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APPLICATION OF LEAN METHODOLOGY IN THE OPTIMISATION OF THE PRODUCTION PROCESS OF ENTREPRENEURS

Abstract: *This paper provides a detailed overview of how Lean philosophy can be applied in the context of electric bicycle production to improve efficiency and reduce losses. The central part of the paper deals with the detailed application of these methods and techniques to the production of electric bicycles. Via a detailed analysis of existing processes and losses, the paper provides specific proposals for optimising the production process, improving quality control, better production planning, and encouraging continuous improvement (Kaizen). The case study provides a comparison between conventional and Lean production of electric bicycles, including a detailed quantification of losses and their ranking according to the magnitude of the impact on overall efficiency. Via specific application of the Lean philosophy, its tools and techniques, this paper shows how to achieve significant improvement in the efficiency of the production process, reduce losses and increase the competitive advantage in the market of electric bicycles.*

Keywords: *Lean; production of electric bicycles; production optimisation; loss reduction*

1. Introduction

Lean methodology, used in various industrial sectors, has a purpose of creating values for the final user by reducing losses and unnecessary activities during production processes. Furthermore, Lean promotes continuous improvement and strives for perfection in every aspect of business. Even though Lean brings along a series of advantages, its application can also represent certain challenges. Firstly, one accentuates increase in productivity via loss elimination as advantage, resulting in quicker and more efficient production (Pawlik et al., 2022). As result, companies can optimise the use of resources by reducing costs and increasing competitors' advantages. Secondly, Lean stimulates the culture of continuous improvement. By constant reexamination and process improvement, organisations can continuously improve their performances and product quality (Marcelino et al., 2023). Thirdly, Lean approach can contribute to company's sustainability. Via reducing waste and resource optimisation, Lan can help companies in becoming economically more sustainable (Awad et al., 2022). Even though Lean offers numerous advantages, its application can also bring along challenges. The first challenge is the resistance to change. Lean methodology application requires thorough change in company's business, which may result in employees' resistance (Maware & Parsley, 2022). The second challenge is the Lean approach implementation complexity. Lean requires clear understanding of all business aspects, which may be challenging for companies without experience in said methodology (Qureshi et al., 2022). The third challenge is Lean initiative sustainability. Without constant dedication and support in all organisational levels, Lean initiatives can become unsustainable in long term (Simonsen et al., 2023). Despite said challenges, Lean methodology provides numerous advantages which make it more attractive to many organisations. The key to successful Lean application is in understanding its principles and Lean approach adjustment to specific needs and contexts of every organisation. In production sector, Lean can help in reducing the production time, increasing product quality and optimising resource use (Pawlik et al., 2022). But, one needs to highlight that Lean application in said sector can be complex, requiring further understanding of production processes and extensive change in mode of operation. Likewise, it is important to mention that Lean approach has also become relevant in sustainability context as well. Lean can help organisations in reducing waste and optimising resource use, contributing to environ-

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ment protection and achieving goals of sustainable development (Tripathi et al., 2022). Despite challenges, Lean provides numerous advantages which make it attractive to various sectors. The key for successful implementation lies in Lean approach adjustment to specific needs and contexts of each organisation, with constant dedication to improvement and openness to change.

