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## Article

# The influence of performance objectives on the implementation of lean manufacturing practices: An analysis based on strategic groups

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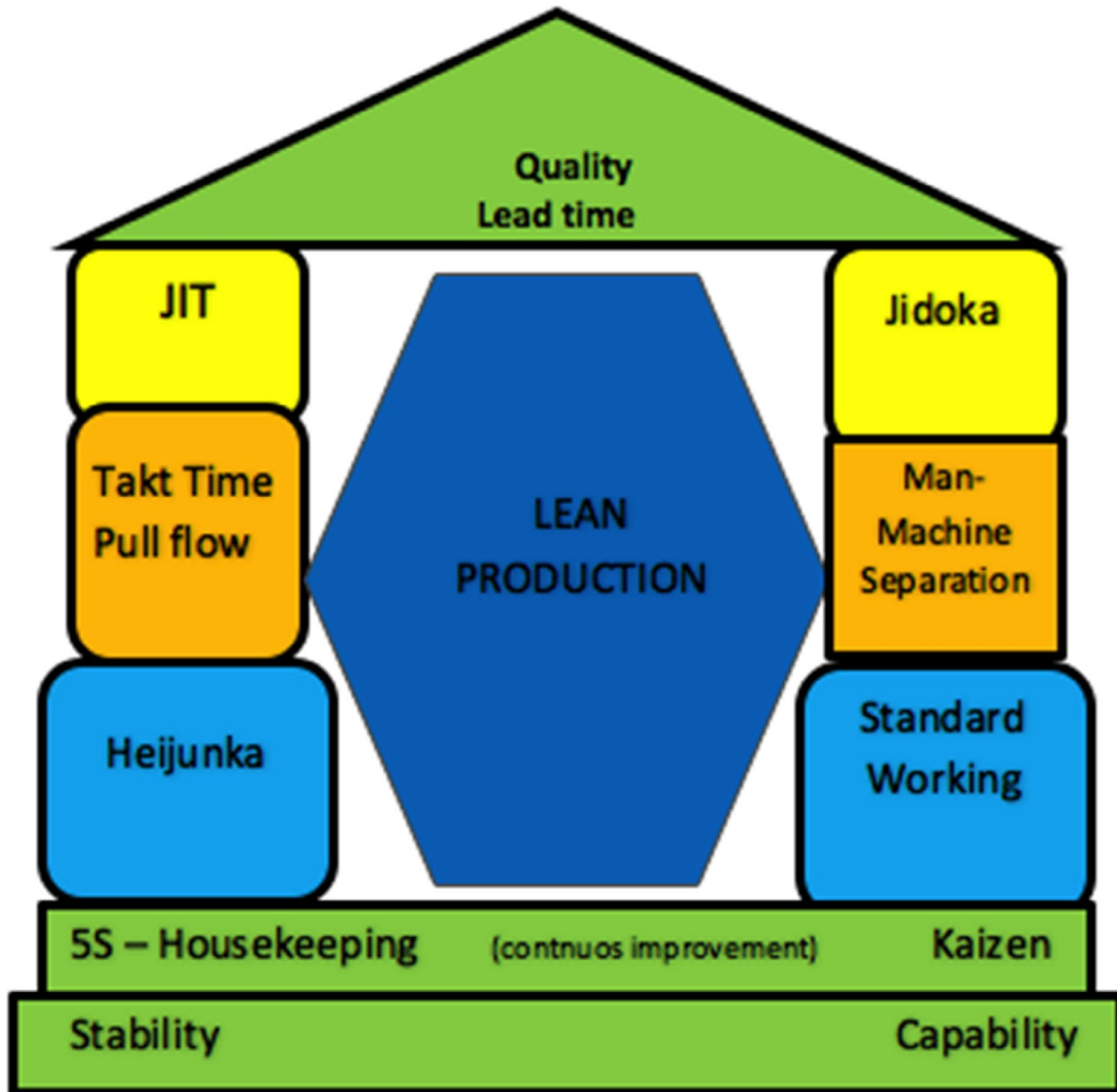
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## OPERATIONS, INFORMATION & TECHNOLOGY | RESEARCH ARTICLE

# The influence of performance objectives on the implementation of lean manufacturing practices: An analysis based on strategic groups

Hamilton Pozo<sup>1\*</sup>, Orlando Roque da Silva<sup>2</sup> and Takeshy Tachizawa<sup>3</sup>

**Abstract:** This paper explores how the choices about, and implementation of, lean production practices are influenced by performance goals prioritized by firms in the context of operations strategy. We analyzed a set of 56 companies (divided into four strategic groups) in the auto parts industry in the cities of Campinas and Jundiaí areas (Brazil). These groups of firms that adopt similar strategic orientations were used to investigate the relationship between the implementation of lean manufacturing practices and the choice of performance objectives. The results suggest that taking into consideration strategic groups can improve the understanding of how performance objectives define lean manufacturing practices adopted by manufacturing companies.

**Subjects:** Manufacturing & Processing; Operations Management; Operations Research; Business, Management and Accounting

**Keywords:** operations strategy; strategic group; lean manufacturing; performance objective; competitive strategies



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### ABOUT THE AUTHOR

Hamilton Pozo, holds a PhD of Business Administration from California C. University and degree of Mechanical Engineer. He has more than 25 years working as a professor and research in Brazil. He was Director of Operations and Strategic Plan in several companies. He helps students to embark the glorious career path in the field. This paper is a part of his project on performance improvement in productivity and quality manufacturing auto parts companies in Brazil.

Orlando Roque da Silva has a degree in Business Administration and a PhD in Production Engineering. The author has experience in the area of Operations Strategy and Innovation Management, working mainly on the following topics: advanced manufacturing, innovation systems and systems dynamics.

Takeshy Tachizawa has a degree and PhD in Business Administration. The author has experience in the area of Operations Strategy and Sustainable Management, working mainly on the following topics: Operation and management system, Supply Chain Sustainable.

