International Journal of Lean Six Sigma

Workers' behaviors, economic performance and the Shingo model: a configurational approach to lean transformations

Andrea Furlan and Mercedes Victoria Auqui Caceres
Department of Economics and Management, University of Padova, Padova, Italy

Received 19 April 2025
Revised 19 September 2025
14 January 2026
Accepted 28 January 2026

Abstract

Purpose – This study aims to determine whether firms that focus on the technical side of lean, without building a foundation of problem-solving skills among workers, generate worse or better economic performance (return on assets) than firms that adopt a more balanced approach.

Design/methodology/approach – Following a configurational approach, the authors use a qualitative comparative analysis method to identify lean− systematic problem-solving (SPS) interactions associated with superior economic performance. Data were collected on a sample of 13 Italian small and medium-sized firms (involving 26 managers and 112 shop-floor workers). Coherently with the underlying principles of the Shingo model, this study offers insights into how firms can optimize lean transformations to achieve superior economic performance through congruent lean−SPS configurations.

Findings – Results show that organizations can achieve superior financial performance only if the selected lean practices are supported by workers who adopt a systematic approach to solve problems.

Originality/value – This research contributes to the operations literature by providing a better understanding of some critical factors that influence the success or failure of lean implementation. The focus on complex configurations enabled us to identify different lean−SPS interactions associated with superior (or low) economic performance, and the authors empirically demonstrate that SPS behavior is indeed the basis for successful lean transformations.

Keywords Lean management, SPS behavior, Shingo model, Systematic problem-solving

Paper type Research paper

1. Introduction

Literature provides evidence documenting that lean initiatives lead to an enhancement of firm performance (Abdulmalek and Rajgopal, 2007). According to some scholars, lean does not necessarily improve companies' results if it is not properly implemented (Dieste *et al.*,

Funding: This research is funded within the National Recovery and Resilience Plan (PNRR) research activities of the consortium of the Interconnected Nord-Est Innovation Ecosystem (iNEST) funded by the European Union Next-GenerationEu (PNRR – Missione 4 Componente 2, Investimento 1.5 – D.D. 105823/06/2022, ECS_00000043). The content of the manuscript represents exclusively the authors' point of view. Neither the European Union nor the European Commission should be considered accountable for its content.

International Journal of Lean Six Sigma
Emerald Publishing Limited
2040-4166
DOI 10.1108/IJLSS-04-2025-0090

2021) and sustaining lean over time often proves to be a challenge (Galeazzo *et al.*, 2024). According to Carvalho *et al.* (2023), many companies make mistakes in implementing lean because they tend to focus on specific tools and systems that are not well adapted to their organizational setting and "the difference between successful and unsuccessful efforts actually relies on their ability to ingrain into its culture timeless and universal operational excellence principles rather than rely on the superficial implementation of tools and programs" (Carvalho *et al.*, 2023, p. 398). Thus, the adoption of only technical tools or systems may not lead to superior results.

In this context, the Shingo model is a model that attempts to guide a successful implementation of lean by considering the integration of "hard" practices (technical tools and systems) with "soft" practices (such as the development of ideal workers' behaviors) to achieve superior results (Kelly and Hines, 2019). However, to the best of our knowledge, existing literature does not provide evidence about whether (and how) the alignment between workers' behaviors and lean practices leads to superior economic performance. There is a lack of clarity on the critical interdependence between ideal behaviors and technical practices and how a proper fit between them translates into better firm performance.

We expect that firms showing a good fit between workers' ideal behaviors (in particular, systematic problem-solving − SPS behavior) and technical lean bundles (i.e. just-in-time − JIT, total quality management − TQM and total productive maintenance − TPM) achieve higher economic performance compared to their counterparts who do not pay attention to such fit. Since we intend to examine and identify congruent and coherent combinations between technical lean bundles and SPS behavior that are associated with superior performance, we use the fuzzy-set qualitative comparative analysis on a sample of 13 firms. To operationalize our causal conditions, we conducted a survey consisting of two questionnaires that rate the level of implementation of our attributes on a seven-point Likert scale. The constructs and items used in the two questionnaires were accurately validated and used by previous studies. Regarding the economic performance, we use return on assets − ROA (calculated as net income over total assets). In particular, we use the average ROA (normalized by industry) of the last three years (2021–2023) for each company.

The study is structured as follows: after this introduction, Section 2 presents the literature review which explores the relationship between lean, systematic problem-solving behavior and the Shingo model. Section 3 outlines the method and Section 4 presents our findings. The discussion, in Section 5, interprets these findings, providing valuable insights into how firms can optimize lean transformations to achieve superior economic performance. Finally, in Section 6, we present the limitations and future research.

2. Literature review

2.1 Lean management

Lean management can be defined as a comprehensive, multidimensional approach that integrates a series of managerial practices into a cohesive system. The goal is implementing these practices synergically to build a high-quality production process, delivering finished products that maximize customer value with minimal waste. Shah and Ward (2003) were the first to classify lean practices in four bundles: just-in-time (JIT), total quality management (TQM), total productive maintenance (TPM) and human resource management (HRM). JIT is one of the most used practices in lean management and is designed to make production flexible and responsive to demand by shifting from a traditional "push" system to a "pull" one. By triggering production only when there is actual demand, JIT helps reducing waste and increasing efficiency. The effective implementation of JIT is subordinated to the presence of synchronized practices adopted throughout the supply chain. As an example, materials used must be immediately replenished and kanban tags are often used to signal reorder needs. TQM refers to a comprehensive approach aimed at delivering high-quality products and processes. To prevent errors and endure quality at every stage of production, it includes practices such as statistical process control to monitor and maintain process standards, error-proofing methods to reduce mistakes and visual management tools to identify deviations from quality benchmarks. TQM seeks to continuously improve quality, as well as to reduce variability and enhance reliability (Jayaram *et al.*, 2010). TPM aims at minimizing downtime and boost workplace stability and standardization. Through proactive actions like involving operators in routine maintenance, implementing safety measures and scheduling regular preventive maintenance, TPM prevents unexpected breakdowns and extends equipment lifespan. Finally, HRM focuses on actively involving employees and enhancing their skills, as well as to ensure the support of top management. Training and developing programs to build competencies and fostering an engaged work culture are only a few of the practices applied to create a collaborative environment that supports continuous improvement (Furlan *et al.*, 2011).

2.2 Shingo model: the fit between lean and workers' behaviors

The Shingo model is "the most well-known and globally accepted model used to guide the implementation of an operational excellence system" (Carvalho *et al.*, 2023, p. 398). The Shingo model is the result of years of scientific research done by the Shingo Institute; an organization affiliated with the Utah State University. The latest version (version 15.2) of this model was updated in 2024 (The Shingo Institute, 2024). The Shingo model can be seen as a further evolution of lean as it includes "the well-established lean focus on the customer (results) and tools but has extended this to include wider system (such as order fulfilment, strategy deployment and people life cycle management), culture and guiding principles" (Kelly and Hines, 2019, p. 1236). These guiding principles are divided into three dimensions:

(1) cultural enables: respect every individual and lead with humility;

(2) continuous improvement: assure quality at the source, improve flow and pull, seek perfection, embrace scientific thinking and focus on process; and

(3) enterprise alignment: create value for the customer, create constancy of purpose and think systemically (The Shingo Institute, 2024, p. 9).

Bravo-Sanchez *et al.* (2018) focus their attention on the integration of lean practices with the principles outlined by the Shingo model, suggesting that the advantages of the lean-Shingo alliance lie in the fact that it fosters a much stronger collective alignment within the organization around the need of designing, developing, implementing and maintaining systems capable of driving an effective cultural transformation.