2. Characteristics of electric bicycles production

Electric bicycles production is significantly more technically demanding than producing conventional bicycles. Key components include electromotor, battery, controller and transmission system. Each said component requires careful designing and production to ensure optimal efficiency and reliability. Electromotor is one of the most important parts of an electric bicycle. Different bicycle models can use different types of motors, including brushless DC motors, asynchronous and synchronous motors with permanent magnets. Each said motor has its advantages and deficiencies and choice of motors depends on specific performance requests and price (Conto and Bianchi, 2023). The battery is another electric bicycle key part which starts the motor. Majority of modern e-bicycles uses lithium-ion batteries for their high energetic density and long lifetime. Nevertheless, batteries need to be regularly renewed by charging, which can impact the e-bicycle use practicality. There are significant challenges connected to extracting battery material and disposing of waste batteries (Apostolou et al., 2018). Controller is an electronic component managing the electricity delivered to the motor, regulating the bicycle speed and power. The controller needs to be well merged with motor and battery to ensure optimal efficiency. Transmission system includes mechanisms transferring power from engine to wheels. Mostly, this includes a chain or a belt and a set of gears which enable the driver to switch the transmission of gear ratio, ie adjust the speed and strain in accordance with terrain and desired speed (Zhang and Tak, 2021). In general, electric bicycles production requires complex manufacturing processes and uses high-tech materials. Furthermore, one requires constant innovations to improve efficiency and reduce costs. Integrating solar panels in electric bicycle design represents a significant step to sustainable mobility. This trend reflects the industry endeavour to increase the electric bicycles energetic efficiency and reduce fossil fuels addiction. Solar panels can be implemented into different bicycle parts, including the bicycle frame, splashboards or specifically designed bags. Solar energy absorbed by the panels is transformed into electric energy used to charge bicycle batteries. This innovative approach helps not only in reducing carbon emission, but it also increases bicycles autonomy, enabling longer rides without the need to charge (Apostolou et al., 2018). Therewith, algorithm implementation for predicting the energy consumption is becoming increasingly important in electric bicycles production. Said algorithms analyse various factors, such as distance, speed, terrain and weather conditions to precisely predict how much energy will be necessary for certain routes. Based on aforementioned information, bicycle controller can optimise energy use, enabling longer battery life and better total efficiency. These technologies not only improve user experience, but they also contribute to electric bicycles sustainability by reducing the need for frequent charging and enabling total energetic efficiency (Burani et al., 2022). Therefore, electric bicycles production characteristics are increasingly directed towards sustainability and energetic efficiency. Along with technological progress and increasing demand for sustainable modes of transportation, it is expected that said innovations will continue to develop.

3. Resarch methodology

This study uses mixed research methodology including qualitative and quantitative approach in order to achieve set goals. Said methodology features following key aspects:

- Literature review

  Detailed study of available literature, including academic articles, books, reports and other relevant sources in order to highlight the topic relevance and contextualise research results.
- Documentation analysis

  Study of internal documents by e-bicycle manufacturers, including production plans, quality reports and other relevant materials. This analysis enables understanding the current state of production process and identifying potential areas to apply the Lean principles.
- Case study

  Detailed analysis of the company producing e-bicycles in order to highlight specific Lean methodology applications and their effects on production. Case study provides practical insights and examples of ways the Lean principles work in the real world.

- Quantitative analysis

  Using the Lean tools for measurement and loss analysis, including ABC (Pareto) analysis. This analysis enables loss quantification, its ranking according to size and identifying key areas for improvement.

Research methodology is deliberately designed with purpose of offering all-inclusive insight into Lean philosophy application in e-bicycles production by combining theoretical knowledge with practical examples and quantitative analysis.

4. Case study: comparison of conventional and lean production of electric bicycles

In the framework of growing electrical bicycles production, it is increasingly important to search for means of optimising production processes and achieving greater efficiency. Lean production methods are often used, focusing on minimising waste and maximising values for clients. In such context, a case study is presented comparing conventional and Lean electric bicycles production, whose goal is to identify possible areas of improvement. The study consists of three key steps. Step one includes analysis and recording of current production state, with special emphasis on Kaizen loss analysis. This step includes identifying and quantifying 7+1 types of losses, expressed in monetary amounts. Step two focuses on analysis and solving two key losses by using the causative agent diagrams. This enables more detailed problem understanding and provides insight into potential improvement directions. Finally, step three suggests a solution for identified losses, with goal of optimising electric bicycles production process. This case study provides useful insights into potential advantages of Lean production in electric bicycle industry and offers practical advice on implementing said methods. The goal of this chapter is to explore advantages and deficiencies of both approaches and determine the way Lean methodology can improve electric bicycle production efficiency and competitiveness. In his book *Toyota* Production System: Beyond Large-Scale Production, Ohno (1988) emphasises the differences between conventional production and Toyota's production, which is based on Lean philosophy. The author emphasises the importance of continuous improvement, loss elimination and focus on creating value for buyers. Liker (2004), in his book The Toyota Way, states that the Lean approach enables companies more flexibility and speed in adjusting to market changes, with regard to conventional production methods. Lean production can lead to cost reduction, product quality increase and customer satisfaction improvement. Based on these authors' cognitions, one can conclude that Lean methodology application in electric bicycles production offers numerous advantages regarding traditional production methods. Lean approach enables companies achieve greater efficiency, product quality and competitive advantages, resulting in their greater attraction in electric bicycles market. Part one of this paper describes the conventional electric bicycle production, citing the main characteristics of this approach, such as focus on mass production, large stocks of raw materials and final products, and less flexibility in terms of adjusting the production to market changes. Likewise, one accentuates problems connected to this approach, such as losses caused by excessive production, unnecessary transport, waiting and production mistakes. Part two of this paper analyses the Lean methodology and its implementation in electric bicycles production. The Lean philosophy main principles are described, such as continuous reduction of losses, unnecessary activities and focus on adding values for buyer. Key Lean tools and methods are cited, such as the value stream (VSM), Kaizen, 5S, Kanban and Poka-yoke and their contribution to improving product efficiency. Afterwards, both approaches to electric bicycles production are compared based on key efficiency indicators, such as productivity, product quality, production costs and the speed of response to market changes. The analysis presents the way the Lean methodology can significantly improve production efficiency, reduce losses and improve electric bicycles competitive manufacturer advantages.