### PUBLIC INTEREST STATEMENT

Lean production, competitive forces are not static but dynamic, and therefore manufacturers of auto parts and vehicles should not only rely on excellence in production, but mainly because increasing differences in operational performance between competitors become and brings together new forms of organization. The main novelty in this paper are extensive efficiency improvements in production strategies when applying lean manufacturing system combining with strategic group. The utilization of presented process could have the advantages of competitive and acceptability in industrial production process. The results suggest that taking into consideration strategic groups can improve the understanding of how performance objectives define lean production practices adopted by manufacturing companies. Understanding these effects can improve the understanding of how performance objectives define this practice adopted by manufacturing companies to lead it to success.

## 1. Introduction

Accordingly, Slack and Lewis (2009) state that operations strategy can have a heavy impact on business competitiveness, not only in the short term but also in the long run. The dilemma is that, when it comes to speeding up operations using distributed resources throughout companies, the impacts are difficult to identify in their entirety. This is the paradox of operations strategy, which is at the heart of the management of companies' strategic intentions and practices and plays a vital role in the success of organizations, but it is so comprehensive that it becomes easy to underestimate its importance.

The structure and competitive strategies of the auto parts industry have undergone profound changes in recent years, mainly due to the diffusion of the complex automotive production model of lean manufacturing. However, we understand that competitive forces are not static but dynamic, and therefore manufacturers of auto parts and vehicles should not only rely on excellence in production, but mainly because increasing differences in operational performance between competitors become and brings together new forms of organization, new management practices, and an intensive use of automated equipment (Holweg & Pil, 2004). The central pillars determining these changes include restructuring practices of automakers and the relationships between these and their suppliers that it is crucial to define involvement among them, and considering involvement as "an act of sharing the activities of a group" (Webster's, 2009, p. 711). Accelerating the process of product innovation and the creation of trade blocs.

The adoption of this model of production through the deployment of lean production practices has contributed to improvements in the operating performance of many companies but has also created some frustration (Womack, Jones, & Roos, 2004). The following questions arise:

- Should lean production be considered an operations strategy in the auto parts industry if it does not always reach the performance levels expected when deploying these practices?
- What is the relationship between the implementation of lean production practices and performance improvements?

This paper examines how the implementation of lean production practices can influence the operating performance of companies in the auto parts industry. As the deployment of these practices is rarely quantified using a cross-section data type (Cua, McKone, & Schroeder, 2001), we used a quantitative approach supported by non-parametric statistics linked to the concept of strategic groups. According Bozarth, Warsing, Flynn, and Flynn (2009), strategic groups have received more attention in research on operations strategy since Porter (2008) focused on these in his book *Competitive Strategy*. The utility of strategic groups manifests itself where there are many competitors, in that it facilitates conclusions in analyses of industrial sectors. However, in these analyses, precision is lost since the focus is on what companies have to be liking to put them in strategic groups. We lose the level of detail in what makes each company different. Nonetheless, the benefit is that we can better understand what happens in industries by focusing only on strategic groups.

## 2. Literature review

### 2.1. Operations strategies

A vast literature already exists on strategies and operations. For this paper, we consider both the most recent publications and some older classics on the analysis of operating strategies. Initially developed by Skinner (1969) and most recently refined by Hayes and Wheelwright (1984), Platts and Gregory (1990), Slack and Lewis (2009), this literature seeks to show that there is no single optimal path for companies operating within their resources, as Henry Ford once believed (Morgan, 2007).

The two central elements of this framework are the competitive priorities and decision categories within which the array of decisions that make up production strategies have to be made (Hayes & Wheelwright, 1984). This basic structure for operations strategy detailed in 1984 is still used in

research by Boyer and Lewis (2002), Hayes, Pisano, Upton, and Wheelwright (2005). There is a high degree of agreement that operations strategies focus on competitiveness in cost, quality, delivery, and flexibility (Dangayach & Deshmukh, 2001).

Operations strategy, however, is changing from a “market-based” to a “resource-based” vision. The first view sees operations as a perfectly adjustable system and focused on successfully following the rules dictated by markets, while the second view suggests that it is more profitable to focus on developing, protecting, and leveraging operational resources of companies when seeking competitive advantage. The study also suggests to the researcher’s world that researchers should propose various frameworks along with implementation steps to adapt the particular framework in organizations.

Most of the models are concentrating only on the manufacturing area rather than on the whole company. It is evident that most of the models belong to the category of the lean production process and, therefore, it becomes necessary to develop models in relation to the lean process. However, Anand and Kodali (2010) proposed a model that allows implementing the lean system specific to any type of organization. Several methods and approaches exist such as computer simulation, statistical analysis, lean tools for improving the efficiency and productivity by determining the best combination of resources in production lines, construction process, energy, services, and supply chains (Zahraee, Hashemi, Abdi, Shahpanah, & Rohani, 2014).

Also, when studying and investigating the production of specific phenomenon of the company-specific production system, it has been a strong and recent trend across many manufacturing industries to develop and deploy such a corporate improvement programmer (Netland, 2015).

This paradigm shift began with evidence that high performance can be mainly explained by the strength of the resources of a company and not by the strength of its market position (Rumelt, 2011; Wernerfelt, 1984). The resource-based view has gained more importance since Prahalad and Hamel (1995) emphasized the link between core competencies and competitiveness. Unfortunately, the application of these concepts in real business strategies may be insufficient (Hayes et al., 2005). Even today, it is difficult to find companies that use operations functions as a competitive weapon. One reason is the difficulty of “operationalizing” the content of operations strategy.

Although the theory of a resource-based perspective has a clear call, there have been studies on advantages based on resources within a more general, network context, extending the theory of resource-based viewpoint further. This view assumes that extended strategic resources that are outside companies emphasize inter-firm relationships. An example of this is the development of Toyota’s highly efficient supply network (Slack & Lewis, 2009).

