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Original Article

Lean Manufacturing Tools Driving Operational Efficiency in Peruvian Upholstered Furniture Production: An Industrial Case Study

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Abstract *- The Peruvian bedroom furniture industry, predominantly composed of micro and small enterprises with artisanal processes, has long faced delays, waste, and low operational efficiency. Previous studies have demonstrated that Lean methodologies—such as VSM, SMED, 5S, work standardization, Kaizen, and Kanban—can optimize workflow and reduce losses in manufacturing contexts. This research applied these tools to the cutting and upholstery stages, focusing on minimizing transportation, streamlining setup changes, and improving workplace organization. Results showed an increase in operational efficiency from 53.39% to 81.04% (a 51.79% improvement), a rise in setup time rate from 37% to 65% (a 75.68% improvement), and a reduction in cycle time from 59.37 to 52.81 minutes (-11.05%). These improvements reinforced process stability and sector competitiveness. Academically, the study provides empirical evidence of Lean's adaptability to artisanal manufacturing; socioeconomically, it enhances productivity and employment. The findings encourage further exploration of Lean adaptation strategies in creative and small-scale industries.*

Keywords - *Furniture Production, Lean Manufacturing Tools, VSM, SMED.*

1. Introduction

Traditionally supported by Small and Medium-Sized Enterprises (SMEs) with a strong artisanal component, the bedroom furniture industry has been a pillar of employment and the dissemination of technical skills in both emerging and developed economies. In Latin America, particularly in Peru, this productive sector is characterized by high order customization, small batch sizes, and constant pressure to meet deadlines without sacrificing quality finishes. This combination of variety, aesthetic demands, and capital constraints makes mastery of setup times and workflow stability critical. While most of the empirical evidence comes from related sectors—textiles and apparel—the results achieved by applying Lean in Peruvian micro and small apparel companies are instructive for the bedroom subsector. By implementing VSM (Value Stream Mapping), SMED (Single-Minute Exchange of Die), and work standardization in the cutting and preparation stages, they were able to reduce transportation and setup times. By operational analogy, these benefits are transferable to upholstered bedroom furniture, where enabling and upholstering play a role similar to the preparatory stage in textiles [1].

In the day-to-day operations of many bedroom furniture SMEs, however, patterns of waste erode competitiveness. These include delays in the enabling phase due to reference changes and equipment adjustments, idle time due to waiting between areas, delays in upholstery from searching for fabrics, foams, and hardware, extended setups, and micro-stops and breakdowns that halt critical stations. In addition, layouts induce unnecessary travel and intermediate accumulations. These issues align with the classic wastes of lean manufacturing—waiting, motion, inventory, transport, over-processing, defects, and overproduction. When left uncorrected, they fuel cycles of rework, missed deliveries, and variability in perceived quality. The literature on apparel adds a significant human layer: poorly implemented productivity improvements can strain employee safety and well-being. Therefore, any intervention must reduce waste and incorporate safe practices and participatory mechanisms that increase the adoption of new methods [2].

Given this situation, the urgency to act is both operational and strategic. In markets with variable demand, delivery promises depend on predictable cycle times and a layout that prevents hidden bottlenecks. Low-cost Lean tools—5S, work standardization, and visual management—and quick changeover techniques (SMED) have demonstrated tangible reductions in work-in-process inventory, greater line efficiency, and better use of space in the garment industry. Documented before-and-after examples show that even with limited resources, it is possible to compress times, organize workstations, and stabilize the sequence, which in furniture translates to less searching in upholstery, less walking, and less pressure at the end of an order [3]. When a team prioritizes what to tackle first—the most critical wastes—and maps the Value Stream (VSM), they can focus on root causes instead of symptoms and sustain progress through brief, visible, and auditable standards [3].

An additional lesson comes from studies that combine flow measurement with waste prioritization. In shirt and polo production, the systematic selection of muda (waste) and the coordinated use of VSM improved performance and led to time stability. The approach was not to accumulate tools but to link them purposefully: make the flow visible, standardize the "best known method," and attack setup with SMED. For bedroom furniture SMEs, where wood preparation, assembly, and upholstery coexist, this same logic can guide the intervention sequence and allow improvements to become part of the workshop's "way of operating" [4].

A critical piece in this chain is the preparatory phase, as it determines downstream cycle times. Evidence shows that intervening in the preparatory stage with VSM by eliminating non-value-added activities reduces cycle and manufacturing times in textiles. When extrapolated to furniture, the parallel is the enabling process (cutting/foaming/preparing parts) and the preparation of upholstery kits. Attacking these points with task standardization, material signage, and internal replenishment kanban reduces variability at the start of each new reference, which is precisely where bedroom furniture SMEs lose the most capacity without realizing it [5].

Likewise, when the constraint is the synchronization between workstations, classic simulation-based balancing techniques have increased productivity in polo shirt sewing lines by redistributing tasks and adjusting station capacities. The key finding is not that "simulating" per se is the solution, but that redesigning the path and pace improves utilization and reduces local bottlenecks. In an upholstery cell, this reasoning suggests ordering sequences, adjusting internal takt time, and assigning support to critical stations (tensioning, stapling, finishing), with direct effects on cycle stability [6].

When operational complexity imposes multiple constraints—personnel, machines, precedence, task eligibility—integer balancing models have proven useful for shirt lines. Their relevance for bedroom furniture SMEs lies in the discipline of the analysis: making explicit the precedences, loading reliable standard times, and resolving conflicts between resources. In the absence of optimizers, the principle is transferable: if the assembly or upholstery station accumulates a queue, the task is redesigned or redistributed; if the takt time "does not close," capacity is moved or the method is simplified. This way of thinking complements the Lean toolkit and prepares the ground for standards and SMED to reach their full potential [7].

