manufacturing enterprises from Albania and Kosovo and on-site observations provided the

qualitative foundation, while the statistical test offered quantitative validation (Table 3).

Table 3. Chi-Square Test Results: Lean-IT Integration and Management Optimization

Statistic	Value
χ^2 (Chi-Square)	6.43
Degrees of Freedom (df)	3
p-value	0.040

Source: created by the authors

The analysis indicates a statistically significant relationship between Lean implementation and IT adoption ($\chi^2(3, N = 14) = 6.43, p = 0.040$). Enterprises that integrate Lean methods with IT-based solutions, such as CRM systems, dashboards, and analytics, report higher management efficiency and faster decision-making compared to those applying either Lean or IT independently.

The results reveal a strong positive association between Lean-IT integration and management optimization, in line with findings from other research [9], [24]. Companies with higher Lean maturity and digitalization levels show fewer process interruptions, greater responsiveness to market dynamics, and improved resource utilization. Conversely, firms with limited IT adoption and partial Lean implementation exhibit weaker correlations, underscoring the reinforcing role of digital technologies in sustaining Lean practices.

These findings quantitatively support the qualitative evidence obtained from interviews and case studies, confirming that digitalization strengthens Lean's capacity for process standardization, visibility, and real-time improvement. The findings also reinforce the hypothesis that integrating Lean principles with IT tools produces a synergistic effect on organizational performance. Digital technologies amplify Lean capabilities by enabling real-time data visibility, accurate process mapping, and rapid feedback loops for waste elimination and decision-making.

Although the relatively small sample size ($n = 14$) limits generalization, the quantitative evidence validates and complements the qualitative findings from the multiple-case study. These conclusions are consistent with previous studies emphasizing the convergence of Lean and Industry 4.0 paradigms [13], [24]. IT-enabled Lean environments foster a data-driven culture, visual management, and continuous improvement (Kaizen), supporting both operational excellence and innovation.

5 Conclusion

The experience of companies that have adapted Lean management principles and applied them to their production/ service systems integrated with information tools and systems has prompted this study. Its aim is to provide businesses in Albania and Kosovo, especially SMEs, with insights and recommendations on how they can improve operational performance by minimizing losses and waste, aided by information systems that specific functions or the entire company can install and use.

5.1 Study contributions

The theoretical contribution of this work is related to the following conclusions:

- The approach that combines traditional management practices with modern digital technologies can bring an integrated system that leads to better decision-making, improved efficiency, and higher flexibility in facing market demand.
 - Combining managerial principles of Lean with digital tools helps to optimize processes and eliminate waste. It enables businesses to provide value for customers, increasing their satisfaction and ensuring they meet the demands of a dynamic market.
 - Organizations that implement such an integrated approach manage to establish a sustainable environment, promoting continuous performance improvement. As a result, cost reduction, operational efficiency increase, and quality improvement allow them to be more competitive in the global market.
 - Additionally, an innovative approach and following of best management practices helps businesses to keep up with environmental changes, ensuring sustainable long-term development.
- The practical implications of this study consist in:
- providing the know-how about the Lean approach and its implementation in connection with information systems available to the surveyed companies and the organizations they are affiliated with, with the intention of further disseminating knowledge in SMEs.
 - raising the awareness of top managers in companies about the opportunities of adopting Lean principles and fitting them into country's culture, traditional management practices and market development in the digital era.
 - making applicable recommendations to companies regarding the implementation of Lean techniques that enable detection and minimization of waste and especially the improvement in using employees' skills, both for factory and offices staff.

- adding empirical evidence and findings from the Albanian and Kosovo business environment to the limited literature available for academic and professional corps interested in this field.

5.2 Future research

Obviously, this study is not free of limitations.

- The relatively small number of cases observed and the fact that they operate in different manufacturing sectors constitute one of the limitations of this work.
- Despite the similarity in management practices, the level of technology they use, and the level of digitalization they have achieved, SMEs from different industry sectors have several differences. Due to this, the findings of the study and the recommendations are applicable within sectors, but not necessarily across other sectors.

There are several avenues to fill in the above gaps and to conduct further and even deeper explorations.

- Future research can cover either other manufacturing sectors or other industries, including logistics, where the lean strategy can be successfully implemented.

-Services in our territories are a large domain of interesting expectations from the implementation of lean principles combined with digital technologies to explore in the future. Future research should aim to expand the sample across service industries to test the transferability of Lean-IT synergy effects.

- Researchers are encouraged to develop computational simulations or digital-twin models to explore how Lean and IT interactions evolve under varying market conditions.

-Longitudinal studies focusing on digital maturity levels, organizational culture, and leadership commitment could further clarify how enterprises sustain continuous improvement through the integration of Lean principles and emerging technologies.

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I.Gj. has contributed to conceptualization, methodology and coordination of the research activity. M.J. has contributed to investigation process and visualization of the material for publication. Both authors have equally contributed to the writing and revision of the present research.

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