Decisions in operations strategy, according to Slack and Lewis (2009), consider a set of areas—such as capacity, supply chains (including procurement and logistics), process technology, organization development—familiar to managers in a wide variety of operations. Researchers involved in manufacturing futures surveys have suggested that actions rather than decisions should be included within operations strategy. Also, it is possible to a simple tool for identifying strategic objectives as part of the design of strategy maps, based on the balanced scorecard, and meant to be used in organizations to establish performance indicators (Bellisario, Appolloni, & Ranalli, 2015).

The use of lean production practices within operations strategy represents both decisions and actions and, therefore, can be an important part of company standards, although lean production practices may not necessarily cover all aspects that make up the decision areas suggested by Slack and Lewis (2009). For example, questions about location are not extensively described in the literature on lean production, and these are not a part of practices suggested in later research. Still, the strategic model of operations is a means by which companies should be able to improve their internal and external processes, which should lead to improved performance

(Bozarth & McDermott, 1998). Slack and Lewis's (2009) model of decision areas and performance objectives is an appropriate benchmark with which to analyze the implementation of lean production.

### 2.2. Lean production practices and performance objectives

Lean production system consists of a set of powerful tools that assisted in the identification and steady elimination of waste such as value stream mapping, warehouse keeping, single minute exchange of die and standardized work (Chopra, Kalra, & Jawalkar, 2014). Several publications, books, and periodicals cover the concepts of the lean production system helping the popularization of its philosophy and since then, the lean concept has become an area of academic interest due to its dissemination in a wide range of industries and countries, particularly in operations management according to Marodin and Saurin (2013). Some recent studies show that the literature review on lean production becomes important and according to Stentoft Arlbjørn and Vagn Freytag (2013) who carried out a deeper research of the literature on lean production presented the impact of this process in various sectors of the industry as well as its impact on the productivity of the industry. The research of Moyano-Fuentes and Sacristán-Díaz (2012) showed the impact that lean production has on the processes with the application of LP principles in all industrial sectors around the world.

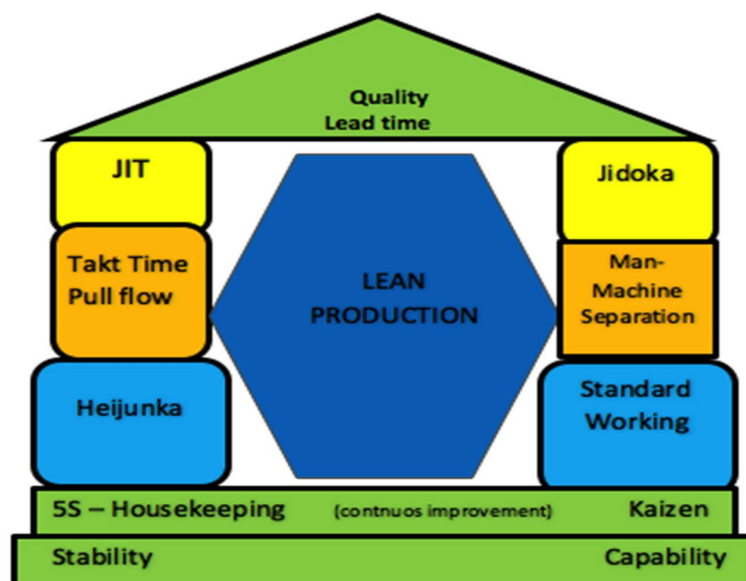
The conceptual framework of lean production used in this research is represented by Figure 1. This is a simplified version of lean operation (manufacture), where companies are grouped into strategic groups according to their competitive priorities in the market.

Many papers have been published since the 1990s on the relationship between lean production practices and performance (Dangayach & Deshmukh, 2001). Generally, it is believed that just-in-time (JIT) practices lead to shorter lead times and lower inventories, and practices of total quality management (TQM) lead to improved quality. Empirical studies show that this relationship is not always in fact true. In recent years we have seen the development of more research on lean production as a concept, in order to validate or refute claims about lean production practices and performance objectives.

Cua et al. (2001) mention some studies that consider the main pillars of lean production to be JIT, TQM, and total productive maintenance (TPM) working together. In the last years, several research efforts summarized in the literature review indicate how lean production show significant improvements by being energy efficient and using best practices this production system reduce wastes (Bergmiller, 2006). In the last 10 years, many researches have been published on lean production

Figure 1. Conceptual lean production.

Source: Adaptation of Hines, Holweg, and Rich (2004).





showing its importance and the results obtained. Marodin and Saurin (2013) in their research on the subject observed similar results (improvement of productivity, motivation of employees, and competitiveness) in his research study.

While researchers recognize the value of investigating these interrelated practices simultaneously (JIT, TQM, and TPM), there are few studies that provide an empirical examination of the joint implementation of TQM, JIT, and TPM practices (Wakchaure, Nandurkar, & Kallurkar, 2011). Based on a literature review of practices considering all three pillars of lean manufacturing (TQM, JIT, and TPM), notably, TQM is quite broadly defined, encompassing relationships between product design, suppliers, and customers, while JIT and TPM have more specific features. Performance objectives, therefore, reflect traditional competitive priorities, such as quality, cost, delivery on time, flexibility to allow changes in volume.

Wakchaure et al. (2011) analyzed practices that best explain performance differences in firms. This was done on two levels: on sets of practices (TQM, JIT, TPM, and common practices) and individual practices. The results showed that JIT, TPM, and TQM were significant in explaining the relationship between lean production and performance objectives. On the practice level alone, not all practices contributed to explaining this relationship. Hence, in a conclusion relevant to this work, the researchers found that it is more appropriate to consider the three pillars of lean production (JIT, TPM, and TQM) together to understand better how they are influenced by performance goals, when these are given priority.