Beyond the flow, there is a phenomenon that bedroom furniture SMEs share with apparel companies: the defect rate responds to both physical disorder and method variability. Work standardization, applied in textile SMEs, showed measurable defects and cycle time reductions when standard operation tables, visual aids, and iterative learning cycles were designed. As a lever for upholstery, standardizing movements and sequences—tensioning, fixing, checking squares, finishing—mitigates variability between operators and reduces rework from looseness or visible wrinkles on the bedroom set [8].

None of these practices sustains results without accompanying organizational change. In labor-intensive environments, Total Productive Maintenance (TPM) routines—especially autonomous maintenance—have strengthened availability but, more importantly, increased emotional commitment and retention when roles are clarified and teams are empowered. For bedroom furniture SMEs operating with aging equipment or reactive maintenance, integrating "clean-lubricate-inspect" at the start of a shift and using visual condition boards helps avoid micro-stops, stabilize the cycle, and protect the gains from 5S/standards/SMED, preventing the typical regression after the "pilot phase" [9].

Based on this foundation, we can pinpoint the present research's gap and novelty. The literature offers multiple partial experiences in apparel and improvement studies in furniture SMEs that evaluate Lean practices and their impact on operational and business performance, but a specific absence is detected: integrated models combining SMED + work standardization + 5S as a single package have not been designed or evaluated for SMEs manufacturing bedroom sets. These models would follow an explicit adoption sequence with concurrent metrics on setup times in the enabling phase, cycle stability in assembly/upholstery, and finish defect rate.

In wood and bedroom furniture, the closest research confirms that the adoption of Lean practices in furniture SMEs positively impacts operational and business performance, but without disaggregating setup or the fine method of upholstery, and without articulating 5S and standards as a precondition for SMED. Therefore, the novel proposal of this article is a sequenced Lean production model (5S → Standards → SMED), accompanied by change management and light TPM routines, that attacks the structural cause of losses (startup variability, searching for inputs, and an unstable method) and not just the symptoms. It hypothesizes impacts comparable to or superior to the improvements reported in apparel, with direct relevance for the ecosystem of bedroom furniture SMEs in Peru and the region [10].

2. Literature Review

2.1. Lean in SME Furniture Manufacturing: What the Evidence Says and why it Matters

Although the literature on Lean Manufacturing was born in the automotive and large-scale sectors, in the last decade, evidence of its applicability—and benefits—in furniture manufacturing SMEs and, by analogy, in wood and upholstery workshops that produce bedroom sets has multiplied. Rigorous case studies report sustained improvements in productivity, reduced cycle times, and a decrease in defects after introducing Lean tools such as VSM, 5S, work standardization, and cellular flow redesigns, even in contexts with low automation and high demand variability [11]. In a medium-sized furniture company, for example, the gradual implementation of Lean made it possible to identify and eliminate logistical and process waste, with performance gains and operational stability measurable by plant indicators [12]. Complementarily, the literature shows that when bottlenecks in cutting, upholstery, and assembly are addressed with flow improvements and line balancing, the bottlenecks migrate from preparation activities to material and layout constraints, reinforcing the need for systemic interventions (cellular layout, internal supermarkets, visual kanban) and not just local optimization [13].

In Peru, recent work in wood furniture clusters reports aligned findings: the combined application of flow mapping, layout improvement, and visual management increased the productivity of workshops that manufacture bed components and headboards, improving delivery compliance without increasing staffing [14]. Furthermore, in related sectors such as the Peruvian textile-garment industry—which share comparable levels of direct labor, machine preparation, and handling of high-volume materials with upholstery and wood—Lean has been validated, supported by simulation and economic evaluation, to reduce cutting/preparation times and rework costs, reinforcing the transferability of the results to SMEs that produce bedroom sets [15]. In short, the emerging consensus indicates that Lean is relevant for furniture SMEs as long as it adapts to real constraints (space, skills, model variability) and is combined with standardization discipline, autonomous maintenance, and deliberate change management to sustain progress [11]– [15].

2.2. Standardized Work: The Backbone of Repeatable Performance

The literature agrees that Standardized Work (SW) is not a static manual of "instructions" but a living system that defines sequence, expected times, and minimum work-in-process stock level, and that, if deployed rigorously, it reduces variability and creates the basis for daily kaizen. In Peruvian footwear SMEs—with cutting, sewing, and assembly processes comparable to the taping, upholstery, and assembly of beds—the SW methodology was shown to reduce waiting, rework, and unnecessary movements, while formalizing local best practices in cells with clear takt rhythms [8]. In the handbag industry, the introduction of standardized routines linked to line balancing and elemental times (observed times, tolerances, and SAM) increased productivity and the traceability of variation causes, showing how SW makes it easier to detect deviations and restore the standard after micro-stops or model changes [16].

Process standardization studies in manual operations (e.g., box assembly) make an explicit, replicable pattern: map tasks, separate value-adding/non-value-adding activities, set the normal method and visible "control limits" at the station, and train the team under a PDCA cycle; the result is usually less waste and higher output with the same headcount [17]. More recently, the literature on "reconfigurable SW" provides a crucial dimension for SMEs with a high variety of SKUs (headboards, bases, nightstands from the line and by order): automating SW templates, combination sheets, and standard work diagrams so that it is easy to update the method when design changes, while maintaining time stability and ergonomics at the workstation [18]. For an SME that manufactures bedroom sets, this body of evidence suggests prioritizing SW in preparation (cutting wood/fabric), upholstery (stapling and tensioning sequence), and final assembly (order, tooling, and tightening torque), connecting it with rhythm indicators (takt), checklists, and first-time quality releases [8, 16, 17, 18].