The Shingo model emphasizes "the behavioural and cultural part of organizations without forgetting the importance of integrating lean philosophy, so that transformation and development can occur with the desired results" (Carvalho *et al.*, 2023, p. 403). In this model, systems must align with the guiding principles through the ideal behaviors they inform. At the base of the Shingo pyramid, we can see the cultural enables related to ideal behaviors required by the model to achieve sustainable ideal results, thus, the key on this model is to align behaviors with the lean tools or systems. As Mitenkov and Tikhonova-Bykodorova (2023, p. 105) suggest, to achieve excellent results employees need to change "the model of their behaviors in work situations." In general, previous research "has emphasized the importance of the human factor for successful lean adoption" (Knapic *et al.*, 2023, p. 293) since the selected tools and systems, by themselves, do not manage the business and are not able to provide superior results. People do it. As Harrisson and Laberge (2002, p. 500) maintain, organizational members are the starting point of any innovate initiative, such as the implementation of lean tools or systems, “they join in the process or they oppose it, they protect interests and propose others.” Bendoly *et al.* (2024, p. 4) indicate that “even when organizations have appropriate equipment and expertise to allow for rapid and effective redeployment of production resources, they may not have processes in place or established operational cultures that easily accommodate such change.”

Consequently, following the Shingo model, we argue that the adoption of lean practices should be designed and implemented in conjunction with employees’ abilities, skills and behaviors; thus, organizations should focus their attention on the match between employees’ behaviors and lean practices. As indicated by Van Assen (2018), it is commonly agreed that the success of lean is not only determined by its technical practices, but also by the so-called soft practices such as behaviors of employees. Nevertheless, evidence concerning the importance of worker behaviors in lean adoption is scant to use a euphemism (Carraro and Galeazzo, 2024; Furlan *et al.*, 2019; Knapic *et al.*, 2023). Frank *et al.* (2025) call for further research on the relationship between lean and workers’ attitudes or behaviors.

As the Shingo model claims, “ideal results require ideal behaviors” which should be “expected and evident in every team member” (The Shingo Institute, 2024, p. 12). The model emphasizes that companies have an enormous job to align (and realign) lean practices to drive ideal behaviors to achieve ideal outcomes. Among the ideal behaviors, the Shingo model stresses the foundational role of a “scientific approach to problem-solving” (The Shingo Institute, 2024, p. 28). Furlan *et al*. (2019) maintain that even if systematic problem-solving (SPS) is widely acknowledged at the root of continuous improvement and kaizen, literature lacks evidence about whether a good fit between lean practices and SPS is associated with better financial performance.

In other words, we still do not know whether firms that focus on the technical side of lean without building a foundation of problem-solving skills among workers perform worse or better than firms that adopt a more balanced approach. Moreover, we lack knowledge on whether there exist optimal configurations between specific lean practices and SPS behavior.

2.3 SPS behavior, lean and the Shingo model: a configurational approach

Literature has focused on two opposite approaches to problem-solving, namely intuitive problem-solving (IPS) and systematic problem-solving (SPS). The former approach relies on the use of heuristics and workarounds to quickly fix problems with minimal cognitive effort. Conversely, the latter approach is based on analytical reasoning and in-depth analyses to identify the root causes of problems and to develop new, enhanced solutions aimed at preventing their reoccurrence (Furlan *et al.*, 2019). While IPS is unlikely to generate new knowledge, SPS encourages employees to acquire new skills, to enhance their ability to combine knowledge and to identify opportunities for improvements (Choo *et al.*, 2007). When shop-floor employees adopt an SPS approach to address the root causes of problems, they need to engage in cognitively effortful activities, such as information retrieving and information processing, thus “SPS is the key to innovation” (Auqui-Caceres and Furlan, 2023, p. 746).

Although few studies have contributed to our understanding of the critical role of SPS behavior in ensuring successful lean adoption (Galeazzo *et al.*, 2024; Kelly and Hines, 2019; Puvanasvaran *et al.*, 2008), they do not provide empirical evidence on the impact on economic performance of lean adoptions that nurture SPS behavior. Moreover, regarding the benefits deriving from the adoption of lean practices there are few research available in literature that document “the gains associated with the implementation of the Shingo model”

(Carvalho *et al.*, 2023, p. 404). Bravo-Sanchez *et al.* (2018) focus on embedding lean principles within the Shingo model, exploring how to align lean tools and systems with the Shingo guiding principles to foster a culture of continuous improvement and customer value. They argue that lean−Shingo integration aims to enhance organizational learning and sustainable success. Kelly and Hines (2019) demonstrate that a successful lean adoption, based on the Shingo model, produces better operational performance, such as reduced cost per unit manufactured, shorter lead times and fewer distressed inventories. In general, the Shingo model is perceived as an approach that can help firms in the search for better results if properly implemented (Edgeman, 2018).

Therefore, our research attempts to quantitatively measure the impact of the adoption of Shingo principles (in particular, lean practices and SPS behavior) on economic performance. To do this, we rely on a contemporary configurational approach (Fainshmidt *et al.*, 2020) to examine how the combinations of lean bundles and workers' SPS behavior may affect firm economic performance. We believe that a configuration approach is the best appropriate to identify set of different lean−SPS configurations associated with superior (or low) firm performance as it identifies "specific combinations of causally relevant ingredients [i.e. lean-SPS interactions] linked to an outcome [i.e. firm economic performance]" (Di Paola *et al.*, 2025, p. 123909).

3. Method

3.1 Research design

Since we aim to explore the complex combinations between technical lean bundles and SPS behavior associated with superior firm results, we choose to use the qualitative comparative analysis (QCA) as the method of our empirical analysis. We use this method because it can handle the configurational perspective (Arellano *et al.*, 2021) and is the most appropriate method to this study due to its advantages over traditional methods (Ragin and Fiss, 2008).

Specifically, we use the fuzzy-set QCA because we intend to capture the relationship between different combinations of our pre-determined attributes (e.g. causal conditions) and firm's economic results (e.g. outcome). This technique applies a configurational approach to analyze an outcome by breaking it into its constituent attributes or causal conditions. Each attribute is treated as an independent set, in which cases (i.e. firms) are assigned a set-membership score according to a predetermined membership degree in the attribute's set. The main task of fuzzy-set QCA is to analyze complex relationships in the form of conjunctural causation (Fiss, 2007). A case can obtain a score ranging from full membership (if the case's attribute entirely corresponds to the ideal type) to non-membership (if the case does not possess the attribute). For example, a firm that has fully implemented lean practices in its plant will obtain a full membership in lean. However, if the firm has only partially implemented lean practices in its plants, it will be attributed some degree of membership in this set.

3.2 Sample and data collection

Our final sample consists of 13 small to medium-sized manufacturing firms (26 managers and 112 workers) located in Northern Italy, a region that encompasses over 52% of the Italian manufacturing firms (ISTAT, 2024). The area was selected because it was at proximate distance from the authors' affiliated university. This sampling approach is appropriate because (a) the population is geographically clustered and social contact with key informants is necessary for effective communication (Galeazzo and Furlan, 2018) because it makes possible for the authors to personally present the survey to the top management of all participants and (b) sample representativeness is not a potential issue for sampling bias in our research due to the use of qualitative comparative analysis which, unlike econometric models, does not rely on the premise that samples have given probability distributions (Fainshmidt *et al.*, 2020).