### **2.3. Strategic groups**

A strategic group is formed by grouping together companies operating with similar strategies. Industry analysis done with the concept of strategic groups assumes that a given company is not in competition with every other company with the same intensity. Generally, an industry consists of several strategic groups, which include companies that have similarities across multiple strategic dimensions, such as degree of specialization, which refers to the extension of product lines; brand image—usually based on advertising and a sales force; and the choice of distribution channels, whether companies' own or other generalist or specialist distributors. Other dimensions include product quality, in terms of raw materials, specifications, and so on; the technological domain, whether companies mimic or lead in adopting new technologies; degree of vertical integration; position in terms of costs; extent of additional services offered, such as technical assistance; pricing policies; and relationships with public authorities, which may be reflected in obtaining grants or submitting the firm to regulations.

The formation of strategic groups is related to companies' ownership of different resources and capabilities, which enable some of them to make specific investments in mobility barriers. Metternich, Bechtloff, and Seifermann (2013) suggested that the effective and efficient clustering of machine or cell is improved by moving employees, workstations, or both into a U-shaped line which improve the employees' interaction that include training problem, process problem solving, training on continuous improvement tools and technique, development of idea management and development of reward and recognition system. Continuous improvement depends on employee perception, adaptation, team work, leader engagement, motivation, initiative, and training.

Companies are likely to adopt different strategies even when they have the same features and capabilities, if they have different preferences as to how to make investments and position themselves in relation to risk. Another factor that explains the differences between business strategies is the historical evolution of industries, since the cost of adopting a strategy tends to be lower for the first companies in an industry. As industries develop, barriers to mobility are strengthened by exogenous causes or as a result of investments made by already established companies.

### 3. Material and methods

The conceptual framework used in this research is represented by Figure 2. This is a simplified version of operations strategy, where companies are grouped into strategic groups according to their competitive priorities.

Two relationships were investigated, one being the relationship between strategic groups and operational performance and the other, relationships between strategic groups and degrees of implementation of lean production pillars (as summed scales). Due to time limitations in this paper, the connections between practices of lean manufacturing and operational performance are not examined directly but instead dealt with by constructing relationships through strategic groups. The call is then addressed indirectly.

#### 3.1. Data analysis and sample

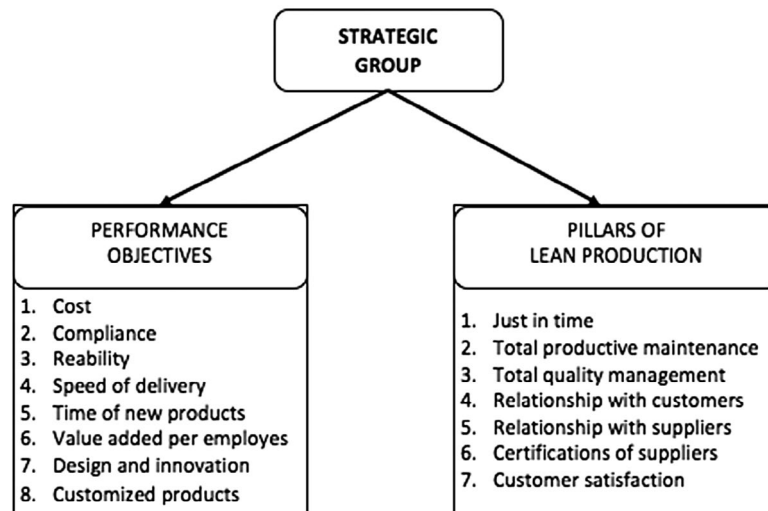
In this research target companies were categorized based on a group of 56 companies located in two cities, Campinas and Jundiai (Brazil), from March to October 2012. These companies are auto parts manufacturers divided into five industries: metallurgical, mechanical processing, plastics, machinery and equipment, and electrical and electronic. Data analysis in quantitative research is characterized as numerical descriptive inferential analysis. In this way, the descriptive analysis was initially developed, proceeding with the modeling of structural equations. The software used for data analysis was BioStat version 5.3.

This research is a cross-sectional study that was conducted in person with direct interviews. It means that various companies have been asked about the same things and measures. Moreover, data collection only conducted through in person. To motivate the companies contributed in this survey, we'll share the results of this research as promised to all respondents.

The questionnaire consisted of four categories of questions: contextual issues, questions about competing priorities, practicalities and issues related to performance goals, and both current performance objectives and performance objectives of the past five years. The performance objectives were considered to be cost, quality, reliability, speed of delivery to the customer, time to market entry of new products, value added per employee, design/innovation, product features, product variety, and customization of products.

The questionnaire focus is to identify the pillars lean production practice and the performance objectives. The first step was designed to evaluate and map the current state of companies in

Figure 2. Conceptual framework.





relation to the lean production particle in relation to performance objectives and their relations. To evaluate this relationship, Cronbach’s alpha was used to estimate the reliability of the questionnaire used in this research. These indicators can be seen in Table 1. Accordingly, some questions were prepared based on lean principles and their corresponding indicators.

According with research by Wanderley, Meira, Souza, and Miranda (2003), the companies were divided into four strategic groups among a number of competing priorities assigned to each of them (Groups GE-A, GE-B GE-C, and GE-D). These priorities are: cost, quality, reliability, speed of delivery, time placing product on the market, design and innovation, product features, variety of products and customized products.

To test the survey and find out whether it implies the intended purpose of it, final version of survey was tested by one private consultant in lean manufacturing in Brazil as well as the project supervisor. Consequently, some small changes were made to improve the survey quality.