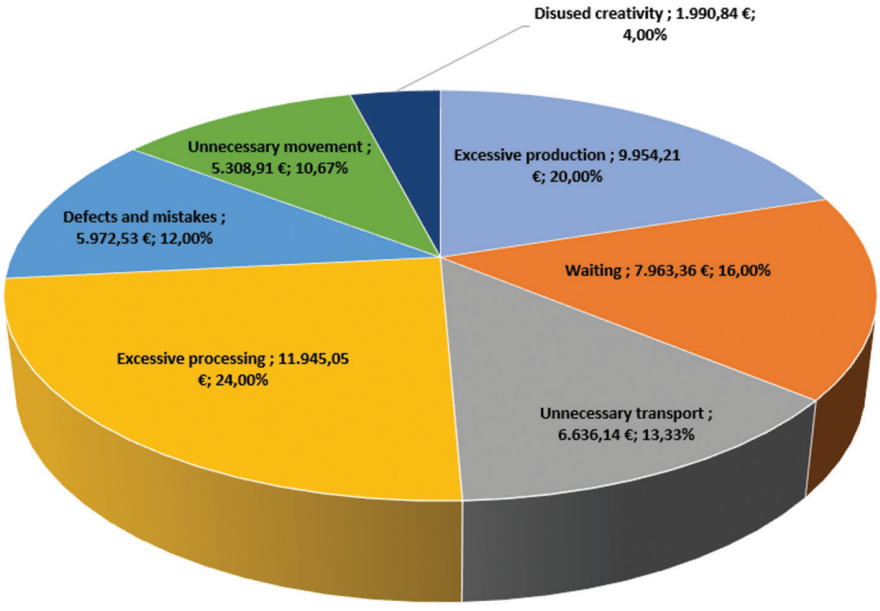
5. Analysis and recording of current condition: kaizen analysis – losses, 7+1 types of losses, quantification (monetary)

This chapter analyses the case study of Lean methodology application in electric bicycles production. The electric bicycles manufacturer decided to transfer to the Lean approach to improve competitiveness and reduce costs. Step one in the process of Lean methodology implementation was analysis and recording of current condition in order to determine possibilities for improvement. For this purpose, the company used Kaizen analysis which focuses on loss identification and reduction. Kaizen analysis determined several types of losses during electric bicycles production:

- Excessive production – producing more than necessary quantities, leading to unnecessary stock retention and increased storage costs. Estimated loss due to excessive production amounts to 9.954,21€ per year.
- Waiting – time lost while workers wait for materials or information necessary for job performance. The loss due to waiting estimates to 7.963,36€ per year.
- Unnecessary transport – material and product transport in between different parts of production process does not add to product value. The loss due to unnecessary transport estimates to 6.636,14€ per year.
- Excessive processing – additional actions performed on the product which do not contribute to its value. The loss due to excessive processing amounts to 11.945,05€ per year.
- Defects and mistakes – products that do not meet the quality criteria, leading to additional correction or replacement costs. The loss due to defects and mistakes estimates to 5.972,53€ per year.
- Unnecessary movement – movement of workers, which does not add to product value, such as unnecessary walking or searching for tools. The loss due to unnecessary movement estimates to 5.308,91€ per year.
- Disused creativity – the loss due to disuse of workers' potential for production and innovation improvement. The loss due to disused creativity estimates to 1.990,84€ per year.