We have collected first-hand data through two questionnaires: the first questionnaire was answered by plant managers or supervisors and the second by shop-floor employees. Together, these questionnaires rate the maturity level of our causal conditions explained below: technical lean bundles and SPS behavior. The data collection took place from February to December of 2024 following a stepwise procedure. First, an initial data set consisting of small to medium-sized Italian manufacturing firms, located in Northern Italy, was selected from the Italian Company Information and Business Intelligence (AIDA) (with on over 200,000 Italian firms provided by Bureau Van Dijk). Second, the research team identified 106 email addresses of key informants from the selected firms. It then sent an email to these key informants by providing a comprehensive overview of the research's purpose and a detailed description of the data collection process. From the initial contact, a total of 24 firms responded to the emails and expressed their willingness to engage in a virtual meeting for further discussion regarding the research. Following these virtual meetings, 11 firms decided to withdraw from the data collection process due to time constraints. Third, the research team conducted in-person visits to each of the participating firms. These visits served to select the work units that would be included in the research. The selection process was carried out collaboratively between the research team and plant managers or supervisors by choosing from the assembly lines, workshops or cells to accurately represent the different operational contexts within the plants. Fourth, to minimize response biases, for the first questionnaire we asked companies to identify two plan managers (supervisors) at each plant, who had at least one-year working tenure in that position, and for the second questionnaire we asked firms to identify at least three shop-floor workers who had at least one-year working tenure in the plant. Finally, the survey took place during regular working hours, with the participants gathered in one or two rooms in their respective plants under the supervision of at least one member of the research team. It was communicated to the respondents that only the researchers would have access to the response data, to create a safe environment for providing honest statements. This approach attempts to mitigate any self-serving biases and improve the reliability and accuracy of participants' responses (Galeazzo *et al.*, 2024; Ketokivi, 2019). Because of missing values, some data was dropped, reducing the final sample size to 26 managers and 112 shop-floor workers from 24 work units across 13 manufacturing plants.

Since we intended to evaluate the lean-SPS configurations generated by the qualitative comparative analysis in a specific plant against the overall financial performance of the firm, we decided to select companies with a single production plant. We believe that in these companies, the operational performance of the single plant directly impacts the financial performance of the entire company. Thus, the economic performance indicators are most likely affected by the lean-SPS combinations adopted by the only plan of the company.

Finally, we collected secondary data on economic performance metrics from the Italian Company Information and Business Intelligence (AIDA). Table 1 provides information about our final sample.

3.3 Measures and calibrations

3.3.1 Outcome (economic performance). Return on assets (ROA) is a standard accounting measure of economic performance and focuses on a firm's overall performance (Xie *et al.*, 2016). ROA is computed as the ratio of net income divided by the total assets; thus, it is a relevant indicator for a company that measures a firm's profitability relative to its total assets. The higher the ROA, the more efficiently a company is using its assets to produce earnings. In a systematic review, Yu (2022) concludes that ROA is the one of the most adopted firm performance measurements in literature.

Table 1. Overview of the sample firms and respondents

Firm	Turnover 2023 (million $)	No. of employees 2023	Average age of employees	Type of production	No. of respondents: Plant manager-supervisors	No. of respondents: Shop floor workers	NACE code	Sector description
Firm 1	8.87	33	31–45	Small batch	2	15	1623	Manufacture of other builders' carpentry and joinery
Firm 2	4.39	29	31–45	Small batch	2	23	1330	Finishing of textiles
Firm 3	16.32	73	46–60	Small batch	2	10	1320	Weaving of textiles
Firm 4	12.68	70	46–60	Small batch	2	19	1310	Preparation and spinning of textiles fibres
Firm 5	2.35	15	31–45	Small batch	2	10	2562	Machining
Firm 6	13.63	69	46–60	Small batch	2	3	1320	Weaving of textiles
Firm 7	27.88	101	31–45	One-piece flow	2	5	2893	Manufacture of machinery for food, beverage and tobacco processing
Firm 8	26.78	78	31–45	One-piece flow	2	6	3100	Manufacture of furniture
Firm 9	14.29	32	31–45	Big batch	2	8	1061	Manufacture of grain mill products
Firm 10	9.95	38	31–45	Small batch	2	3	3101	Manufacture of office and shop furniture
Firm 11	5.93	24	31–45	Small batch	2	4	2512	Manufacture of metal doors and windows
Firm 12	3.30	14	31–45	Small batch	2	3	4673	Manufacture of construction materials and sanitary equipment
Firm 13	2.81	17	31–45	Big batch	2	3	4619	Manufacture of various products without any predominance

Several studies use ROA (or similar measures) to evaluate the impact of lean on firm performance. Camuffo and Poletto (2024) have extensively documented that the adoption of lean as a pervasive, enterprise-wide management system generates abnormal profitability. They measure profitability using the ratio of return on invested capital (ROIC = net operating profit after taxes/net invested capital), which, similar to ROA, evaluates a company's ability to generate profits. Galeazzo and Furlan (2018) use a configurational approach to measure the impact of lean bundles on ROA. They find that none of the lean bundles is able to explain alone firm's high ROA but lean bundles always have to be complemented by other lean bundles.

We also adopt some empirical measures to minimize the likelihood that the impact on ROA can be explained by factors other than lean practices and avoid confounding effects on ROA. First, we use the average ROA of the last three years (2021–2023) for each company. We use three years to try to capture the economic impact of the long-term strategic benefits of lean−SPS configurations. Second, to account for the industry effect, we use a "normalized ROA" by comparing the average ROA of the firm with the average ROA of the corresponding firms belonging to the same sector. European NACE codes (four digits) were used to assign firms to their sectors. Finally, as explained above, we choose companies with only one plant. Since lean practices and workers' behaviors represent the backbone of the management system of the only plant of the firms, they are likely to have a direct impact on the economic profits of the entire company.

3.3.2 Causal conditions. As explained above, Shah and Ward (2003) postulate four bundles of lean practices: these are just-in-time (JIT), total quality management (TQM), total productive maintenance (TPM) and human resource management (HRM). These four bundles of practices are still the most addressed by literature (Van Assen and de Mast, 2019; Ciano *et al.*, 2021). Some scholars conceptualize JIT, TQM and TPM as technically oriented practices while HRM is considered as socially oriented practices (Bocquet *et al.*, 2019). HRM can be conceptualized as the glue that holds the technically oriented practices together (Longoni *et al.*, 2013). Since our research aims to determine whether firms showing better fit between worker's SPS behavior (a social attribute) and technical lean practices can achieve superior financial performance, we focus our attention on the three technically oriented practices: JIT, TQM and TPM.

Systematic problem-solving (SPS) behavior presupposes that shop-floor employees apply knowledge in "determining why the deviation from normal routines occurred, in selecting the relevant inputs to well structure the problem and the desired goal, in identifying the goal-directed actions and in understanding any other state of the problem-solving process" (Furlan *et al.*, 2019, p. 282). SPS assists problem-solvers to "successfully implement and sustain the improvement-based programs at the shop floor and make rational choices to shape the strategy of the firm for the long-term vision" (Mohaghegh and Furlan, 2020, p. 1051). We use the measurement constructs and items developed by Furlan *et al.* (2019) to measure the extent to which the workers of a firm adopt SPS behavior.

3.3.3 Operationalization of causal conditions. As Fainshmidt *et al.* (2020, p. 457) suggest, "QCA with four causal conditions requires a minimum sample size of 12, while seven causal conditions require a sample of about 30." Since our final sample is made of 13 manufacturing firms, our four causal conditions (three lean bundles and SPS behavior) are in line with the sample size required by the QCA method.

To operationalize the three technical lean bundles (JIT, TQM and TPM), we use a first questionnaire whose items and scales have been previously established, validated and used (Furlan *et al.*, 2011; Galeazzo and Furlan, 2018; Galeazzo *et al.*, 2024). All the measures were drawn from Furlan *et al.* (2011), which consider well-established lean practices linked to each bundle proposed by Shah and Ward (2003). The questionnaire aims to accurately detect the quality, extent and intensity of the adoption of lean practices within the plants. Moreover, with our configuration approach, we attempt to investigate the joint implementation of these three lean bundles rather than their implementation in isolation because there is evidence supporting that the adoption of these three bundles simultaneously is associated with better firm performance (Cua *et al.*, 2001). Regarding workers' SPS behavior, we use a second questionnaire developed by Furlan *et al.* (2019) which is based on an in-depth review of the literature on operations management and behavioral psychology. All questionnaires' items have been previously validated and used in previous studies (Furlan *et al.*, 2019; Galeazzo and Furlan, 2019; Galeazzo *et al.*, 2024). This survey attempts to capture the behavioral approach of individuals to adopt a step-by-step approach to problem-solving, to identify whether workers adopt a SPS behavioral approach (problem identification, generation of possible alternatives, solution selection and evaluation).