**Table 1. Pillar of lean production and their indicators in this research**

Pillar of lean production	Indicators lean manufacturing practices
JIT	1. Production processes
	2. Reduction in cycle time
	3. Agile manufacturing
	4. Rapid techniques and tools
	5. Production systems focused on the factory
	6. JIT production flow/continuous
	7. Pull system/Kanban
	8. Bottleneck/removal restriction
TPM	1. Autonomous maintenance
	2. Planning and scheduling of maintenance
	3. Preventive or predictive maintenance
	4. Program improvements in safety
TQM	1. Formal programs of continuous improvement
	2. Software quality management
	3. Total quality management
	4. Measures of process capability
	5. Benchmarking
TECH	1. Planning systems and advanced programming
	2. Enterprise resource planning systems
	3. Finite capacity scheduling
	4. Demand management/forecast
RCLI	1. Continuous program replenishment
	2. Customers participate in product development
	3. Evaluation of industrial plant by clients
	4. Survey of customer satisfaction
RFOR	1. Major suppliers based on JIT deliveries
	2. Stocks managed by supplier
	3. Suppliers commit themselves to reducing costs
	4. Suppliers involved in development of new products
CFOR	1. Program for certification of suppliers
	2. Suppliers evaluated based on total cost

Source: Research data.

#### 4. Analysis and results

In this study, we used Cronbach’s alpha to estimate the reliability of the questionnaire used in this research. We measured correlations between questionnaire responses by analyzing answers given by respondents, looking at average correlations between questions. The software used was BioStat version 5.3 for data analysis.

The general rule used was that the existing scales should exceed a Cronbach’s alpha level of 0.70. This proved to be the case for the three pillars considered: JIT, TPM, and TQM. Compared to Cua et al. (2001), the JIT and TPM pillars have the same content, while the third pillar was divided into TQM itself, client relations (RCLI), supplier relations (RFOR), and supplier certification (CFOR) for this study—although RCLI and RFOR presented values below the minimum Cronbach’s alpha of 0.70. The pillar “technology” (TECH) is also a pillar of lean production, per se, and it was included to check the influence of technology on lean production practices. These interrelated pillars and practices are shown in Table 2.

**Table 2. Pillars of analysis and their lean production practice**

Pillar of lean production	Lean manufacturing practices	Cronbach’s $\alpha$ ( $\alpha_c$ )
JIT ( $\alpha_c = 0.826$ )	1. Production processes	0.610
	2. Reduction in cycle time	0.571
	3. Agile manufacturing	0.742
	4. Rapid techniques and tools	0.733
	5. Production systems focused on the factory	0.708
	6. JIT production flow/continuous	0.658
	7. Pull system/Kanban	0.754
	8. Bottleneck/removal restriction	0.523
TPM ( $\alpha_c = 0.717$ )	1. Autonomous maintenance	0.679
	2. Planning and scheduling of maintenance	0.601
	3. Preventive or predictive maintenance	0.904
	4. Program improvements in safety	0.748
TQM ( $\alpha_c = 0.720$ )	1. Formal programs of continuous improvement	0.570
	2. Software quality management	0.794
	3. Total quality management	0.885
	4. Measures of process capability	0.667
	5. Benchmarking	0.617
TECH ( $\alpha_c = 0.681$ )	1. Planning systems and advanced programming	0.630
	2. Enterprise resource planning systems	0.741
	3. Finite capacity scheduling	0.832
	4. Demand management/forecast	0.678
RCLI ( $\alpha_c = 0.641$ )	1. Continuous program replenishment	0.771
	2. Customers participate in product development	0.712
	3. Evaluation of industrial plant by clients	0.606
	4. Survey of customer satisfaction	0.701
RFOR ( $\alpha_c = 0.742$ )	1. Major suppliers based on JIT deliveries	0.730
	2. Stocks managed by supplier	0.595
	3. Suppliers commit themselves to reducing costs	0.773
	4. Suppliers involved in development of new products	0.720
CFOR ( $\alpha_c = 0.619$ )	1. Program for certification of suppliers	0.680
	2. Suppliers evaluated based on total cost	0.572

Source: Research data.

Before describing the data analysis is necessary to present the results of another analysis that led to the formation of strategic groups. Four strategic groups were identified, all significantly different in their most important competitive priorities. The companies received 100 points to distribute among a number of competing priorities, and this was the basis for the identification of groups. This process has been suggested a somewhat different way by Hill (2000) and used by Berry, Hill, and Klompmaker (1999) with success. The strategic groups are named based on its competitive priorities considered most important, as shown by Table 3 and Graphic 1.

This result is similar to research by Wanderley et al. (2003), entitled priorities competitive in the strategic management of manufacture: a study in Pernambuco State (BR) processing industries. This study presents the competitive priorities in Pernambuco processing industry, where they were surveyed 101 industrial processing companies with over 200 employees and listed in the Industrial Registry of Pernambuco (IRP).

Thus, the strategic group A (GE-A) has a very high focus almost exclusively on cost and quality to a lesser extent, accordingly, the delivery rate and variety of products. Competitive priority time to introduce new products on the market has little influence in this strategic group. These results point to low value-added products that dispute the market almost exclusively based on the selling price.

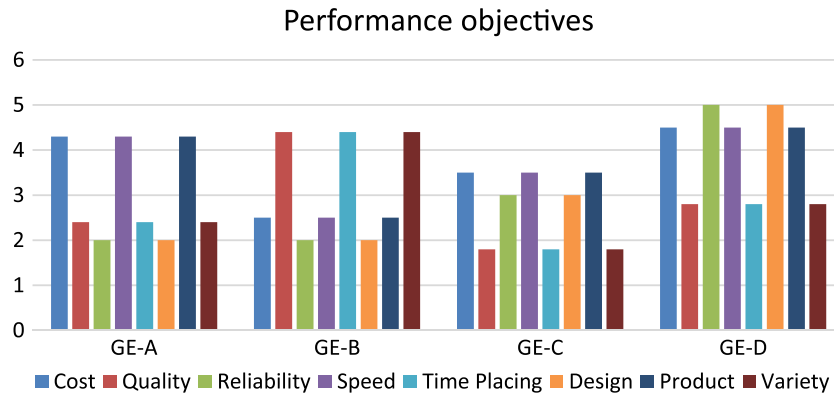
**Table 3. Classification of performance objectives in strategic groups**

Competitive priority	Strategic groups			
	GE-A	GE-B	GE-C	GE-D
Cost				
Average	46.3	18.0	18.2	3.8
Classification	1	3	2	4
Quality				
Average	14.1	36.2	20.3	18.4
Classification	4	1	3	2
Reliability				
Average	10.9	26.2	30.1	9.8
Classification	3	2	1	4
Speed of delivery				
Average	11.4	7.3	20.1	3.2
Classification	2	3	1	4
Time placing product on the market				
Average	4.8	24.4	5.9	6.3
Classification	4	1	3	2
Design and innovation				
Average	8.8	12.8	5.1	41.9
Classification	3	2	4	1
Product features				
Average	8.9	15.2	5.9	17.5
Classification	3	2	4	1
Variety of products				
Average	10.9	15.1	6.2	20.1
Classification	3	2	4	1
Customized products				
Average	8.9	14.1	8.7	15.7
Classification	4	2	3	1

Source: Research data.