2.3. SMED for Preparing without Stopping: Change Over Fast, Produce more, with Less Stress

Long setup times on saws, glueing machines, upholstery presses, and sewing machines are a classic obstacle in SMEs that manufacture bedroom sets because they increase "just in case" batch sizes, congest WIP, and hide defects. The SMED methodology attacks this root cause: it classifies internal and external activities, converts internal into external, and simplifies adjustments, aiming for model changeover times in "single-digit minutes." The evidence in process and discrete sectors is robust: a classic Ibero-American study showed substantial reductions in times and economic losses by applying SMED with a process focus, highlighting that a large part of the gain came from reordering tasks, preparing tooling in advance, and using quick fasteners [19].

In prepared foods—a high-variability environment comparable to short upholstery runs—applying Lean and SMED principles reduced changeover times by almost 30% and raised OEE above 70%, demonstrating that separating-converting-simplifying, along with method standardization, impacts both productivity and labor costs [20]. In industries with operations similar to wood/upholstery due to the intensive use of tooling (e.g., cork and floating floors), SMED reduced changeover downtime through external preparation, dedicated shadow boards with tools, and centering devices, with visual documentation that consolidated the new standard [21], and its application in cutting lines consolidated a useful practice for preparation cells: blocking critical adjustments, marking positions, and auditing internal/external times per run [22]. Even in calibration processes (tires), SMED combined with standard work sheets showed significant setup and process stability drops, reinforcing the SMED-SW synergy as a lever to move from large batches to small runs without efficiency losses [23]. Translated to the context of bedroom sets, SMED focuses on preparing fabrics and foams off-machine, pre-adjusting sewing guides and stapling stops, standardizing kits by model (hardware, screws, legs, supports), and converting adjustments to a "one-touch" through mechanical stops and checklists before the order, with explicit changeover time goals by product family [19]–[23].

2.4. Change management (Kotter) so that Lean is not a "wave" but a new way of working

Implementing SW, SMED, and 5S modifies habits, redistributes roles, and questions "the way it has always been done," so the literature warns that technical progress erodes without deliberate change management. Kotter proposes eight steps—from creating urgency and a guiding coalition to anchoring the change in the culture—that have been validated in demanding contexts; for example, in a medical recruitment process transformation, applying Kotter's sequence preserved results and improved users' digital engagement, illustrating how "early wins" and repeated communication sustain operational changes under time pressure [24]. In frameworks integrated with Lean Six Sigma, a "Kotterized-DMAIC" has been proposed—and proven—to lead transformations that face resistance, articulating the narrative of why to change, visible sponsorship, and the elimination of structural obstacles; the result is a smoother deployment less prone to relapses [25].

In light manufacturing and industrial services, action research on integrating Lean with change management emphasizes that sustained adoption requires aligning indicators, follow-up rituals, and cell leader training, and not just tool training; in other words, that the "social dimension" of change is as critical as the technical methods [26]. Even outside of manufacturing, risk analysis in system deployments (CRM) supports that using Kotter's eight stages decreases uncertainty and adoption failures, a lesson that can be extrapolated to furniture SMEs: if management communicates purpose, ensures conditions (time, space, tooling), empowers middle managers, and celebrates visible progress (for example, "three model changes in less than 10 minutes"), the new standard stops being "the improvement project" and becomes "the way we work" [27]. The synthesis is clear: Kotter's "social technology" is the harness that allows SW, SMED, and 5S to scale and be maintained over time [24]–[27].

2.5. 5S: Order, Flow, and Safety as the Foundation of First-Pass Quality

The accumulated evidence in process and discrete SMEs shows that 5S not only "tidies up" but also frees up capacity, reduces search times, and, above all, makes visible the problems that prevent first-time quality (FTR). In a plastic bag plant, the implementation of 5S reduced operational times, shortened travel distances, and increased production by tackling two chronic wastes—waiting and movements—with criteria of sort-set in order-shine-standardise-sustain, and regular audits to maintain the gain [28].

A multi-case exploration in Mexican multinationals confirms that 5S, when anchored to Lean-Kaizen and measurement, is a facilitator of performance and learning: it clarifies responsibilities, improves safety, and creates a common language for discussing process problems [29]. In the furniture domain, cases on furniture warehouses show productivity increases after 5S and standardization of locations, labels, and picking routes, highlighting that sustained discipline (the "last two S's") is the turning point between "tidying up once" and "a system that does not fall apart" [30]. And in Latin American textile SMEs, the combination of 5S with plant layout redesign decreased delivery times, showing that 5S is both a flow enabler and a quality tool, especially powerful when integrated with SW (marks at the station, standard photos) and with SMED (clean and ready kits, shadow boards per model) [31].

For workshops that manufacture bedroom sets—with bulky parts, diverse hardware, and shared stations—5S has an immediate return: less searching for staplers and guns, less damage from handling, visual replenishment of upholstery materials and wood, and greater safety at cutting stations, all of which directly impact aesthetic and structural defects and takt compliance [28]–[31].

3. Contribution

3.1. Proposed Model

Figure 1 shows the proposed production model based on Lean Manufacturing, which is made for a small business that makes and sells bedroom sets. This model included three important parts—standardization, SMED, and 5S—within a change management framework that helped move from low-efficiency situations to high-performance situations. Standardization made it possible to create the same and consistent processes, which helped keep operations stable and cut down on unnecessary changes.