Finally, the constructs used in this study are evaluated in terms of reliability and validity. Our reliability test verifies the internal consistency of the constructs of the multi-item scales. We measure Cronbach's alpha (α) with a threshold value of 0.70 (Galeazzo and Furlan, 2018; Pappas and Woodside, 2021) and find that all constructs exceed the cut-off threshold, indicating that our research constructs are reliable and acceptable. To examine the validity of our constructs, our validity test requires that the average variance extracted (AVE) be greater than 0.50 (Pappas and Woodside, 2021; Sartal *et al.*, 2022). All constructs exceed the cut-off threshold, indicating that our measures satisfy the criteria for supporting convergent validity of the multi-item scales.

Table 2 reports our construct elements, measurement items, Cronbach's α, AVE and the list of papers that used the same constructs.

The first questionnaire was administered to supervisors (managers) of the plant to investigate the level of adoption of technical lean bundles, and a second questionnaire was administered to the shop-floor employees (workers) to examine SPS behavior. Both questionnaires consist of a series of statements. For each of them, the respondent indicates to what extent he or she agrees with them on a seven-point Likert scale, where 1 indicates totally disagree, 2 indicates mostly disagree, 3 indicates slightly disagree, 4 indicates neither agree nor disagree, 5 indicates slightly agree, 6 indicates mostly agree and 7 indicates totally agree. The seven point Likert scale is often used in empirical research examining lean practices (Galeazzo and Furlan, 2018; Ciasullo *et al.*, 2024) and employees preferences or behaviors in lean implementation (Knapic *et al.*, 2023; Medeiros *et al.*, 2025) since a seven-point Likert scale has been shown to be more accurate and a better reflection of a respondent's true evaluation (Sharma, 2017), and is perhaps the most popular method for measuring attitudes because is easily understood by the respondents (Heo *et al.*, 2022).

To convert the scores of each causal condition into data required by the QCA method, the multiple-item scales for each condition were aggregated at the firm-level by averaging the scores of all respondents that belonged to the same firm (Galeazzo and Furlan, 2018). This averaging approach is commonly used in studies examining employee characteristics factors for employees in lean implementation such as creativity, innovation and confidence (Knapic *et al.*, 2023). Furthermore, to support our conceptualization and operationalization of our causal conditions as firm-level constructs, we calculated the intra-class correlation (ICC) with a threshold of 0.6 (Cicchetti, 1994). Our final sample includes firms whose ICC values exceed the necessary threshold value.

3.3.4 Calibration process. Qualitative comparative analysis (QCA) method operates on Boolean algebra requiring all values to fall between 0 and 1 which indicates the level of their membership, where the value of 1 denotes full set membership, while 0 denotes no set

Table 2. Constructs and items used to measure causal conditions

Causal conditions	Construct element	Cronbach's $\alpha > 0.70$	AVE > 0.50	Example of some items-questions	Studies
1. TQM	Total quality management (TQM)	0.935	0.541	• The production processes in our plant are designed to avoid errors (they are "fool-proof") • Information on quality levels is provided to staff in a timely manner	Furlan *et al.*, 2011; Galeazzo and Furlan, 2018; Galeazzo *et al.*, 2024
2. JIT	Just-in-time (JIT)	0.912	0.689	• Our suppliers operate by filling our containers (kanban), rather than by purchasing orders • Our customers receive "just-in-time" deliveries from us	
3. TPM	Total productive maintenance (TPM)	0.918	0.592	• Workers understand the cause and effect of equipment deterioration • We estimate the lifespan of our equipment, so we can plan for repair or replacement	
4. SPS behavior	Systematic approach to solve problems	0.818	0.613	• When I find myself facing a problem, I usually first analyse the situation to identify the most important elements to solve it • When I make a decision, I compare the alternatives and evaluate the advantages and disadvantages of each of them compared to all the others	Furlan *et al.*, 2019; Galeazzo and Furlan, 2019; Galeazzo *et al.*, 2024

membership. The transformation of variables into calibrated set is done by fuzzy-set QCA program, by setting three meaningful thresholds: full membership, full non-membership, and the cross-over point. Since the calculated average values for all our causal conditions are between 1 and 7 a transformation is needed. This transformation process is called calibration. To calibrate our constructions measured with a seven-point Likert scale, we follow the procedure used by Pappas *et al.* (2016), that is, the full membership threshold was fixed at the rating of 6; the full non-membership threshold was fixed at the rating of 2; and the crossover point was fixed at 4. This study follows this approach since it enables more accurate comparisons and often leads to solutions with better overall consistency and coverage (Pappas and Woodside, 2021).

It is important to notice that because ROA (our performance outcome) was derived from published financial statements, it has not been subjected to a reliability analysis. However, calibration is still required. To ensure comparability across sectors, ROA values were assessed relative to their sector's ROA distribution. To do this, the 25th, 50th and 75th percentiles of the ROA distribution for each industry were identified (Arellano *et al.*, 2021; Galeazzo and Furlan, 2018). High ROA was calibrated using the 75th percentile of the ROA distribution within the relevant industry as the threshold for full-set membership value, the 50th percentile as the crossover point, and the 25th percentile as the full-set non-membership value. Low ROA was defined as the absence of high ROA. Our approach to distinguish between high ROA and low ROA intends to provide not only success factors but also factors that may lead to poor performance. Following these assumptions and calibrations, the final data set used for the fuzzy-set QCA was created.

3.4 Data analysis

Qualitative comparative analysis (QCA) generates "truth table configurations" which summarize all the possible logical combinations among causal conditions associated with the outcomes of interests (i.e. a high or a low ROA). The truth table configurations are based on the counterfactual analysis of the logically possible combinations. The truth table provides three types of solutions: complex, intermediate, and parsimonious. The complex solution does not use the counterfactual analysis, thus providing complicated solutions that are difficult to understand. In contrast, the intermediate and parsimonious solutions use the counterfactual analysis. The intermediate solution is more conservative because it only uses easy counterfactuals (Ragin and Sonnett, 2005). The parsimonious solution uses both easy and difficult counterfactuals, which allows producing the most reduced form of the solution. Following what conventional wisdom suggests (Pappas and Woodside, 2021), this article relies on intermediate and parsimonious solutions to identify core and peripheral conditions related to an associated outcome. Core conditions are those that are part of both parsimonious and intermediate solutions, and peripheral conditions are those that are eliminated in the parsimonious solution and thus appear only in the intermediate solution. Thus, combining the parsimonious and intermediate solutions, we can identify and mark the core conditions of the parsimonious solution that also appear in the intermediate solution. A condition is core when it has a strong causal relationship with the outcome of interest, whereas a condition is peripheral when it plays a contributing role (Fiss, 2011). The truth table also provides information about coverage and consistency of each configuration. Coverage indicates the empirical relevance of the configuration associated with the outcome, that is, the probability that the same solution is obtained by reproducing the experiment (Ragin, 2006). Raw coverage informs on the empirical overlap of conditions across configurations associated with the same outcome and unique coverage informs on the relative importance of each configuration associated with the same outcome (Fiss, 2007). In the next section, we present results on how our casual conditions (i.e. TQM, JIT, TPM and SPS) interact with each other to generate high (or low) ROA.