**Graphic 1. Classification of performance objectives in strategic groups.**

Source: Research data.



The strategic group B (GE-B) and strategic group C (GE-C) has an emphasis on quality and delivery reliability, but differ on the time to introduce new products on the market (GE-B is dominant) and speed in delivery (GE-C is dominant). Design and innovation has little influence on the GE-C, while in Group B, the speed of delivery is the least of priorities. These results point to regular supply of items for automakers, hence the need to prioritize the quality, reliability, speed in delivery and the introduction of new products on the market.

The strategic group D (GE-D) has a competitive priority to meet the feature (esthetic) in their products. This is a new perspective, where customer and subjectivity of style and fashion changes can heavily influence the performance of the company. This fact is consistent with the cost being the lowest priority. Firms in this group emphasize the esthetic appearance of the cost. The variety of products, quality and product features also influence but to a lesser degree than the design and the innovation. Thus, the group gives low priority to the cost and the lead time to introduce new products on the market.

After analysis, the results point to an apparent inconsistency within the GE-D when to prioritize design and innovation the lead-time factor for market entry appears, also as important. Is with Schumpeter (1978) calls the temporary monopoly, or is, the advantage gained by being the first to put the innovative product to other companies to copy the idea and launch similar products. As the GE-D does not prioritize this time he loses the temporary monopoly advantage.

All tests for differences between the strategic groups were non-parametric. Parametric tests assume, among other things, normal populations groups and homogeneity of variance. In practice, these conditions are based on the central limit theorem, which normally requires the use of many cases (Virgillito, 2006). Since this study used a small amount of cases, the assumptions for parametric tests are not necessarily applicable, which is why we used non-parametric tests.

One of the tests used was the Kruskal-Willis test, non-parametric, used to compare three or more samples. It was used to test the null hypothesis—that all populations have identical distribution of functions—against the alternative hypothesis that at least two of the populations have different distribution functions. This test was performed and revealed that cost, quality, delivery reliability, speed of delivery, design and innovation, and product characteristics differ significantly between groups. The time to put the product to the market, the product variety and customization of products were not significantly different between groups.

Thus, the Kruskal-Willis test showed that the strategic groups differ significantly from each other. The Mann-Whitney test, conducted later, also showed that the groups differ in their main competitive priorities, i.e. price for the GE-A, line quality and delivery reliability for the GE-B, delivery reliability and speed delivery to GE-C and finally design and innovation for the GE-D.

#### 4.1. Strategic groups and performance

When we analyzed the role of strategic groups in choices of priority performance goals, a further question appeared: Do the strategic groups alone explain choices of performance goals?

To answer this question, it was necessary to show statistically significant differences between the groups and then turn our attention to a more qualitative assessment. Table 4 shows the statistical results. Strategic group A presents the lowest value added per employee of the four groups. Strategic group D has the highest value added per employee. However, as revealed in Table 4, strategic group D is in a vulnerable position, because, for this group, the cost of guarantees, rate of rejection by customers, and production costs increase significantly more than for the other groups. Indeed, the other groups showed decreasing values for these three measures.

One possible explanation for strategic group D being quite different from the others may be the fact that growing numbers of customers are becoming more demanding with respect to the design of products. The fact of this strategic group showing an overly low yearly added value per employee indicates that it has a low contribution margin, probably due to price competition. Therefore, this group has to focus on lowering costs, so cost is a priority. Group A has a well-defined strategic choice of performance goals when compared with other strategic groups, as shown in Table 5. The group

**Table 4. Significant differences in performance between groups with strategic application of Mann–Whitney<sup>a</sup>**

Items	GE-A × GE-B	GE-A × GE-C	GE-A × GE-D	GE-B × GE-C	GE-B × GE-D	GE-C × GE-D
Value added per employee in the year	0.056 (B) a	0.054 (C)	0.164 (D)	–	–	–
Warranty cost	–	–	0.011 (D)	–	–	0.018 (D)
Rate of rejection customer	–	–	0.068 (D)	–	–	0.153 (D)
Cost of production (without materials)	–	–	0.020 (D)	–	0.043 (D)	–
Cost of production (with materials)	–	–	0.091 (D)	–	0.241 (D)	0.072 (D)

Source: Research data.

<sup>a</sup>The letters in parentheses indicate the strategic group that has the greatest value, where there is no other significant difference in value.

**Table 5. Scoring for classification of competitive priorities related to performance objectives**

Items		GP-A	GP-B	GP-C	GP-D
Cost	1. Scrap and rework	1 <sup>a</sup>	3	2	4
	2. Cost of warranty	1	3	2	4
	3. Cost of quality	1	3	2	4
	4. Inventory turnover of raw materials	1	3	2	4
	5. Inventory turnover of goods in process	2	3	4	1
	6. Inventories of finished goods	2	4	1	3
	Average	1.63	3.13	2.00	3.25
Quality	7. Finished product with no rework	2	3	1	4
	8. Defect rate in plants	3	1	4	2
	9. Rejection ratio per customer	2	1	3	4
	Average	2.33	1.67	2.67	3.33
Reliability	10. Delivery on time	4	2	1	3
	Average	4	2	1	3
Speed of delivery	11. Lead time of purchase	3	4	2	1
	12. Lead production team	4	3	2	1
	13. Lead sales team	4	3	2	1
	Average	3.67	3.33	2.00	1.00

Source: Research data.