In total, the company identified losses in the amount of 49.771,05€ per year, indicating significant potential for electric bicycles production via Lean methodology.

After identifying key losses during electric bicycles production, the company initiated their reduction via Lean tools and methods. Value Stream Mapping (VSM) application enabled material and information flow visualisation during production process and identification of improvement possibilities. Furthermore, 5S tool implementation assisted with workspace optimisation, unnecessary movement reduction and productivity improvement. Value Stream Mapping (VSM) was the key tool during this process. Via material and information flow visualisation during production process, the company managed to notice improvement possibilities. Based on VSM analysis, one could understand better where losses are made and the ways to reduce or eliminate them. Parallel to VSM application, the company also implemented 5S tool to optimise working environment. Five steps of 5S (sorting, systematic cleaning, shine, standardisation and maintenance) enabled organising and maintaining the workspace, reducing workers' unnecessary movements and productivity increase. By applying said tools, the company managed to decrease excessive stock, reduce waiting between production steps, optimise material transport and reduce defective products quantity and production mistakes. Also, due to better workspace organisation, the workers became more efficient, which added to loss reduction. Said changes resulted in company's market



Source: Author

Graph 1. Determining several types of losses during electric bicycles production based on Kaizen analysis

competitive advantage increase, while simultaneously reducing production costs and increasing profitability. Using Kanban system of work management contributed to reducing excessive production and delays by controlling inventory and optimising value flow. Poka-yoke tool, aimed at preventing mistakes via product design and process, has reduced losses caused by defects and production mistakes. By applying Kanban system of work management, the company has improved its processes during electric bicycles production. Kanban is a visual system which enables product monitoring in various production phases, which helps during inventory control and value flow optimisation. By implementing this system, the company managed to reduce excessive production and standstills, resulting in loss reduction and efficiency increase. Poka-yoke tool ensures mistake reduction caused by defects and production mistakes. Focused on preventing mistakes via product and process design, Poka-yoke techniques ensure mistake reduction or elimination. Application of said tool resulted in greater product quality, less complaints and reduction of costs connected to repairs or repeated production. Kanban system and Poke-yoke tool integration has significantly improved electric bicycles production efficiency. Losses were reduced, market competitiveness was increased and greater flexibility in production adjustment to change was realised. These results show how Lean methodology can be crucial to product optimisation and achieving long term success. Via continuous improvement (Kaizen), the company has achieved significant savings and increase in competitiveness value. Lean methodology application managed to reduce total losses in over 17%, resulting in significant increase in profitability and flexibility in adjusting production to market changes. By applying continuous improvement, ie Kaizen approach, the company has systematically analysed its production processes in order to identify improvement and optimisation possibilities. A series of small, incremental changes achieved significant loss reduction, leading to greater efficiency and productivity. Lean methodology, with emphasis on Kaizen, enabled successful total costs reduction of over 17%. This was achieved by eliminating unnecessary steps and activities, workspace optimisation, loss reduction and product quality increase. These changes resulted in significant profitability increase, contributing to competitors' company value in the electric bicycles market. Besides profitability increase, Lean methodology enabled company's greater flexibility in production adjustment to market changes. By reacting quickly to changes in demand and process optimisation, the company has managed to satisfy buyers' needs, simultaneously reducing costs and improving product quality. Continuous improvement via Kaizen approach and Lean methodology application enabled significant savings, competitive advantage increase and greater flexibility in production adjustment to changes in electric bicycle market. Case study presents the way Lean methodology application in electric bicycles production can lead to significant improvement in efficiency and loss reduction. Identifying and quantifying key losses enables directing companies' efforts to areas with the greatest improvement potential, which achieves better results and increases competitive advantage. By systematically analysing production processes and introducing corresponding Lean tools, companies can achieve better results and increase market competitive advantage. Lean approach offers framework for loss elimination, process optimisation, product quality increase and flexibility improvement in reacting to market changes. This case study presents the importance of systematic and structured approach in recognising, quantifying and solving key losses during electric bicycles production. Lean methodology application can achieve significant savings, improve efficiency and competitive value, resulting in sustainable growth and market success.