4. Findings

4.1 Analysis of necessary conditions

We ran a necessity analysis before conducting the sufficiency analysis. We test whether our four causal conditions (just-in-time – JIT, total quality management – TQM, total productive maintenance – TPM and systematic problem-solving – SPS behavior) are necessary to produce the desired outcome (i.e. high return on assets – ROA). Values over the threshold of 0.9 indicate necessity (Arellano *et al.*, 2021; Ragin, 2006). According to our results, among all conditions, SPS behavior was the only condition with a consistency value superior to 0.9. Thus, the necessity analysis revealed that SPS behavior is by itself necessary for firms to achieve superior financial performance, in other words, the presence of workers adopting a SPS approach to solve problems in the workplace is always associated with superior economic performance.

4.2 Analysis of sufficient conditions

The second analysis performed – to identify sufficient conditions – involves the "Truth Table" algorithm. The analysis was performed using the fuzzy-set qualitative comparative analysis (QCA) 4.1 software, which automatically generates the possible configurations of causal conditions. This method enables us to understand which mix of conditions are associated with the desired outcome and gives insight into how these conditions interact with one another. Two truth table analyses were derived, one having high ROA as the performance outcome, and one having Low ROA. As explained above, we define Low ROA as the absence of high ROA. Both analyses were performed using all the selected four causal conditions. We describe the truth tables results for the parsimonious and intermediate solutions since working with both solutions can offer a more detailed and aggregated view of the findings.

All configurations for high ROA and low ROA are described in Figure 1, where each column represents a configuration associated with the selected outcome. Within each configuration, each condition is represented by a symbol. Black circles indicate the presence of a condition that leads to the outcome (i.e. the outcome may be achieved by the presence of a high level of adoption of the condition). Crossed-out circles indicate the absence of a condition for the generation of the outcome (i.e. the outcome may be achieved by the absence of a high level of adoption of the condition). In addition, combining the parsimonious and intermediate solutions, we mark core conditions with big circles, while small circles indicate conditions that are peripheral. Finally, blank spaces indicate "do not care," meaning that the presence or absence of the condition is not relevant in the configuration.

As we can see, all configurations exceed our threshold values:

- the threshold for raw coverage of 0.45 that demonstrates goodness of fit (Woodside, 2013);
- the threshold value of 0.01 for unique coverage (i.e. the share of cases that uniquely take a given path to the outcome), (Arellano *et al.*, 2021); and
- the threshold value of 0.80 for consistency (Pappas and Woodside, 2021).

The truth table analysis provides three different configurations having a High ROA and one configuration having a low ROA (Figure 1).

	High ROA			Low ROA
Configuration	C1	C2	C3	C4
TQM		⊗	⬤	●
JIT	⊗		●	●
TPM	●	●	⊗	
SPS Behavior	⬤	⬤	⬤	⊗
Consistency	0.846	0.874	0.923	0.855
Raw coverage	0.712	0.662	0.498	0.790
Unique coverage	0.103	0.052	0.025	0.790
Overall solution consistency		0.812		0.855
Overall solution coverage		0.835		0.790

TQM: Total Quality Management
JIT: Just-In-Time
TPM: Total Productive Maintenance
SPS Behavior: Systematic Problem-Solving Behavior
(●) Indicate the presence of a condition, and ( ) Indicate its absence.
Large circles indicate core conditions, and small ones indicate peripheral conditions.
Blank spaces indicate "do not care."

Figure 1. Configurations for high ROA and low ROA

4.2.1 Configurations for high ROA. The overall solution consistency of our configurations is 0.812, exceeding the accepted threshold of 0.80 (Fiss, 2011). Consistency ensures the validity of our results. Moreover, the truth table provides information about the overall solution coverage which describes the extent to which the outcome of interest (i.e. high ROA) may be explained by the configurations and is comparable with the *R*-square reported on regression-based methods (Pappas and Woodside, 2021). Our results indicate an overall solution coverage of 0.835, which suggests that a substantial proportion of the outcome is covered by the three solutions, which is in line with other studies using QCA.

The first configuration (C1) associated with superior financial performance is characterized by the presence of high level of adoption of SPS behavior and TPM and the absence of high level of adoption of JIT, while the adoption of TQM is indifferent. The second configuration (C2) proposes that a firm may achieve a High ROA when there is the presence of high level of adoption of SPS behavior and TPM and the absence of high level of adoption of TQM, while the adoption of JIT is indifferent. The last configuration (C3) is characterized by the presence of high level of adoption of SPS behavior, TQM and JIT, and the absence of high level of adoption of TPM. The results reveal that all the identified configurations exhibit the presence of high level of SPS behavior as a core feature to achieve superior ROA, which is consistent with the results of the necessary conditions. This suggests the fundamental role played by SPS in addressing workplace issues. Furthermore, we can see that while the presence of SPS behavior is always associated with superior financial results, technical lean bundles can vary their presence. Our results support the idea that while an organization may choose between different technical lean practices (for example prioritizing its commitment to quality over maintenance), it can achieve superior financial performance only if the selected lean practices are supported by workers who adopt a systematic approach to face problems.

4.2.2 Configuration for low ROA. The configuration C4 is associated with low ROA and is characterized by the presence of high level of adoption of TQM and JIT, and the absence of high level of adoption of SPS behavior. This result indicates that companies that encourage the adoption of lean practices related to quality control and streamlined processes activated by customers' demand without the support of workers with high skills of effective problem-solving will not obtain financial benefits from these practices. This is in line with prior studies (Gelinas, 1999; Safayeni and Purdy, 1999) claiming that to have positive accomplishments, a pre-requisite for implementing JIT is operators who effectively handle problems. Ullah (1991) also emphasizes the critical role of workers' attitudes and behaviors to solve complex problems in implementing TQM programs. Thus, organizations need to be aware of the strong influence that workers exhibiting SPS behavior can have whenever they attempt to undertake the implementation of lean practices to obtain tangible economic benefits from this implementation.

4.3 Robustness tests

We conduct a set of robustness tests to assess how sensitive our results were toward changes in the model parameters and alternative approaches to calibration. First, we tested the robustness of our results in relation to a more conservative model (threshold value of 0.85 for consistency) and a more lenient model (threshold value of 0.75 for consistency). Second, we conduct two robustness tests using alternative calibration approaches: (a) High ROA was calibrated using the 60th percentile of the ROA distribution within the relevant industry as the threshold for full-set membership value, the 40th percentile as the crossover point, and the 20th percentile as the full-set non-membership value, and (b) High ROA was calibrated using the 80th percentile of the ROA distribution within the relevant industry as the threshold for full-set membership value, the 60th percentile as the crossover point, and the 40th percentile as the full-set non-membership value. Finally, we conduct a robustness test incorporating a new causal condition, defined as "capital intensity – (CI)" to control whether there are changes in the results since our expectation is that CI may impact the mix of technical lean bundles to be implemented, and at the same time CI can be a relevant driver for a firm's financial performance (Miller and Richard, 2004). We measure CI as fixed assets scaled by total revenues (Miller, 1986; Miller and Richard, 2004), calculated with financial data extracted from AIDA. This test indicates that our results are highly stable with two configurations that corroborate our prior combinations of lean bundles and SPS leading high ROA (the presence of high level of adoption of TQM, JIT and SPS behavior when there is a low level of CI and the presence of high level of adoption of TPM and SPS behavior when there is a high level of CI), and one configuration that shows that there is an alternative combination eliciting high ROA composed by the presence of a high level of adoption of TQM, TPM and SPS behavior when there is a low level of CI. Overall, our robustness tests suggest that the findings remain substantively unchanged, thereby corroborating the configurational perspective between technical lean bundles and SPS behavior developed in this study.

5. Discussion

Lean has proven successful across a wide range of industries, yet it still faces significant challenges, as evidenced by numerous failed lean transformations (Komkowski *et al.*, 2025). Research reports failure rates of 60–90% in implementing lean programs in small- to medium-sized enterprises (Pearce *et al.*, 2018). We argue that this is partly due to a gap in both the literature and practice about the management and impact of simultaneously implementing multiple lean bundles, as well as the interaction between the technical and behavioral aspects of lean.