<sup>a</sup>Points are based on the rating that each group receives for the strategic performance measure in question.

also gives a high degree of importance to quality, but its importance is not as evident as other performance goals.

The prioritization of cost and quality performance objectives by strategic group A offsets its delivery speed and reliability. Strategic group B places a higher degree of priority on quality, but, overall, this group has the worst score. This group emphasizes quality and reliability, which is also reflected in the choice of lean production practices. Strategic group C has its prioritization better distributed in its total score, but it puts an emphasis on speed of delivery and reliability. This strategic group shows a high degree of external fit, so much so that it is able to deliver what the market wants quickly and reliably.

Finally, strategic group D's prioritization shows evidence of good speed of delivery, but, overall, this group does not emphasize any of the performance objectives that have a direct relationship to practices of lean production, as shown in Table 5. Quality alone seems to have a high degree of importance, but, in reality, this is a consequence of prioritization of design and innovation. In the Table 4, shows that strategic group D has a significantly worse outcome than other groups regarding rejection rates per customer. The data analysis shows that its rate of rejection, unlike other groups that focus on action, is due to poor acceptance of its products' design.

This can lead to the conclusion that an adjustment is needed in choices of lean production practices in this group. However, this strategic group is new in the context of determining research operations. It also has a strong emphasis on multifunctional performance goals. Therefore, it should not be judged solely on the basis of the degree of priority given to performance goals. Nonetheless, an analysis of the performance objectives of this group indicates that it needs to improve its choices in the future if these companies want to be able to sustain a high value added per employee.

#### 4.2. Strategic groups and implementation of pillars of lean production

To analyze the implementation of pillars of lean production by strategic groups, we based this on the results shown in Table 1 and the degree of implementation of these pillars in different groups. Various tests to measure the differences between groups were performed. First, we ran a Kruskal-Willis test for differences between the groups and then performed a Mann-Whitney test for differences between the pillars, seen individually and group to group. Finally, using the Wilcoxon test, we looked at whether the deployment of the pillars of lean production is different in each group. The results are shown in Table 6 and Graphic 2.

**Table 6. Degree of implementation of lean production practices in strategic groups**

Group strategic	JIT	TPM	TQM	TECN	RCLI	RFOR	CFOR
GE-A	-	(1, 2, 3, 4) <sup>a</sup>	-1, 2	-2, 4	-4	-1, 3	-2
Average	2.915	3.362	2.942	2.310	2.694	2.433	2.914
Classification	1	1	1	4	3	1	2
GE-B	(3, 5, 6, 7)	-1	(3, 4, 5)	-1, 3	-3, 4		-1
Average	2.440	2.898	2.711	3.280	2.822	2.087	2.953
Classification	4	2	2	1	2	3	1
GE-C	(1, 2, 3, 4)	-	-	-	-	-1, 2	-
Average	2.875	2.803	2.693	2.769	2.884	2.066	2.564
Classification	2	3	3	3	1	4	3
GE-D	-1, 4	-4	-2	-4	-2, 3	-4	-
Average	2.813	2.810	2.197	2.805	2.486	2.258	2.205
Classification	3	4	4	2	4	2	4

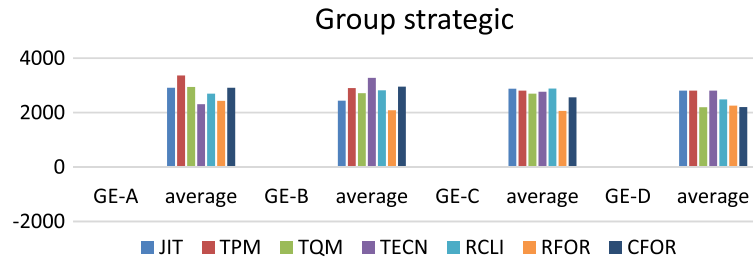
Source: Research data.

<sup>a</sup>Numbers in brackets refer to the lean production practices adopted, as shown in Table 1.



**Graphic 2. Average of degree of lean production practices in strategic groups.**

Source: Research data.



The Kruskal-Willis test revealed no significance, which indicates that all strategic groups should be considered as coming from the same population in terms of lean production practices. This finding is quite different when compared with the Kruskal-Willis test's results on competitive priorities in the strategic groups. The Mann-Whitney test for different degrees of implementation of pillars of lean production, when applied to the four strategic groups, showed that the other strategic groups differ from strategic group C in their degree of implementation of TPM and differ from group D in the degree of strategic deployment of TQM.

The Wilcoxon test for differences in the groups confirmed that the groups emphasize different pillars. For example, strategic group A has a significantly greater degree of implementation of TPM than most of the other pillars, while strategic group B has a significantly lower degree of deployment of RFOR. The Wilcoxon test showed that the groups differ in who chooses to apply what, but this difference is not significant between groups.

Table 6 indicates which groups emphasize the strategic pillars JIT, TPM, TQM, and RFOR. Table 1 shows that lean production practices, including these pillars, generally are favorable for lower and short-term costs, so these strategic groups reveal a high degree of internal adjustment.

An emphasis on CFOR was expected for group B because it has a strategic focus on quality rather than cost. Moreover, the implementation of new technologies by this strategic group can be explained by its emphasis on delivery reliability.

It can also be noted that the most customer-oriented group is strategic group C, which has the highest score for RCLI. This pillar is mainly the aspect of time in relation to customers and is thus consistent with the strategic focus of group C. Strategic group B is number two in TQM, while strategic group C is number two in JIT, which is also in line with their goals. Hence, these groups show a high degree of internal consistency.