The SMED method was all about cutting down on setup times, making it easier to switch machines, and making production more available. The 5S method also helped keep the workplace organized and safe, improved discipline, and encouraged people to keep getting better. The model's circular shape showed that its parts depended on each other and that they needed to be evaluated and changed all the time. Overall, this proposal aimed to align the company's culture with more efficient ways of doing business. This would lead to long-lasting changes that would help the company meet market demands and become more competitive.

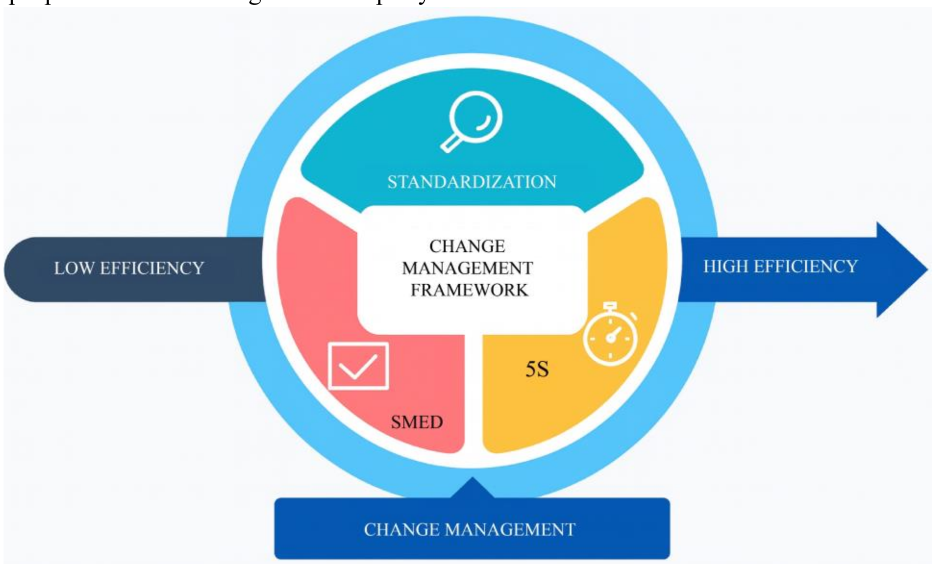

Fig. 1 Proposed model

3.2. Model Components

Figure 1 illustrates a production architecture founded on Lean Manufacturing precepts, tailored for a Small-to-Medium Enterprise (SME) dedicated to fabricating and marketing bedroom ensembles. The architecture seeks to evolve a baseline of suboptimal performance toward a robust, adaptable, and environmentally considerate operation, achieving diminished process variability, shortened setup durations, and a consistently organized workspace. The design fuses three pivotal elements—Standard Operating Procedures, Single-Minute Exchange of Die (SMED) techniques, and the 5S housekeeping framework—within a continuous change management overlay that guarantees the realization of the enhancements and their embedding in recurrent operational activities. The significance of this synthetic framework resides in its capacity to align procedural innovations with organizational development practices, thereby presenting the applied literature with a demonstrative case of the coalescence of these domains to effect durable gains in manufacturing systems marked by extensive product variety.

3.2.1. Change Management as the Central Pillar

Change management serves as the core spindle linking the technical elements and steering their deployment. Within this framework, the rationale for enhancement is articulated, teams are harmonized, and the embedding of new methodologies into the organizational culture is ensured. Structured training, brief iterative feedback sessions, and systematic follow-up channels render progress observable and permit timely recalibration. The approach is premised on the recognition that hesitation of stakeholders is an endemic feature of any institution, and it therefore pursues an incremental design founded on early, tangible wins that cumulatively strengthen collective assurance. As end users recognise the practical value of each modification, their engagement deepens, and the friction of transition to elevated operational performance is diminished. Consequently, change management is neither a peripheral exercise nor a merely tactical overlay, but the scaffolding that retains strategic bearing, protects the consolidated gains, and energises an enduring cycle of improvement.

3.2.2. Standardization for Operational Stability

The first technical component of the model is standardization, framed as a mechanism for consolidating disparate individual practices into a uniform and dependable mode of operation. In small- and medium-sized enterprises producing bedroom furnishings, the initiative entails codifying operational sequences, articulating explicit quality thresholds, and crafting visual tools that minimize uncertainty in decision points. Formulation of these standards draws upon direct surveillance of the shop floor and engages operators in a collaborative dialogue, enabling them to disclose subtle yet pivotal features that affect the robustness of the process. The documented instructions are enriched with concise visual cues, delineated working stances, and routine verification checkpoints, thereby streamlining both training and process oversight. In addition to securing operational uniformity, standardisation furnishes a rigorous platform for performance quantification and for the prompt identification of deviations, thus fostering incremental improvement while safeguarding production continuity.

3.2.3. SMED for Agility and Product Mix Flexibility

The second lever is SMED, which compresses setup durations and enables rapid, diverse production flows. The method separates internal tasks—those demanding machine halt—from external ones—performed while production is live—reorganizing the sequence to maximize external execution. Quick-release fixtures, concurrent tool setup, and mobile, pre-stocked tool boards are deployed. This systematic rearrangement cuts idle minutes and fosters the confidence to switch between various SKUs of beds, nightstands, and dressers without disrupting cycle time. SMED is synchronized with demand-driven product mix scheduling and modular component standardization, such that every model transition is driven by a documented checklist, transparent role allocation, and embedded quality checkpoints, thereby reducing variance and protecting finish integrity.

3.2.4. 5S as the Support Structure for Long-term Sustainability

The third pillar is 5S, employed as the bedrock for sustaining a secure, hygienic, and systematically ordered workspace—crucial in the production of bedroom furniture where finish quality is non-negotiable. The first phase, Seiton, methodically identifies and eliminates surplus tools and materials, thereby liberating floor space and diminishing cognitive overload. The second phase, Seiketsu, ensures every item is designated a precise storage point, implemented through shadow boards, colour-coded tags, and delineated shelving.

