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# LEAN INVENTORY PRACTICES AND OPERATIONAL PERFORMANCE OF LISTED OIL AND GAS COMPANIES IN NIGERIA

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***Abstract*:** This study investigates the relationship between lean inventory practices and firm operational performance in the oil and gas industry in Nigeria. The study considers lean inventory practices in terms of just in time, total preventive maintenance, and total quality management. The empirical analysis is based on cross-sectional data collected through a structured questionnaire instrument from 100 managers representing 10 companies that are listed in the oil and gas sector of the Nigerian stock exchange. All variables are measured using the Likert-type questions with 5 ordered options. The results from empirical analysis show that just in time, total preventive maintenance, and total quality management all have a positive relationship with firm operational performance. However, the effect total quality management is much higher in magnitude while the effect of total preventive maintenance is not statistically significant. The combined effect of the three lean inventory strategies significantly explains about 29% of the total variation in firm operational performance. Therefore, we contend that integration of lean inventory strategies in the existing business model would significantly enhance the operational performance of oil and gas companies in Nigeria.

**Key words**: Lean inventory practices, just in time, total preventive maintenance, total quality management, firm operational performance

## INTRODUCTION

The rapidly changing and fiercely competitive global business environment over the past two decades has forced manufacturing firms all over the world to adopt new manufacturing approaches (Meredith & McTavish, 1992). Particularly salient among these is the concept of lean production (Womack & Jones, 1996; Womack, et al., 1990). Lean production is a multi-dimensional approach that encompasses a wide variety of management practices, including just in time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system. The core thrust of lean production is that these practices can work synergistically to create a streamlined, high-quality system that produces finished products at the pace of customer demand with little or no waste. Anecdotal evidence suggests that several organizational factors may enable or inhibit the implementation of lean practices among manufacturing plants.

Lean thinking is arguably the most important strategy for withstanding intense competition and achieving world-class performance (Panwar et al., 2017). Womack et al. (1991) first coined the term "Lean production" in their seminal book, The Machine that Changed the World. However, the origin of lean thinking is generally attributed to Toyota, whose production system was originally referred to as just-in-time (JIT) but is now commonly called the Toyota Production System (TPS). Lean thinking emphasizes excellence through the elimination of waste and a focus on continuous improvement. Schonberger (1987, p.5) refers lean as "the most important productivity enhancing management innovation since the turn of the century." Prior empirical research has often linked lean manufacturing to operational performance (Cua et al., 2001; Hallgren & Olhager, 2009; Narasimhan et al., 2006; Shah & Ward, 2003) and financial performance (Fullerton et al., 2003; Fullerton & Wempe, 2009; Hofer et al., 2012; Kaynak, 2003; Kinney & Wempe, 2002; Yang et al., 2011).

One facet of lean inventory practices that has attracted considerable academic attention is the Just in Time (JIT) practices (Shah & Ward, 2003). JIT has been defined as a waste reduction strategy that focuses on continuous improvement and is associated with throughput time reduction, improved internal and external quality, improved labour productivity, improved employee behaviour, reduced inventory levels and decreased unit cost (Chong et al., 2001). Thus, JIT practice is a lean inventory strategy that focuses on improving firm productivity and delivery performance.

Another dimension of lean inventory practices that has also attracted considerable scholarly attention is Total Quality Management (TQM). TQM has since become part of strategic business thinking and is defined by Powell (1995) as an integrated management strategy that focuses on amongst others, continuous improvement in inventory management, meeting customer requirements, reducing rework, increased employee involvement and teamwork, and competitive benchmarking. According to Shah and Ward (2003), TQM and JIT practices are the two dimensions of lean inventory practices that have attracted considerable scholarly attention.

The third dimension of lean inventory practices that has emerged from the literature is total preventive maintenance (TPM). TPM, which is generally aimed to optimize the overall equipment effectiveness, includes practices that are primarily designed to optimize equipment effectiveness through planned predictive and preventive maintenance of the equipment and using maintenance optimization techniques. According to Panwar et al. (2018), successful implementation of TPM helps to reduce energy consumption and accidents as well as improve employee safety in the Indian process industry.

There is scanty but growing empirical literature on lean inventory practices and firm performance. However, much of the previous studies have been focused on the developed countries, hence there is need for further studies in the line of scientific investigation.