The strategic choices of group D are difficult to explain, in part because other practices beyond pillars of lean production can be extremely important for these companies and we do not have enough information about these practices. However, based on the data at hand, we can see that this group emphasizes TECH and RFOR. The first has to do with the use of technologies to develop new products and the second has to do with relationships with suppliers with respect to lower costs and shorter delivery times. This seems to be valid when considering delivery problems, but, as Table 4 shows, that group does not prioritize cost or quality. Based on Table 2, it can be seen that this group does not emphasize good performance in delivery, so this group does not have a high degree of internal adjustment.

The numbers in parentheses in Table 6 refer to the practices of lean production including TECH, which is not really a pillar of lean production but is an aid to understanding applications. These data suggest that strategic group A has more extensively applied lean production practices, followed by strategic group B, which for some yet unidentified reason is particularly interested in deploying technological, finite capacity scheduling. The group has deployed fewer lean production practices than strategic group D.

The analysis leads us to conclude that strategic groups A, B, and C have implemented lean production practices in terms of performance objectives and that prioritized groups are selective about the pillars that receive greater emphasis. This is most clearly demonstrated by strategic group A. Strategic group C shows overall good performance, which can be achieved without the implementation of a series of lean production practices. An analysis of the combination of the operating performance of group D with its strategic deployments of lean practices can lead to two possible conclusions: that these companies are not good at running their operations strategy or some of the companies included in the analysis do not attribute an important role to strategies for operations. Given these possibilities, we cannot reach more definite conclusions about that group.

### 5. Discussion of results

Data analysis showed that the strategic groups differ, both with regard to different sets of performance goals and to the sets of pillars of lean production that they choose to deploy. The analyses also indicated that there are links between the deployment of pillars of lean production and the performance objectives prioritized. For example, the groups showed that the strategic deployment of the pillars TPM, TQM, and RFOR apparently goes hand in hand with good performance at low cost. However, a high degree of deployment is not necessary to achieve a satisfactory performance in key areas, as strategic group C demonstrated. This strategic group has good performance in speed of delivery but only uses pillars of lean production (i.e. JIT and RFOR) at a moderate level.

According to the present study, which shows the relations between strategic groups with performance objectives and the pillars of lean production. The magnificence of strategic group success is growing day by day because of its positive impact on industrial performance. It is evident that the result obtained with the results helps similar results presented in papers published in recent years. The study showed that empirical approaches in recent years on the topic, according to Stentoft Arlbjørn and Vagn Freytag (2013) is important for competitive organizations. The fundamental bases of group strategy were implemented at the operational level to improve productivity and reduce non-value-activities. This is one of the reasons for the research (performance goals and pillars of lean production) within the group strategy at the operational level that helped companies to improve their performance.

This study provides evidence that more complex relationships between pillars of lean production and performance goals can be found. Not all pillars are equally important for all performance objectives. Moreover, there is reason to believe that there are relationships between how the members of each group strategically deploy pillars of lean production and performance objectives that have not been discovered or understood in depth.

This study shows that the use of strategic groups could help explain how choices of pillars of lean production and their practices are influenced by the performance goals prioritized by companies to achieve higher levels of competitiveness. Studies that address performance objectives can gain more insight by considering strategies for business operations. Given resource constraints, companies may not want to improve everything all the time: they have to focus their efforts. Strategic groups can be a valuable tool for understanding the choices that companies must make to achieve high levels of excellence, assisting these companies in their choice of the necessary lean production practices.

Manufacturing concepts are being adopted by modern manufacturing organizations to achieve competitive advantage. Lean manufacturing ensures waste elimination, streamlined processes and value addition and the research show that and modern manufacturing engineers are required to understand the importance of strategic groups. The result in Table 3 classification of performance objectives in strategic groups shows the high focus:

- Group GB-A on cost and (low value-added products that dispute the market almost exclusively based on the selling price);
- Group GE-B on quality and place time product on market (has their emphasis);
- Group GE-C on reliability and speed of delivery (speed of delivery and reliability are the priorities);
- Group GE-D on design and innovation, product features, variety of products and customized products (firms in this group emphasize the esthetic appearance of the cost. The variety of products, quality and product features also influence but to a lesser degree than the design and the innovation).

In Table 5, the competitive priorities related to performance objectives, shows the high performance:

- Group GP-A on cost;
- Group GP-B on quality;
- Group GP-C on reliability;
- Group GP-D on speed of delivery.

The Wilcoxon test looked at whether the deployment of the pillars of lean production is different in each group and the groups emphasize the strategic pillars in Table 6 and shows:

- Group GE-A emphasis on JIT, TPM, TQM, and RFOR;
- Group GE-B emphasis on TECN and CFOR;
- Group GE-C emphasis on RCLI;
- Group GE-D emphasis secondary on TECN and RCLI.

## 6. Conclusion

This study established connections between the defined groups' strategic pillars of lean production and performance goals using cross-sectional data. Different strategic groups have different performance goals and emphasize the application of different pillars and lean production practices. In particular, strategic groups A and D show that they are parting ways. The results are indicative only, and the sample size is too small to obtain highly significant statistical results. However, the results summarized in Tables 2–6 indicate that ratings of lean production practices using strategic groups can produce important results in operations strategy and that there is reason to investigate lean production practices further in this context.

This study identified a new strategic group, where esthetics and industrial design are given priority. Several articles have recently been published demonstrating the importance of image, design, and esthetics in manufacturing companies, as well as how design can influence operations strategies. Within the limitations of this study and the sample, the linkage between pillars of lean production and performance goals has been thoroughly explored, as has the role played by lean production practices.

In general, as Frohlich and Dixon (2001) argue, there is a need to replicate studies. Therefore, more studies should be conducted in different sectors of the economy in different geographical regions so that a general picture can be formed of how operations strategies are handled by different strategic groups in their lean production practices, as well as what results are obtained and how they are affected by prioritized performance objectives.

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### Cover image

Source: Adaptation of Hines, Holweg, and Rich (2004).

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