5.1 Analysis and solving two key losses via causative agent diagram application

As part of the analysis, two key losses were selected, recognised as the most important for optimising electric bicycles production:

- Excessive production
- Losses caused by production mistakes (defects)

Excessive production cause can be connected to several factors:

- Incompatibility between demand and production
- Ineffective production planning
- Resource overload

The cause of losses caused by production mistakes can be connected to several factors:

- Lack of raw material quality
- Inadequate product design
- Weak quality control

By applying Lean tools, such as Poka-yoke for mistake prevention, Kanban for inventory control and excessive production reduction, and Kaizen for continuous improvement, the company can iden-

Table 1. Display of causes for excessive production

Type of loss	Sub-type of loss	Cause
Excessive production	Incompatibility between supply and demand	Imprecise demand prognosis
Excessive production	Incompatibility between supply and demand	Weak communication with sales department
Excessive production	Ineffective production planning	Too optimistic plans
Excessive production	Ineffective production planning	Lack of feedback from production lines
Excessive production	Resource overload	Lack of capacity
Excessive production	Resource overload	Bad resource distribution

Source: Author

Table 2. Structure of losses caused by production mistakes

Type of loss	Sub-type of loss	Cause
Losses caused by production mistakes (defects)	Lack of raw material quality	Bad quality of supplier
Losses caused by production mistakes (defects)	Lack of raw material quality	Inadequate raw material storage
Losses caused by production mistakes (defects)	Inadequate product design	Unclear specifications
Losses caused by production mistakes (defects)	Inadequate product design	Bad communication between design and production
Losses caused by production mistakes (defects)	Weak quality control	Lack of standards
Losses caused by production mistakes (defects)	Weak quality control	Inefficient quality control in product lines

Source: Author

tify said causes and reduce losses during electric bicycles production. The cause of excessive production can be linked to several factors, and solving excessive production in electric bicycles production can be achieved by addressing key factors causing this problem:

- Incompatibility between demand and production

  In order to reduce excessive production, it is important to coordinate production with realistic market demand. This can be achieved by improving communication between sales and production departments and developing more precise demand prognosis. Likewise, application of Just-In-Time (JIT) production can ensure the production only when it is necessary, which reduces excessive production.
- Inefficient production planning

  In order to reduce excessive production, production plans have to be realistic and based on actual production lines capacities. Introducing feedback from production lines enables production plans adjustment in order to coordinate better with market needs and production capacities.
- Resource overload

  Resource overload can result in excessive production if production lines capacities are used inefficiently. Improving resource distribution by better planning and coordination can help while optimising and reducing excessive production. Furthermore, introducing even production (Heijunka) can help balancing overload in production lines and ensure more stable production.

This table provides clear solution visualisation for every key problem contributing to excessive production. Said solutions can be further analyzed and adjusted to specific needs of electric bicycles production. By applying Lean tools, such as Kanban, the company can better control inventory and reduce excessive production by optimising value flow during production process.

Table 3. Presentation of excessive production solutions in electric bicycles production

Key problems	Solutions
Incompatibility between demand and production	Improving communication between sales and production department
	Developing more precise demand prognosis
	Applying Just-In-Time production
Inefficient production planning	Creating realistic production plans based on actual production lines capacities
	Introducing feedback from production lines
Resource overload	Improving resource distribution via better planning and coordination
	Introducing even production

Source: Author

The cause of losses caused by production mistakes can be connected to several factors:

- Lack of raw materials quality

  In order to reduce losses caused by production mistakes, it is important to ensure the use of high quality raw materials. A company should carefully choose its suppliers and conduct regular raw material quality controls. This process can include raw material sampling and testing, grading the suppliers and developing long-term partnerships with reliable suppliers.
- Inadequate product design

