Production Management Model Based on Lean Manufacturing and Change Management Aimed at Reducing Order Fulfillment Times in Micro and Small Wooden Furniture Companies in Peru

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Abstract. This research study seeks to identify and prioritize the causes of order fulfillment delays in a small wooden furniture manufacturing company. The authors propose a 5-phase Lean Optimization model to address and reduce this problem. Post-implementation results yielded a 54.87% reduction in material search and transportation times, a 32.86% reduction in travel times between stations, and a 19.81% increase in line efficiency. In addition, order fulfillment percentages increased from 12.5% to 60%.

1. Introduction

Around the world, the wooden furniture industry is the second most important business activity in wood product manufacturing, of which China is the leading producer with a 41% global market share, and Latin America only reports a 3% market share. In addition, furniture accounts for only 0.7% of the total foreign trade in the world, amounting to US $134 billion [1]. Regarding Peru, although sector production has been increasing in recent years, this activity only contributes 1%–2% on an average to the non-primary goods GDP and between 0.2% and 0.3% to the total national GDP [2]. Likewise, neither the wood industry nor the furniture industry is sufficiently developed in Peru. In fact, about 97% of the furniture industry is traditionally family-owned, using artisan methods and characterized by limited technological progress and low dissemination of production techniques [3]. This situation directly affects competitive levels against other countries for this sector. For example, according to a study that assesses the competitive profile of the wooden furniture industry, Peru exhibits a low competitive level in terms of improving production processes and lines, thus evidencing a disadvantage against top reference countries such as China, Brazil, and Chile [4]. Therefore, micro and

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small wooden furniture companies usually lack the productive development required to adequately meet the order fulfillment deadlines requested by their customers.

The wooden furniture industry, with a 78% market share in the wood manufacturing sector, represents one of the industries with higher added value within the wooden products currently moved in the Peruvian market. In addition, 44% of the entire wooden furniture production industry in Peru is in the city of Lima [4]. Further, this industry accounts for 47% of the employment generated in the wood manufacturing sector, being able to generate approximately 700,000 jobs [5]. However, this industry, despite having a vast amount of forest resources available (78 million hectares), imports more wood products than it exports, thus generating a trade balance deficit and making this sector’s inability for meeting internal demands evident [6]. Likewise, in exports, Peru is surpassed by other countries with fewer timber resources, such as Chile, which exports 31 times more wood products than Peru [4]. Consequently, the combination of a small-scale production, the limited response capabilities against large orders, and the need for change within the organizational core of the different micro and small companies that comprise the sector renders Peru unable to position itself as a prominent power in South America and the rest of the world in terms of wooden furniture production. Therefore, it becomes a competitive market. For these reasons, the improvement of processes and production lines in micro and small wooden furniture companies to reduce order fulfillment times through efficient production techniques is the first step toward fostering sector development and growth.

The underlying motivation of this project is to generate a viable and functional model by integrating change management with different lean manufacturing tools adapted to the productive environment of the micro and small wooden furniture companies in Lima, Peru, which is aimed at efficiently solving order fulfillment delays as per the needs of the sector. Furthermore, this research study seeks to prove the effectiveness of combining two approaches, such as lean manufacturing and change management, for reducing order fulfillment times in micro and small wooden furniture companies.

This paper is divided into the following sections: introduction, state of the art, contribution, and validation and discussion. Finally, the paper denotes the conclusions from the research study and lists all the references consulted.

2. State of The Art

2.1. Production Management Models Based on Change Management

The change management model proposed by John Kotter is often used as a catalyst for steering efforts throughout change adaptation in an organization. However, some research studies underscore that positive results depend on the scope defined for the tool, the interactive communication among staff members, and the strategic approach proposed [7][8]. In turn, these studies also argue that this tool exhibits high levels of effectiveness at multiple management levels within a company, as long as it is supported by leadership and organization techniques [9]. Additionally, this tool is mostly used for maximizing impacts from the results and steering the project toward establishing permanent changes over time, whether small or large, thus guaranteeing successful transformation of the services, productive resources, and staff members of the organization [8][9]. Nevertheless, in some cases, changes can be successful even when model steps and sequential order are bypassed [10].

2.2. Production Management Models Using Lean Manufacturing

Some studies that focus on the application of lean manufacturing tools propose an improvement plan to reduce clutter and disorganization in micro and small companies with the purpose of increasing production, organizing workstations, reducing time spent searching for tools, and reducing preparation times [11][12]. Likewise, other authors argue that lean manufacturing can also be applied to optimize SME plant layouts and reduce travel distances between workstations, eliminate bottlenecks, and generate a continuous production flow. For this, manufacturing cells must first be designed on the basis of production process flows before their application according to the result obtained [13].
Other studies report that lean manufacturing tools have yielded successful and effective results in terms of an equitable workload distribution and the optimization of human and machine resource allocation [14][15]. These results are obtained because lean tools focus on increasing production capacity, productivity, and line efficiency [16][17][18]. These different studies consistently agree that lean manufacturing tools are used in companies to reduce unnecessary activities, cycle times, production process times, and order fulfillment times.

3. Contribution

3.1. Proposed Model

The general model depicted in Figure 1 uses lean methodology to promote customer satisfaction by eliminating activities that do not add value, which, in turn, reduces cycle times, improves line efficiency, and increases production capacities. Although this model uses lean techniques, it uses change management as a catalyzing tool to educate and prepare staff members during the transition toward a lean manufacturing model.