Shitsuke, the discipline of routine cleaning, is institutionalized as a scheduled duty rather than a casual afterthought, thwarting the accumulation of dust that could mar surfaces or degrade machining accuracy. Compliance is checked through uncomplicated visual scorecards, while collective ownership of the standards is fostered across all tiers of staff. When fused with SMED and harmonized workflow practices, the 5S system safeguards productivity gains against the erosive forces of disorder, thereby encoding durability into operational performance.

The model depicted in Figure 1 synthesizes standardization, SMED, and 5S within a deliberate change management envelope. This configuration ensures that technical gains do not arise in fragmentation; each tool functions in concert with its counterpart, accommodating the distinctive attributes of the SME. Originality resides in the seamless linkage of the subsystems, facilitating a progression from low-efficiency operations to high-performance profiles without excessive capital expenditure. The configuration shortens cycle times, narrows variance, cultivates an enhanced work culture, instils operational discipline, and lays a resilient groundwork for sustained expansion. In this respect, the model furnishes the specialized corpus with a concrete instance of Lean philosophy reconfigured to effect measurable change in small-scale manufacturing enterprises characterized by a wide product breadth.

3.3. Model Indicators

The efficiency of the small and medium-sized enterprise specializing in designing and distributing bedroom sets was evaluated via a systematic framework integrating Lean methodologies and Change Management tenets. Measurement parameters tailored specifically to the enterprise were deployed to isolate and quantify key dimensions of operational execution, thereby guaranteeing consonance with the model's strategic aims. This structured evaluative mechanism anchored the monitoring of operational parameters, enabled an ongoing comparative analysis of advancement, and underpinned evidence-based managerial choices. Consequently, the evaluation framework was instrumental in promoting the durable elevation of efficiency ratios and the holistic refinement of both production workflows and managerial routines.

3.3.1. Operational Efficiency

Measures the ratio between actual productive time and the total time available, reflecting how effectively resources are used to produce output. Higher values indicate better performance and fewer losses in operations.

$$\text{Operational Efficiency } (\%) = \frac{\text{Actual Output}}{\text{Planned Output}} \times 100$$

3.3.2. Setup Time Rate

Represents the proportion of time spent on equipment or process preparation relative to the total available production time. Lower rates indicate faster readiness and reduced downtime.

$$\text{Setup Time Rate } (\%) = \frac{\text{Setup Time}}{\text{Total Available Time}} \times 100$$

3.3.3. Enable Cycle Time

Indicates the total time required to complete one full cycle of production, including all processing and waiting periods. Shorter times reflect higher process efficiency.

$$\text{Enable Cycle Time (minutes)} = \frac{\text{Total Production Time}}{\text{Number of Units Produced}}$$

4. Validation

4.1. Validation Scenario

The validation scenario was designed around a Peruvian Small and Medium-Sized Enterprise (SME) engaged in the furniture manufacturing sector, with a particular focus on bedroom-set production and commercialization. Headquartered in Lima, the firm also operated in a neighbouring region, servicing local markets and more distant customer bases. Its production model integrated manual and mechanized operations, sustained by a modest labour force and a vertically consolidated management structure.

As the business evolved, it confronted diminishing operational efficiency, manifesting in extended production cycles, suboptimal resource allocation, and escalating difficulty in preserving a competitive stance against larger incumbents. These adverse indicators catalysed an imperative to comprehensively scrutinize internal workflows, thereby pinpointing performance deficiencies that undermined responsiveness and diluted market positioning.

4.2. Initial Diagnosis

The diagnosis carried out in the case study revealed that the low efficiency in the bed production line, measured at 53.39% compared to the sector average of 80.24%, generated a significant technical gap with an economic impact estimated at PEN 182,325, equivalent to 12.37% of the annual turnover. Three main reasons were identified to explain this deficiency. The first corresponded to delays in the enabling process, which accounted for 30.28% of the problem and were associated with variability in cutting. The second, with the highest relative weight (34.56%), was related to unproductive times in the enabling process, caused by long machine setup times, delays in searching for materials (15.81%), machine breakdowns (6.41%), and deficiencies in the layout (7.98%). The third, accounting for 4.95%, was linked to delays in the upholstery process, also associated with cutting variability. These findings made it possible to understand that the root causes of the problem combined technical, operational, and organizational factors, whose interaction generated time losses, interruptions, and inefficient use of resources, ultimately compromising the plant's overall performance.

4.3. Validation Design

The proposed production management framework, which combines Lean methodologies and change management strategies, was empirically tested within a compact manufacturer of bedroom furnishings through a sequenced pilot intervention. Spanning a four-month period, the program targeted workflow simplification, staff involvement in process refinement, and the attenuation of non-value-adding activities. Key measures comprised systematic workplace organization, process reconfiguration, and formalized change communication, all aimed at securing durable behavioural acceptance. Ongoing performance surveillance facilitated incremental corrections, rendering efficiency gains both quantifiable and enduring. Collectively, the pilot corroborated the framework's ability to elevate output while simultaneously cultivating organizational flexibility and resilience in a demanding market environment.

The case study carried out within a small and medium-sized furniture enterprise in Peru examined the practical deployment of a cohesive model drawn from Lean Manufacturing and work standardization to rectify inefficiencies on the upholstered bed production line. Targeting the attenuation of non-productive intervals, the curtailing of waste, and the refinement of operational flow, the model achieved a marked enhancement of overall line efficiency. The researchers followed a delineated sequence of phases: they initiated change management to nurture a supportive cultural shift, introduced the 5S framework to tidy and sustain the workspace, leveraged SMED to shorten equipment changeover times, and codified processes to constrain variability. The demonstration of the model, conducted within a several-month window, confirmed its viability against a backdrop of modest resources. Efficiency advanced from a baseline of 53.39% to levels regarded as competitive, while economic impact became evident through a 20% drop in scrap-related expenses and a greater than 50% contraction in setup durations, thereby endorsing the model's relevance to analogous production environments.