  Inadequate design of a product can lead to production mistakes. In order to reduce such losses, it is important to develop a clear and precise product design based on actual users' needs and technical production possibilities. Improving communication between design and production department, as well as introducing standardised development and design revision procedures, can reduce mistakes and defects in production.
- Weak quality control

  In order to reduce losses caused by production mistakes, it is necessary to improve quality during the entire production process. Introducing regular quality inspections, internal revisions and statistical process control (SPC) can identify and solve problems prior to significant losses. Likewise, employee training should be conducted in order to increase awareness of the importance of product quality and reduce frequency of production mistakes.

Application of Lean tools, such as Poka-yoke, can improve company's mistake prevention via product and process design, which will reduce losses caused by production defects and mistakes.

6. Suggestion for solving identified losses

A suggestion for solving losses in electric bicycles production can be based on following key aspects:

- Optimising production process

  Implementing Lean methodology can help a company in optimising production process and reducing losses. Applying tools such as Value Stream Mapping (VSM), 5S and Kanban can improve production efficiency, reduce unnecessary steps and activities and optimise value flow.
- Quality control

  Improving quality control throughout the entire production process, including raw material quality control, product design and final inspection, can reduce losses caused by production mistakes. Applying Poka-yoke tool for mistake prevention can additionally improve product quality.
- Better production planning

  Developing more efficient production planning, which better reflects the actual market demand, can reduce excessive production and connected losses. Introducing tools for demand planning, such as prognosis and Just-In-Time (JIT) methods, can improve synchronisation between demand and production.
- Continuous improvement (Kaizen)

  Encouraging employees to actively participate in the process of continuous improvement, by providing improvement suggestions and including into teams for improvement, can help a company achieve better results and reduce losses. Regular conduction of Kaizen events and result improvement evaluation enables continuous tracking of progress and adjustment of loss reduction strategies.

By implementing these suggestions, a company can reduce electric bicycles production losses, increase competitive values and achieve greater flexibility in adjusting the production to market changes.

7. Conclusion

This paper provides an all-inclusive insight in the concept of Lean philosophy and its application in electric bicycles production. Key losses and challenges manufacturers face have been identified via detailed research of Lean tools and their application, and an analysis has been made on the way Lean tools can contribute to reducing said losses and improving production efficiency. In particular, research has shown that continuous improvement principles can apply to the context of electric bicycles production. Including employees was of crucial importance for successful Lean philosophy implementation, stimulating the culture of constant learning, innovations and adjustment. Analysing all aspects of Lean philosophy and its application in electric bicycles production can draw the following conclusion: Lean philosophy, strongly based on constant improvement principles, respect towards people and work standardisation, has a far-reaching impact on organisation culture, production and customer satisfaction. Characteristics and challenges in electric bicycles production have been identified and analysed, and it has been demonstrated how Lean philosophy and tools can be applied in solving said challenges. This paper also identified key losses during electric bicycles production and presented how said losses can be minimised by applying Lean tools. By implementing principles of continuous improvement (Kaizen), electric bicycles manufacturers can constantly improve their production processes by increasing efficiency and product quality. In the end, this paper confirms that Lean methodology application can have significant impact on efficiency and product quality in electric bicycles production, providing manufacturers with competitive advantage in the market. Lean philosophy has proven to be very efficient in the context of electric bicycles production. By applying Lean principles, electric bicycles manufacturers are able to solve key problems and challenges, optimise production process, reduce losses, improve quality and increase customer satisfaction. Continuous improvement, the essence of Lean philosophy, enables organisations continuous adaptation, innovation and success in competitive surroundings. Specific steps and results of Lean methodology application are presented via case study, providing clear indicators on advantages of said approach. Case study analysis has shown significant differences between conventional and Lean production of electric bicycles. Applying Lean philosophy has led to loss decrease, efficiency and product quality increase and greater competitive advantage for electric bicycles manufacturers. Lean philosophy possesses deep and transforming impact on organisational culture and production. By stimulating continuous improvement and learning, Lean approach has enabled organisations adjustment and innovations by increasing employee engagement and creating surroundings which stimulate innovations.