First, firms neglect the complexity and challenges surrounding successful coexistence between technical lean bundles (just-in-time − JIT, total quality management − TQM, total productive maintenance − TPM). Although researchers recognize the value of investigating the effects of jointly implementing JIT, TQM and TPM (Cua *et al.*, 2001), studies generally investigate the adoption and impact of these lean bundles in isolation. There are few studies that provide empirical examinations of the combined implementation of lean bundles. Therefore, we intend to contribute to lean literature by offering insights into how firms can optimize lean transformations to achieve superior economic performance through simultaneous adoptions of these lean bundles.

Second, as some authors argue, implementing technical lean tools represents at the most 20% of the effort in lean transformation; the other 80% of the effort is expended on changing behaviors of employees and leaders (Van Assen, 2018). In lean transformation contexts, changing behaviors can be challenging (Van Dun and Wilderom, 2016) and, even in firms that extensively implement lean practices, workers can disregard systemic problem-solving (SPS) by adopting workarounds to find quick fixes to their problems (Morrison, 2015). The Shingo model proposes a set of guiding principles to build a sustainable culture of organizational excellence that lays the foundation for lean transformations that achieve superior financial results. The Shingo model pays substantial attention to the behavioral side of lean by indicating, for example, a systematic approach to solving problems as an ideal behavior. Scholars recognize that an effective problem-solving "can be an important source of value creation" (Decreton *et al.*, 2023, p. 2566). Recently, problem-solving skills and/or behavior have become a relevant topic in operations management literature (Galeazzo *et al.*, 2024). However, to the best of our knowledge, there is no study that empirically demonstrates the importance of SPS behavior for a successful lean transformation. Thus, we aim to contribute to academic literature by providing empirical evidence that firms that focus exclusively on the technical side of lean (JIT, TQM and TPM), without developing effective problem-solving skills among workers, show low performance.

Finally, to date, very few studies have measured the impact of lean adoption on firms' economic outcomes. Some studies suggest a positive impact on financial indicators, but only indirectly, due to improved operational performance. For example, Gangaraju *et al.* (2025) claim a positive effect on companies' economic performance by referencing improved operational indicators such as customer query time and delivery performance, yet they do not provide direct evidence of economic improvements. Hence, we contribute to lean management literature by measuring how technical lean bundles can be successfully combined in different ways with SPS behavior to be associated with high economic performance.

Overall, this research contributes to the operations literature by providing a better understanding of some critical factors that influence the success or failure of lean implementation. Our focus on complex configurations enabled us to identify different lean−SPS interactions associated with superior (or low) economic performance, and we empirically demonstrate whether SPS behavior is indeed the basis for successful lean transformations.

5.1 The foundational nature of SPS behavior

This article documents the ubiquitous role of SPS behavior in driving superior economic performance. This study reveals that SPS behavior is an essential element for achieving strong financial outcomes. We quantitatively document its impact on ROA, complementing recent literature that examines the relationship between SPS behavior and firm success.

As Thakur *et al.* (2024, p. 1701) conclude, problem-solving capabilities may serve as the foundation for competitive advantage by helping organizations to "utilize resources in strategically effective ways." Similarly, Verissimo *et al.* (2024) argue that an effective problem-solving approach "not only improves operational efficiency but also strengthens the position of organizations in the market" and "represents a source of sustainable competitive advantage" (2024, p. 100277). Furlan *et al.* (2019) argue that workers' SPS behavior is essential to understand the micro-dynamics of improvement routines enacted to achieve operational excellence.

We provide empirical evidence on the vital role that SPS behavior plays in ensuring strong economic performance, as our findings indicate that SPS behavior is a necessary condition associated with high ROA. Most notably, we reveal that firms with advanced implementation of TQM and JIT, but without workers adopting SPS behavior, have poor financial performance, hence, our results suggest that firms that develop lean programs without fostering a strong problem-solving culture are bound to experience disappointing results.

Our study underscores the necessity for organizations to cultivate a work environment that encourages a systematic approach to problem-solving among all employees, including shop-floor workers. We suggest that SPS behavior is the single greatest driver of competitive advantage and, ultimately, of satisfying economic performance.

5.2 Complementary between SPS behavior and lean bundles

Our paper shows that the impact of combinations of technical lean bundles and SPS behavior on ROA is much more complicated than previously thought. Findings reveal that, to achieve concrete economic benefits, technical bundles of lean must be always complemented by SPS behavior because we found that SPS behavior is omnipresent in all the lean combinations associated with high ROA. This suggests that employees with higher problem-solving competences are critical in all lean transformations.

This result may be seen as a reflection of the socio-technical system theory (STS) which asserts that firms are composed of two interdependent systems: social system (e.g. people) and a technical system (e.g. tools, techniques) (Manz and Stewart, 1997). Several authors claim that a better performance "can be achieved by a simultaneous emphasis on both the technical and social subsystems" (Hadid and Mansouri, 2014, p. 752). Hadid *et al.* (2016) argue that "emphasizing the technical side of a system by investing more on its practices and neglecting the social system (by investing less on its practices), or vice versa, will not lead to the optimal performance" (p. 623). This perspective is supported by recent research that highlights the importance of addressing these socio-cultural aspects in adopting lean, emphasizing that a better "understanding of individuals attitude or behaviors is fundamental to successful lean implementation" (Medeiros *et al.*, 2025, p. 3).

Our findings confirm that an organization can accomplish superior economic performance only when the technical system (in this study, technical lean bundles) is collectively developed with the social system (in this study, workers' SPS behavior). Workers who enact SPS behavior can reflect on traditional practices, relating these reflections to a set of standards and rules that transcend their immediate job role, and interact with other workers in this process. Thus, we suggest that employees adopting SPS behavior are more appropriate to support the implementation of technical lean practices (tools or systems).

Overall, we contribute to the theoretical understanding of lean as a set of interdependent lean bundles, as past studies on complementarity among lean practices have only provided a fragmented understanding of the complex, interdependent relationships between different lean bundles (Galeazzo and Furlan, 2018). We demonstrate how technical lean bundles can be successfully combined in different ways with SPS behavior to be associated with high economic performance.

Our findings also provide clear implications for practitioners. Managers can use our configurations to understand how to position their organizations and choose the most appropriate configuration. Following the Shingo model, practitioners can leverage our results to guide their lean efforts, focusing on the technical lean bundles that best fit their specific organizational context, while simultaneously building a culture based on a strong foundation of SPS behavior.

6. Limitations and future research

While our study provides valuable insights into a configurational approach to lean transformation, it is important to acknowledge certain limitations that may guide future research endeavors.

First, our study provides a static analysis of configurations between lean and systematic problem-solving behavior, and this may overlook temporal evolution as this research does not consider the different phases of lean adoption. Future research should study whether (and how) firms transition between different configurations over time and how these transitions are related to their financial performance. Second, this article excludes human resources management (HRM) practices from the investigation. Thus, exploring how the integration of specific HRM practices might moderate the effect of our configurations on return on assets (ROA) would be a promising further research avenue. Finally, our results offer initial insights into the application of the configurational approach (using the fuzzy-set qualitative comparative analysis) to lean transformations. Further research is needed to explore a higher number of causal conditions to identify which configurations of lean-SPS behavior better fit specific sectors or firm characteristics. Related to this limitation, our explanation for concurrent configurations of technical lean practices is speculative and requires more empirical validation. We believe that more research on the contingency nature of technical lean bundles is needed to explore whether the adoption of these bundles depends on lean maturity, industrial contexts or technological features of production processes.

Acknowledgements

The authors are truly grateful to Roberto Santolamazza and Enrico Segantin (Trasferimento Tecnologico e Innovazione, t2i, Italy) for their invaluable support during the data collection process. The authors also thank the two anonymous reviewers for their insights and support. Previous versions of the paper were discussed at various conferences and meetings organized by the Interconnected Nord-Est Innovation Ecosystem (iNEST), Italy and at several seminars organized by the Department of Economics and Management of the University of Padova, Italy.