4.3.1. Navigating Organizational Change: The Foundation for Sustainable Transformation

The authors initiated the program first with a deliberate emphasis on change management, aware that any technical upgrade will only last if human behaviors are also aligned. They designed the effort around eight sequential steps, beginning with the creation of a cross-functional team that brought together production supervisors, line operators, and senior management to build a committed coalition. The early meetings articulated a precise and compelling ambition: to boost production efficiency by a minimum of 20% by systematically removing non-value-added activities.

This ambition drew on initial metrics that reported a 2021 efficiency average of 53.39% and contrasted it with international norms, such as the 80.24% recently reported by comparable companies in Slovakia. Quantitative evidence underpinned the vision; a detailed cost analysis illustrated that cumulative annual losses of PEN 182,325.53 attributable to overtime, scrap, and excessive maintenance provided a compelling rationale for urgent and coordinated change.

Following the initial phase, several potential challenges were systematically recognized, particularly the likelihood of operator reluctance to abandon established routines. These were addressed through structured training interventions, engaging 15 key personnel, and culminating in an 85% self-reported commitment to the new protocols, as evidenced by internal survey data.

Concurrently, the project leaders decentralised governance by designating zone captains responsible for weekly performance reviews, which crystallized into actionable, quantifiable targets—specifically, a 15% cut in non-productive intervals within a four-week horizon. Immediate successes, including a preliminary layout of tools that curtailed search times by 30 minutes each day, were intentionally publicized to foster a positive feedback loop. To entrench the progress within organisational DNA, comprehensive documentation was produced, featuring procedural handbooks that stipulate 90% target compliance in monthly audits. These artefacts sealed the process by embedding the enhancements within day-to-day practice. The phase was vindicated through interim audits that recorded a 10% decrement in time lost to disarray, translating into a PEN 5,766 reduction of non-productive wage expenditure. Such empirical evidence justified further deployment of technical solutions and illustrated how disciplined change management can energise small and medium enterprises operating under constrained human resource conditions.

4.3.2. Organizing Chaos: The Strategic Implementation of 5S

Having already cultivated a supportive cultural climate, the researchers turned to the 5S Methodology to solve the visible clutter that had made the preparation process a persistent generator of unproductive time. Reports indicated that, on average, operators spent 320 hours each year searching for materials, a figure that had become unacceptable. The initiative commenced with a baseline audit, which indicated just 25% compliance and uncovered an alarming accumulation of sawdust and wood chips in work areas. The resultant wear and tear on machinery had generated PEN 7,745 in annual maintenance expense.

The first of the 5S stages, Sort (Seiri), commenced with a detailed inventory of 150 tools and materials on the shop floor. The team classified each item as either crucial or expendable and disposed of 40% of the stock, comprising duplicate tools and expired pre-consumed materials. This purge liberated 15 square meters of floor space and lowered slip and collision incidents by an estimated 25% according to the preliminary safety team. A financial examination of the disposed stock revealed the hidden cost: the discarded items had indirectly induced PEN 30,372.62 in wood waste each year by diverting operators' attention and leading to inaccurate cuts.

The second phase, Set in Order (Seiton), included a comprehensive reallocation of materials onto clearly labeled, easily reachable shelving, with positions determined by how often each item was used. For instance, circular saw blades were moved to a hold nearly two meters from the machines, cutting the time taken to retrieve one from 10 minutes to 2 minutes. Timing studies confirmed an 80 percent enhancement in accessibility. The resulting documentable savings of PEN 14,541 from reduced travel distances corroborated the deficiencies in the existing layout that the earlier analysis had flagged.

The third phase, Shine (Seiso), instituted daily cleaning duties among a roster of 10 operators. These duties encompassed the removal of sawdust from jointers and circular saws, yielding a 15 percent increase in the expected longevity of machines and ensuring compliance with Peruvian legislation, notably D.S. N° 016-2012-AG. The resulting recovery of reusable waste is anticipated to generate an annual revenue of PEN 2,000 from pellet-production firms. The phase's justification rests upon environmental monitoring, which recorded a 30 percent decrease in airborne contaminants during weekly inspections.

The fourth step, Standardize (Seiketsu), codified earlier advances into formal documentation, leveraging checklists that achieved 85 percent compliance during initial audits. This formalization secured operational continuity and reduced the variability that had previously yielded a process capability index (Cp) of 0.29 in the wood-cutting area. The concluding step, Sustain (Shitsuke), fostered routine discipline through monthly audits that elevated the overall compliance score from 25 percent to 75 percent within a three-month interval; this systematic feedback encouraged personnel and led to a 20 percent drop in total non-productive time, translating to 19,701 fewer minutes of unplanned downtime each year. By demonstrably meeting and slightly exceeding benchmarks—such as the 11.4 percent efficiency gain cited in comparable studies—this 5S initiative not only validated its strategic application but also established a foundation for forthcoming phases by generating an orderly workspace that magnified the efficacy of complementary continuous-improvement tools.