Literature

Liker, J., & Hoseus, M. (2008). Toyota Culture: The Heart and Soul of the Toyota Way.

Martinelli, M., Lippi, M., & Gamberini, R. (2022). Poka Yoke Meets Deep Learning: A Proof of Concept for an Assembly Line Application. Appl. Sci., 12(21), 11071. https://doi.org/10.3390/app122111071

Milewski, D. (2022). Managerial and Economical Aspects of the Just-In-Time System "Lean Management in the Time of Pandemic". Sustainability, 14(3), 1204. https://doi.org/10.3390/su14031204

Phan, A. C., Nguyen, H. T., Nguyen, H. A., & Matsui, Y. (2019). Effect of Total Quality Management Practices and JIT Production Practices on Flexibility Performance: Empirical Evidence from International Manufacturing Plants. Sustainability, 11(11), 3093. https://doi.org/10.3390/su11113093

Proença, A. P., Gaspar, P. D., & Lima, T. M. (2022). Lean Optimization Techniques for Improvement of Production Flows and Logistics Management: The Case Study of a Fruits Distribution Center. Processes, 10(7), 1384. https://doi.org/10.3390/pr10071384

Rahardjo, B., Wang, F. K., Yeh, R. H., & Chen, Y. P. (2023). Lean Manufacturing in Industry 4.0: A Smart and Sustainable Manufacturing System. Machines, 11(1), 72. https://doi.org/10.3390/machines11010072

Rivera-Gómez, H., Montaño-Arango, O., Corona-Armenta, J. R., Garnica-González, J., Ortega-Reyes, A. O., & Anaya-Fuentes, G. E. (2019). JIT Production Strategy and Maintenance for Quality Deteriorating Systems. Appl. Sci., 9(6), 1180. https://doi.org/10.3390/app9061180

Sustainability, 15(7), 6161. https://doi.org/10.3390/su15076161

Tošanović, N., & Štefanić, N. (2022a). Evaluation of Pull Production Control Mechanisms by Simulation. Processes, 10(1), 5. https://doi.org/10.3390/pr10010005

Tošanović, N., & Štefanić, N. (2022b). Influence of Bottleneck on Productivity of Production Processes Controlled by Different Pull Control Mechanisms. Applied Sciences, 12(3), 1395. https://doi.org/10.3390/app12031395

Tseng, S.-H., Wee, H.-M., Reong, S., & Wu, C.-I. (2019). Considering JIT in Assigning Task for Return Vehicle in Green Supply Chain. Sustainability, 11(22), 6464. https://doi.org/10.3390/su11226464

Trojanowska, J., Husár, J., Hrehova, S., & Knapčíková, L. (2023). Poka Yoke in Smart Production Systems with Pick to Light Implementation to Increase Efficiency: A Study. https://doi.org/10.20944/preprints202305.1829.v1

Valaskova, K., Kliestik, T., & Nagy, M. (2023). Global Value Chains and Industry 4.0 in the Context of Lean Workplaces for Enhancing Company Performance and Its Comprehension via the Digital Readiness and Expertise of Workforce in the V4 Nations. Mathematics, 11(3), 601. https://doi.org/10.3390/math11030601

Wang, J., Yin, J., Khan, R. U., Wang, S., & Zheng, T. (2021). A Study of Inbound Logistics Mode Based on JIT Production in Cruise Ship Construction.. Sustainability, 13, 1588. https://doi.org/10.3390/su13031588

Womack, J., Jones, D., & Roos, D. (1990). The Machine That Changed the World. Rawson Associates.

Yao, F., Alkan, B., Ahmad, B., & Harrison, R. (2020). Improving Just-in-Time Delivery Performance of IoT-Enabled Flexible Manufacturing Systems with AGV Based Material Transportation. Sensors, 20(21), 6333. https://doi.org/10.3390/s20216333

Yamaguchi, M., Shima, K., Yoshida, T., & Otsuka, T. (2018). Status Estimation and In-Process Connection of Kanbans Using BLE Beacons and LPWA Network to Implement Intra-Traceability for the Kanban System. Sustainability, 10(7), 2506. https://doi.org/10.3390/su10072506