- Establish and Measure Change: Its objective is to establish and generate the need for change in the organization through the deployment of the first six steps of John Kotter’s change management model.
- Workstation Organization: The 5S methodology is implemented for establishing order in workstations.
- Production Line Optimization: Through the work study, the most efficient method is identified and applied. Then, line balancing is used to determine the optimum number of workstations.
- Layout Optimization: In this phase, considering the results obtained in the previous phases, an AFP analysis is conducted for grouping stations into manufacturing cells and determining the ideal workflow.
- Results Analysis: Finally, the model applies the last two steps from the Kotter model, which consolidates improvements and changes in order to polish and present the results to the company. Likewise, the new culture is anchored in the company.

![Proposed Production Model](image-url)

**Figure 1.** Proposed production model
3.2. Proposed Method

Figure 2. Model application flowchart

The method proposed for the implementation of the optimization model comprises five phases, which detail the corresponding sequence of activities.

3.3. Indicators

3.3.1. Production Capacity. Target: To measure how much the company’s production capacity has increased after applying the improvements proposed.

\[
\frac{\text{Total Production Time}}{\text{Cycle Time}} \quad (1)
\]

3.3.2. Line Efficiency. Target: To measure how much line efficiency has increased after reducing cycle times and optimizing the number of workstations.

\[
\frac{\text{Total Production Time}}{\text{Cycle Time} \times \text{No. Stations}} \times 100\% \quad (2)
\]
3.3.3. Orders Fulfilled on Time. Target: To assess how much compliance with order fulfillment deadlines has increased after the proposed model was applied.

\[
\frac{\text{Orders Fulfilled on Time}}{\text{Total Number of Orders}} \times 100\% \tag{3}
\]

4. Validation

4.1. Case Study

The research study was performed in La Casa del Buen Maestro E.I.R.L., a small wooden furniture production company located in the Villa El Salvador industrial park in Lima, Peru.

4.2. Initial Assessment

After assessing the sales reported for each product, chairs were selected as the flagship product of the company. Therefore, a chair production line was selected for this study.

- Order Fulfillment Delays: 2–4 days
- Delay Percentages: 87.5%
- Cycle Time: 53.6 minutes
- Takt time: 37.3 minutes
- Processing Time: 229.3 minutes
- Line Efficiency: 61.11%

This assessment evidences high production times as the main cause of the problem identified. In turn, this cause is generated by the following sub-causes:

- % High Cycle Times: 36.66%
- % Inadequate Layout: 32.21%
- % Delays due to Time Spent Searching for Materials: 18.47%

![Figure 3. Current chair production layout](image)

*Figure 3.* denotes the current plant layout, which evidences crossings between workstations and long travel distances between stations, which translates into high transportation times.
4.3. Model Implementation in the Case Study

4.3.1. Phase 1: Establishing and Measuring Change. According to production staff survey respondents, 100% of the workers support the changes implemented. Likewise, training sessions were conducted to reduce the index of resistance to change, which decreased from 32.14% to 3.57%.

4.3.2. Phase 2: Workstation Organization. During this phase, the 5S methodology was successfully deployed in order to sort, set in order, and shine the work environment for optimum performance, with overall positive results. However, only regular results were reported for the third S, as the company did not have a cement floor. In other words, the floor was completely covered by sand, wood shavings, and sawdust, which prevented the floor from being completely cleaned.

![Before and after 5S implementation](image)

**Figure 4.** Before and after 5S implementation

4.3.3. Phase 3: Production Line Optimization

**Work Study**

Times were recorded for straight cut activities because this operation was identified as a production bottleneck. Then, the proposed improvements, including the corresponding procedure sheet, were implemented.

![Improvements made to the Cutting Station](image)

**Figure 5.** Improvements made to the Cutting Station

After implementing these improvements, cycle times were reduced by 19.96% when stopping tracing wood with a tape measure.

**Line Balancing**

Staff members are reorganized to distribute the workload of the operator in the station where cycle times originate.
4.3.4. Phase 4: Layout Optimization. Cell Manufacturing eliminates crosses and shortens travel times between stations.

![Proposed layout with cell manufacturing](image)

**Figure 6.** Proposed layout with cell manufacturing

4.4. Results Analysis

| Indicators                          | Before       | After        | % Variation |
|------------------------------------|--------------|--------------|-------------|
| Resistance to Change Index         | 32.14 %      | 3.57 %       | -19.69 %    |
| Cycle Times                        | 53.6 minutes | 42.9 minutes | -19.96 %    |
| Search for Materials and Tools     | 8.2 minutes  | 3.7 minutes  | 54.87 %     |
| Time between Stations              | 14.3 minutes | 9.6 minutes  | 32.86 %     |
| Processing Times                   | 229.3 minutes| 208.2 minutes| 9.20 %      |
| % Efficiency                       | 61.11 %      | 80.92 %      |             |
| % Compliance in Order Fulfilment   | 12.5 %       | 60 %         | 47.5 %      |

In this phase, the company appoints a team responsible for future growth and continuous improvement.

5. Conclusions

By implementing the proposed model, the time spent searching for materials was reduced by 54.87%. In addition, cycle times reported a 20% decrease in chair production, from 53.6 min/chair to 42.9 min/chair. Further, a 32.14% reduction was reported in travel times between workstations. As per these results, on-time order fulfillment experienced a 47.5% increase (from 12.5% to 60%). Model implementation also increased line efficiency by 19.81%, and production capacity grew from 189 chairs/month to 236 chairs/month.

John Kotter’s change management model was used as a catalyst, proving to be a proper support tool for managing the transition from a traditional model to a lean model.
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