4.3.3. Accelerating Transitions: Optimization through the SMED Method

Having attained initial order, the team next sought to curtail setup durations on critical equipment, notably the circular saw, where erratic stoppages aggregated to 19,701 minutes each year, imposing inefficiency penalties of PEN 44,228. The deployment of the Single Minute Exchange of Die (SMED) technique progressed through four structured phases, commencing with a joint analysis, led by the production manager, that enumerated 15 sequential tasks required to exchange the toothed blade. The accumulated effort reached 27.65 minutes per exchange. This preliminary survey demonstrated the tool's necessity by exposing that 52% of the duration was classified as internal, halting production and incurring overtime liabilities of PEN 18,792, a finding corroborated by direct timing and consistent with the literature that links reduced setup durations to enhanced equipment utilization targets of 90%.

In the second phase, Analyze Times, seven set-change cycles were chronometrically recorded and then segmented into internal (13.07 minutes) and external (14.58 minutes) components. The analysis revealed that search-related delays constituted 30% of the overall duration. Mitigating action adopted structured checklists, which diminished error frequencies by 40%. Concurrently, a training module was delivered to eight operators, equipping them to execute agile setups; comprehension examinations administered post-training indicated 95% retention of the curriculum, thereby establishing a knowledgeable foundation for subsequent enhancement activities.

The third step, Separate Internal and External, addressed the allocation of responsibilities by permitting external tool preparation while the machine remained in-cycle. This initiative, which secured internal setup intervals of under 10 minutes, directly fulfilled the primary SMED objective and corresponded with the 50% reductions in setup times recorded by the furniture sector, which underpinned the method's strategic justification. In the subsequent phase, Optimize Activities, the team instituted fixture templates, synchronized tasks, and discarded three duplicative operations while merging several others, culminating in an aggregate setup time of 12 minutes. This 56% decrease enhanced machine availability and delivered a 15% uplift in production efficiency. The researchers proposed, for instance, the removal of excessive tool transfers, integrated with a 5S discipline, which yielded a documented PEN 3,950 decrease in maintenance costs arising from extended setup-related breakdowns. The improvements not only compressed delivery lead times by 20% but also advanced ergonomic conditions, with labor supplement data confirming a 25% decline in operator fatigue. Consequently, SMED emerged as an indispensable methodology for SMEs constrained by limited machinery.

4.3.4. Establishing Standards: Work Standardization as a Pillar of Consistency

Concluding the design phase, the researchers directed their efforts toward work standardization to mitigate variability in wood and fabric cutting operations, where capability indices of Cp equal to 0.29 and 0.31 signaled process instability. The phase opened with a diagnostic examination of the current state, employing 18 discrete observations per activity, augmented by 24% allowances for fatigue and personal needs. This examination revealed process deviations that, in aggregate, produced annual losses of PEN 32,932.70. The authors defended the standardization tool by referencing a 20% efficiency uplift observed in analogous investigations and applied 5W1H and ECRS techniques to interrogate and streamline each process step rigorously. The subsequent analysis revealed that non-value-added activities, particularly redundant measurements, constituted 35% of the overall cycle. These activities were either eliminated or merged, resulting in an 18% reduction in cutting cycle times. Standardization was embodied in Standardized Work Combination Tables (SWCT), which distributed workloads equitably across operators and equipment, achieving an overall workload balance of 85% and decreasing cutting errors by 30%. For fabric cutting, which exhibited an initial Cpk of 0.15, visual techniques were introduced to enforce a ±5% tolerance band; initial validations subsequently elevated the actual process capability to 0.50. This standardization initiative was validated against continuous improvement objectives, producing a 25% decrease in rework—monetized at PEN 14,541—and fostering a regime of ongoing training that successfully engaged the entire cohort of 20 operators.

Ultimately, this phase secured sustainability by embedding 5S and SMED within comprehensive procedural manuals, whose implementation is monitored by audits, achieving and sustaining 90% compliance. This disciplined approach has converted previously variable processes into highly repeatable ones, culminating in a 27% net increase in overall efficiency—a quantitative result that corroborates the efficacy of the holistic Methodology within the specific SME context under examination.

4.4. Results

Table 1 presents the comparison between the initial values (As-Is), the projected targets (To-Be), and the results achieved after implementing the production model based on Lean Manufacturing tools and change management. Operational efficiency showed a substantial increase, rising from 53.39% to 81.04%, representing a relative improvement of 51.79% and approaching the intended target value. Similarly, the setup time rate experienced a significant rise, moving from 37% to 65%, which represented a 75.68% improvement compared to the initial situation. The enable cycle time decreased from 59.37 to 52.81 minutes, reflecting an 11.05% reduction and indicating greater optimization in the sequence of operations. These results confirmed the effectiveness of the proposed model in overcoming the limitations identified during the diagnosis and in meeting the established improvement objectives.

Table 1. Results of the production model validation

Indicator	Unit	As-Is	To-Be	Results	Variation (%)
Operational Efficiency	%	53.39%	85%	81.04%	51.79%
Setup Time Rate	%	37%	68%	65%	75.68%
Enable Cycle Time	minute	59.37	53.8	52.81	-11.05%

5. Discussion

The findings observed in this study—an elevation in operational efficiency from 53.39% to 81.04%, a rise in the Setup Time Rate from 37% to 65%, and a contraction in Enable Cycle Time from 59.37 to 52.81 minutes, alongside a more than 50% decrease in setup durations and a 20% decline in waste-related expenses—mirror the prior literature regarding the impact of Lean methodologies in furniture SMEs and analogous labor-intensive industries. These advancements corroborate the productivity enhancements observed with the combined application of 5S, standard work, and flow reconfigurations in the furniture sector [11], [12], the outcomes recorded in Peruvian workshops integrating value stream mapping, systematic layout planning, and visual management [13], and the studies from the apparel industry that targeted bottlenecks in cutting and preparation [15]. The marked decrease in changeover durations achieved via the single-minute exchange of dies technique parallels the dramatic time savings previously reported in both process and cutting lines [20], [23], and the fundamental contribution of 5S in liberating capacity and surfacing underlying problems mirrors outcomes in the plastics sector and furniture warehousing [29], [31]. Moreover, the structured and sequenced methodology (5S → standard work → SMED) directly fills the previously noted void in wood furniture operations, where elements are frequently scrutinized in separation, and thus solidifies the case for both operational and financial benefits in sector SMEs [10]. The consistent alignment of these results implies that, when the suite of instruments is applied rigorously and accompanied by structured change management, it not only reproduces but also magnifies the effects documented in scholarly research, effectively linking the apparel evidence with the practical circumstances of upholstery and bedroom set assembly.