References

Abdulmalek, F.A. and Rajgopal, J. (2007), "Analyzing the benefits of lean manufacturing and value stream mapping via simulation: a sector case study", *International Journal of Production Economics*, Vol. 107 No. 1, pp. 223-236.

Arellano, M.C., Meuer, J. and Netland, T.H. (2021), "Commitment follows beliefs: a configurational perspective on operations managers' commitment to practice adoption", *Journal of Operations Management*, Vol. 67 No. 4, pp. 450-475.

Auqui-Caceres, M.V. and Furlan, A. (2023), "Revitalizing double-loop learning in organizational contexts: a systematic review and research agenda", *European Management Review*, Vol. 20 No. 4, pp. 741-761.

Bendoly, E., Chandrasekaran, A., Handfield, R., Khajavi, S.H., Roscoe, S. and Ferreira Lima, M.D.R. (2024), "The role of generative design and additive manufacturing capabilities in developing human-AI symbiosis: evidence from multiple case studies", *Decision Sciences*, Vol. 55 No. 4, pp. 325-345.

Bocquet, R., Dubouloz, S. and Chakor, T. (2019), "Lean manufacturing, human resource management and worker health: Are there smart bundles of practices along the adoption process?", *Journal of Innovation Economics and Management*, Vol. n° 30 No. 3, pp. 113-144.

Bravo-Sanchez, C., Dorazio, V., Denmark, R., Heuer, A.J. and Parrott, J.S. (2018), "Development of an interprofessional lean facilitator assessment scale", *Journal of Interprofessional Care*, Vol. 32 No. 3, pp. 370-373.

Camuffo, A. and Poletto, A. (2024), "Enterprise-wide lean management systems: a test of the abnormal profitability hypothesis", *International Journal of Operations and Production Management*, Vol. 44 No. 2, pp. 483-514.

Carraro, M. and Galeazzo, A. (2024), "How to drive proactivity in lean settings", In *A Research Agenda for Lean Management,* Edward Elgar Publishing, pp. 149-164.

Carvalho, M., Sá, J.C., Marques, P.A., Santos, G. and Pereira, A.M. (2023), "Development of a conceptual model integrating management systems and the shingo model towards operational excellence", *Total Quality Management and Business Excellence*, Vol. 34 Nos 3-4, pp. 397-420.

Choo, A.S., Linderman, K.W. and Schroeder, R.G. (2007), "Method and context perspectives on learning and knowledge creation in quality management", *Journal of Operations Management*, Vol. 25 No. 4, pp. 918-931.

Ciano, M.P., Dallasega, P., Orzes, G. and Rossi, T. (2021), "One-to-one relationships between industry 4.0 technologies and lean production techniques: a multiple case study", *International Journal of Production Research*, Vol. 59 No. 5, pp. 1386-1410.

Ciasullo, M.V., Douglas, A., Romeo, E. and Capolupo, N. (2024), "Lean six sigma and quality performance in Italian public and private hospitals: a gender perspective", *International Journal of Quality and Reliability Management*, Vol. 41 No. 3, pp. 964-989.

Cicchetti, D.V. (1994), "Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology", *Psychological Assessment*, Vol. 6 No. 4, pp. 284-290.

Cua, K.O., McKone, K.E. and Schroeder, R.G. (2001), "Relationships between implementation of TQM, JIT, and TPM and manufacturing performance", *Journal of Operations Management*, Vol. 19 No. 6, pp. 675-694.

Decreton, B., Tippmann, E., Nell, P.C. and Parker, A. (2023), "More effective solutions? Senior managers and non-routine problem solving", *Strategic Management Journal*, Vol. 44 No. 10, pp. 2566-2593.

Di Paola, N., Chari, S., Iannacci, F. and Kraus, S. (2025), "Configurational theory in business and management research: status quo and guidelines for the application of qualitative comparative analysis (QCA)", *Technological Forecasting and Social Change*, Vol. 211, p. 123907.

Dieste, M., Panizzolo, R. and Garza-Reyes, J.A. (2021), "A systematic literature review regarding the influence of lean manufacturing on firms' financial performance", *Journal of Manufacturing Technology Management*, Vol. 32 No. 9, pp. 101-121.

Edgeman, R. (2018), "Excellence models as complex management systems: an examination of the shingo operational excellence model", *Business Process Management Journal*, Vol. 24 No. 6, pp. 1321-1338.

Fainshmidt, S., Witt, M.A., Aguilera, R.V. and Verbeke, A. (2020), "The contributions of qualitative comparative analysis (QCA) to international business research", *Journal of International Business Studies*, Vol. 51 No. 4, pp. 455-466.

Fiss, P.C. (2007), "A set-theoretic approach to organizational configurations", *Academy of Management Review*, Vol. 32 No. 4, pp. 1180-1198.

Fiss, P.C. (2011), "Building better causal theories: a fuzzy set approach to typologies in organizational research", *Academy of Management Journal*, Vol. 54 No. 2, pp. 393-420.

Frank, A.G., Sturgeon, T.J., Benitez, G.B., Marodin, G.A. and Ferreira e Cunha, S. (2025), "How lean and industry 4.0 affect worker outcomes and operational performance: a quantitative assessment of competing models", *International Journal of Production Economics*, Vol. 279, pp. 1-16.

Furlan, A., Galeazzo, A. and Paggiaro, A. (2019), "Organizational and perceived learning in the workplace: a multilevel perspective on employees' problem solving", *Organization Science*, Vol. 30 No. 2, pp. 280-297.

Furlan, A., Vinelli, A. and Pont, G.D. (2011), "Complementarity and lean manufacturing bundles: an empirical analysis", *International Journal of Operations and Production Management*, Vol. 31 No. 8, pp. 835-850.

Galeazzo, A. and Furlan, A. (2018), "Lean bundles and configurations: a fsQCA approach", *International Journal of Operations and Production Management*, Vol. 38 No. 2, pp. 513-533.

Galeazzo, A. and Furlan, A. (2019), "Good problem solvers? Leveraging knowledge sharing mechanisms and management support", *Journal of Knowledge Management*, Vol. 23 No. 6, pp. 1017-1038.

Galeazzo, A., Furlan, A., Tosetto, D. and Vinelli, A. (2024), "Are lean and digital engaging better problem solvers? An empirical study on italian manufacturing firms", *International Journal of Operations and Production Management*, Vol. 44 No. 6, pp. 1217-1248.

Gangaraju, P.K., Raj, R., Kumar, V., Akhil, N.S.B., De, T. and Kaswan, M.S. (2025), "Financial performance in industry 4.0 agile supply chains: evidence from manufacturing companies", *The TQM Journal*, Vol. 37 No. 1, pp. 222-248.

Gelinas, R. (1999), "The just-in-time implementation project", *International Journal of Project Management*, Vol. 17 No. 3, pp. 171-179.

Hadid, W. and Mansouri, S.A. (2014), "The lean-performance relationship in services: a theoretical model", *International Journal of Operations and Production Management*, Vol. 34 No. 6, pp. 750-785.

Hadid, W., Mansouri, S.A. and Gallear, D. (2016), "Is lean service promising? A socio-technical perspective", *International Journal of Operations and Production Management*, Vol. 36 No. 6, pp. 618-642.

Harrisson, D. and Laberge, M. (2002), "Innovation, identities and resistance: the social construction of an innovation network", *Journal of Management Studies*, Vol. 39 No. 4, pp. 497-521.

Heo, C.Y., Kim, B., Park, K. and Back, R.M. (2022), "A comparison of best-worst scaling and likert scale methods on peer-to-peer accommodation attributes", *Journal of Business Research*, Vol. 148, pp. 368-377.