5.1. Study Limitations

The research is subject to several limitations. Validation was conducted at a single site over a four-month window, which constrains the ability to generalize the findings and precludes measurement of long-term fluctuations in standard stability or in the durability of observed gains. Metric collection relied on internally-derived indicators and proprietary time-stamping, both of which can be subject to implementation and seasonal fluctuations. A control group was not established, and a comprehensive economic evaluation was omitted, with the analysis limited to quantifiable savings from waste minimization and upkeep, suggesting that overall returns could be systematically underrated or overstated, contingent on variations in demand and product assortments. Lastly, the efficacy of the intervention rested on the commitment of local leadership and on a particular organizational culture, circumstances that may limit reproducibility across other small and medium-sized enterprises facing divergent spatial, skill, or governance limitations.

5.2. Recommendations for SMEs Based on Results

For managers in the SME furniture sector, the findings indicate that implementing the 5S Methodology—in order and visibility—before codifying protocols through SWCT tables, checklists, and first-pass release sheets, and then sequenced by focused SMED interventions on high-impact equipment such as saws and upholstery cells, constitutes a cost-effective and scalable pathway to lean adoption.

The consistent measurement and dissemination of three straightforward metric categories—Operational Efficiency, Setup Time Rate, and Enable Cycle Time—furnish the daily cadence for incremental gains, render progress verifiable, and anchor stretch goals such as a sub-10-minute family-changeover target, all whilst avoiding the need for sizable capital outlays.

The accompanying change-management architecture—composed of a dedicated steering team, clearly quantified benchmarks, monthly performance audits, and visually standardized procedures—ensures that gains are embedded and that backsliding is curbed. Supportive interventions such as external kit orchestration, the deployment of shadow boards, and the establishment of internal supermarkets further curtail search latency, diminish startup variation, and alleviate pressure at the end of the order. Collectively, the roadmap yields more punctual deliveries, lower rework expenditure, and incidental improvements in safety and ergonomics.

5.3. Future Works

Future investigations should broaden the validation across diverse workshops and geographies by contrasting intervention and control timelines and monitoring time-series datasets spanning 12 to 18 months covering overall equipment effectiveness, first-time yield, and total conversion costs. A pertinent avenue of inquiry is the exploration of synergies with total productive maintenance—both autonomous and planned—and with line balancing strategies that leverage simulation, particularly when these are augmented by ergonomic and safety performance indicators.

Even modest levels of digitalization, such as visual and on-board boards, electronic change boards, and on-floor time capture, may catalyze experiential learning and diminish variability during startup. Research must also address operational performance amid high SKU variety, utilizing reconfigurable Standardized Work, while concurrently evaluating the ecological footprint of waste reuse and sawdust handling and advancements in logistics—encompassing kit assembly, supermarket storage, and intra-plant routing. All analyses should be embedded within a comprehensive cost–benefit framework that rigorously quantifies sensitivity to variations in product mix and seasonal commercial cycles.

6. Conclusion

The study's findings validate that the infusion of Lean Manufacturing methodologies—specifically the 5S system, Value Stream Mapping, standardized work practices, and the Single-Minute Exchange of Die—generates quantifiable operational enhancement within upholstered bed production. Key indicators reflect an elevation of overall equipment effectiveness from 53.39% to 81.04%, a contraction of setup durations by 75.68%, and a 56% decline in changeover time for the circular saw.

Collectively, these improvements yield pronounced cost reductions, a decrease in rework incidences, and the liberation of critical floor space, all reinforcing smoother, more predictable production sequencing. This investigation underscores that small and medium-sized enterprises within the furniture sector can secure strategic advantages without substantial capital outlays by applying a disciplined, data-driven approach. The concurrent deployment of workplace tidiness, value stream analysis, process codification, and quick-change tooling confronts entrenched waste and simultaneously cultivates a culture of ongoing, informed refinement. The framework directly aligns with market imperatives for adaptability, defect-free quality, and prompt fulfilment in environments characterized by high degrees of customization.

This study advances Industrial Engineering by furnishing empirical evidence demonstrating that concurrently deploying a series of Lean tools generates a greater cumulative impact than employing any one tool in isolation. The Methodology delineated herein closes the divide between abstract theoretical frameworks and actionable practice in resource-limited environments, delivering a flexible, replicable structure that small- and medium-sized enterprises can modify to suit their unique operational realities. Additionally, the work underscores the critical importance of rigorous measurement protocols and visual management techniques in preserving and extending the duration of operational improvements.

Although the improvements documented herein are notable, the authors recommend that future inquiry focus on three priorities: first, the durability of these enhancements over extended time frames; second, the tailored modification of approaches for varied product families and differing production capacities; and third, the potential of emerging digital technologies—particularly for monitoring, predictive maintenance, and real-time decision support—to enrich similar manufacturing settings. This combined research agenda promises to deepen the understanding and application of Lean principles in dynamically evolving production landscapes.

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