ISTAT (2024), "Censimento permanente delle imprese 2023: primi risultati", available at: www.istat.it/it/files/2023/11/REPORTCensimprese.pdf (accessed 10 January 2025).

Jayaram, J., Das, A. and Nicolae, M. (2010), "Looking beyond the obvious: unraveling the Toyota Production System", *International Journal of Production Economics*, Vol. 128 No. 1, pp. 280-291.

Kelly, S. and Hines, P. (2019), "Discreetly embedding the Shingo principles of enterprise excellence at abbott diagnostics manufacturing facility in Longford Ireland", *Total Quality Management and Business Excellence*, Vol. 30 Nos 11-12, pp. 1235-1256.

Ketokivi, M. (2019), "Avoiding bias and fallacy in survey research: a behavioral multilevel approach", *Journal of Operations Management*, Vol. 65 No. 4, pp. 380-402.

Knapic, V., Rusjan, B. and Božič, K. (2023), "Importance of first-line employees in lean implementation in SMEs: a systematic literature review", *International Journal of Lean Six Sigma*, Vol. 14 No. 2, pp. 277-308.

Komkowski, T., Sony, M., Antony, J., Lizarelli, F.L., Garza-Reyes, J.A. and Tortorella, G.L. (2025), "Operational practices for integrating lean and industry 4.0 - a dynamic capabilities perspective", *International Journal of Production Research*, Vol. 63 No. 4, pp. 1517-1537.

Longoni, A., Pagell, M., Johnston, D. and Veltri, A. (2013), "When does lean hurt? – an exploration of lean practices and worker health and safety outcomes", *International Journal of Production Research*, Vol. 51 No. 11, pp. 3300-3320.

Manz, C.C. and Stewart, G.L. (1997), "Attaining flexible stability by integrating total quality management and socio-technical systems theory", *Organization Science*, Vol. 8 No. 1, pp. 59-70.

Medeiros, N., Filho, G., Callefi, M., Devós Ganga, G., Norte da Silva, J., Thürer, M., Lopes Negrão, L. and Lizarelli, F. (2025), "Measuring employee involvement in lean manufacturing efforts: proposal of a robust scale", *International Journal of Production Research*, pp. 1-26.

Miller, D. (1986), "Configurations of strategy and structure: towards a synthesis", *Strategic Management Journal*, Vol. 7 No. 3, pp. 233-249.

Miller, T.W. and Richard, E.M. (2004), "Drivers of the value of the firm: profitability, growth, and capital intensity", *Journal of Accounting and Finance Research*, Vol. 12 No. 6, pp. 70-79.

Mitenkov, A.V. and Tikhonova-Bykodorova, I.V. (2023), "Transformation of values of employees of an industrial enterprise based on the Shingo model", *Russian Journal of Industrial Economics*, Vol. 16 No. 1, pp. 105-117.

Mohaghegh, M. and Furlan, A. (2020), "Systematic problem-solving and its antecedents: a synthesis of the literature", *Management Research Review*, Vol. 43 No. 9, pp. 1033-1062.

Morrison, B. (2015), "The problem with workarounds is that they work: the persistence of resource shortages", *Journal of Operations Management*, Vol. 39-40 No. 1, pp. 79-91.

Pappas, I.O., Kourouthanassis, P.E., Giannakos, M.N. and Chrissikopoulos, V. (2016), "Explaining online shopping behavior with fsQCA: the role of cognitive and affective perceptions", *Journal of Business Research*, Vol. 69 No. 2, pp. 794-803.

Pappas, I.O. and Woodside, A.G. (2021), "Fuzzy-set qualitative comparative analysis (fsQCA): guidelines for research practice in information systems and marketing", *International Journal of Information Management*, Vol. 58, pp. 1-23.

Pearce, A., Pons, D. and Neitzert, T. (2018), "Implementing lean - outcomes from SME case studies", *Operations Research Perspectives*, Vol. 5 No. C, pp. 94-104.

Puvanasvaran, A., Megat, M., Tang, S., Muhamad, M. and Hamouda, A. (2008), "A review of problem-solving capabilities in lean process management", *American Journal of Applied Sciences*, Vol. 5 No. 5, pp. 504-511.

Ragin, C.C. and Sonnett, J. (2005), "Between complexity and parsimony: limited diversity, counterfactual cases, and comparative analysis", In *Vergleichen in Der Politikwissenschaft*, Springer-Verlag, pp. 180-197.

Ragin, C.C. (2006), "Set relations in social research: evaluating their consistency and coverage", *Political Analysis*, Vol. 14 No. 3, pp. 291-310.

Ragin, C.C. and Fiss, P.C. (2008), "Net effects analysis versus configurational analysis: an empirical demonstration", In Ragin, C.C. (Ed.). *Redesigning Social Inquiry: Fuzzy Sets and Beyond*, University of Chicago Press, Chicago, IL, pp. 190-212.

Safayeni, F. and Purdy, L.A. (1999), "Behavioral case study of just-in-time implementation", *Journal of Operations Management*, Vol. 10 No. 2, pp. 213-228.

Sartal, A., Llach, J. and León-Mateos, F. (2022), "Do technologies really affect that much? Exploring the potential of several industry 4.0 technologies in today's lean manufacturing shop floors", *Operational Research*, Vol. 22 No. 5, pp. 6075-6106.

Shah, R. and Ward, P.T. (2003), "Lean manufacturing: context, practice bundles, and performance", *Journal of Operations Management*, Vol. 21 No. 2, pp. 129-149.

Sharma, G. (2017), “Pros and cons of different sampling techniques”, *International Journal of Applied Research*, Vol. 3, pp. 749-752.

Thakur, S.J., Bhatnagar, J., Farndale, E. and Aeron, P. (2024), “Human resource analytics, creative problem-solving capabilities and firm performance: mediator moderator analysis using PLS-SEM”, *Personnel Review*, Vol. 53 No. 7, pp. 1687-1709.

The Shingo Institute (2024), *The Shingo Model*, UT State University Press.

Ullah, P. (1991), “The psychology of TQM”, *Managing Service Quality: An International Journal*, Vol. 1 No. 2, pp. 79-81.

Van Assen, M.F. and de Mast, J. (2019), “Visual performance management as a fitness factor for lean”, *International Journal of Production Research*, Vol. 57 No. 1, pp. 285-297.

Van Assen, M.F. (2018), “The moderating effect of management behavior for lean and process improvement”, *Operations Management Research*, Vol. 11 Nos 1-2, pp. 1-13.

Van Dun, D.H. and Wilderom, C.P.M. (2016), “Lean-team effectiveness through leader values and members’ informing”, *International Journal of Operations and Production Management*, Vol. 36 No. 11, pp. 1530-1550.

Verissimo, C., Pereira, L., Fernandes, A. and Martinho, R. (2024), “Complex problem solving as a source of competitive advantage”, *Journal of Open Innsovation: Technology, Market, and Complexity*, Vol. 10 No. 2, p. 100258.

Woodside, A.G. (2013), “Moving beyond multiple regression analysis to algorithms: calling for adoption of a paradigm shift from symmetric to asymmetric thinking in data analysis and crafting theory”, *Journal of Business Research*, Vol. 66 No. 4, pp. 463-472.

Xie, X., Huo, J., Qi, G. and Zhu, K.X. (2016), “Green process innovation and financial performance in emerging economies: moderating effects of absorptive capacity and green subsidies”, *IEEE Transactions on Engineering Management*, Vol. 63 No. 1, pp. 101-112.

Yu, M. (2022), “CEO duality and firm performance: a systematic review and research agenda”, *European Management Review*, Vol. 20 No. 2, pp. 346-358.

Further reading

Hair, J.F., Anderson, R.E., Tatham, R.L., and Black, W.C. (2006), *Multivariate Data Analysis*, Prentice-Hall, New York, NY.

Corresponding author

Andrea Furlan can be contacted at: andrea.furlan@unipd.it