This study contributes to the growing literature by examining the impact of lean inventory practices on firm operational performance, focusing on listed oil and gas companies in Nigeria. The study has three specific objectives as follows:

1. To determine the extent to which just in time inventory practices affects firm operational performance.
2. To determine the extent to which total preventive maintenance affects firm operational performance.
3. To determine the extent to which total quality management affects firm operational performance.

The current study, as compared with the previous studies on lean-performance relationship in Nigeria, is distinct as it is, to our knowledge, the first to examine three dimensions of lean inventory practices; namely, just in time practices, total preventive maintenance practices, total quality management, in a single empirical study. A closely related work is the recent study by Nnadi and Ndu Oko (2021), which relates two dimensions of lean inventory: namely, just in time and total quality management on productivity and delivery performance. Thus, total preventive maintenance is not considered in that study. Also, Nnadi and Ndu Oko (2021) focuses on both listed and non-listed companies operating only in Rivers State, the current study focuses on listed companies in Nigeria irrespective of their operational base. It therefore follows that our results would provide a new perspective into lean inventory-performance relationship.

The remainder of the study has four sections. The next section contains the review of the theoretical and empirical literature on lean-performance relationship. Section 3 describes the research methodology in terms of the data, sample, measurement, and empirical model. Section 4 contains data analysis and discussion of findings, while section 5 concludes the study.

## LITERATURE REVIEW

### Theoretical Framework

This study contends that lean inventory is a valuable internal resource that improves operational performance and competitiveness of a firm, hence its theoretical framework is consistent with the influential resource-based theory.

The resource-based view of the firm (RBV) was initially introduced by Wernerfelt (1984) as a theoretical model for firm competitiveness. However, theory was popularized by Barney (1991) who link firm competitiveness to firm-specific resources. According to RBV, organizations that want to achieve sustainable performance must possess and control valuable resources that are not evenly distributed across firms (Barney, 1991). Also, such resources or capabilities can be tangible or intangible. While tangible resources include land, location and financial resources, intangible resources include leadership skills, organisational processes, and organizational knowledge.

In this study, we argue that lean inventory practices fit Barney's (1991) VRIO model for competitive advantage, since not all firms can afford what it takes to implement lean inventory strategies due to financial constraint or limited organizational knowledge. Hence, our theoretical model incorporates just in time, total preventive maintenance, and total quality management as firm-specific determinants of operational performance and sustained competitive advantage.

### Empirical Review

Shaw and Ward (2003) employ the hierarchical regression to investigate the effects of four dimensions of lean practices (just in time practices, total quality management, total preventive management, and human resource management) on operational performance of US firms. Based on data collected from 1757 managers of manufacturing, they find, among other things, that all the four dimensions of lean inventory exert a significant effect on firm operational performance.

In a case study research, Bon and Garai (2011) investigated whether the implementation of just in time would enhance inventory management in Electronics component industry at stamping production of FCM using descriptive analysis. The study uses quantitative data collected through observations and FCM documentation. Comparing before and after implementation of just in time using Microsoft Excel shows that just in time implementation enhances inventory management through reduction of level of inventory.

Demeter and Matyusz (2011) empirically tested the argument that firms that adopt lean manufacturing practices record higher inventory turnover than those that do use lean practices using a sample of 255 large companies (84 traditional firms and 171 lean firms). The firms were selected from 12 countries: namely, Argentina, Australia, Belgium, Brazil, China, Canada, Denmark, Estonia, Greece, Germany, Hungary, and Ireland. They measure lean practices as the ratio for JIT delivery from suppliers, the ratio for JIT delivery to customers, scrap and rework costs, throughput time efficiency and late delivery, while inventory turnover is measured by raw material inventory days of production, work in process inventory days of production and finished goods inventory days of production. They find that lean practices are powerful tools for improving inventory turnover. They conclude that manufacturing firms that implement lean practices have significantly higher inventory turnover for all types of inventories (raw material, work in process and finished goods) than traditional companies.

Nawanir et al. (2013) examine the impact of lean practices on both operational and business performance of manufacturing companies in Indonesia using multiple regression analysis. While operational performance is measured by quality of products and services, inventory reduction, fast and timely delivery, and cost reduction, business performance is measured by sales, profitability, and customer satisfaction. They find that lean practices (resource flexibility, cellular layout, pull systems, quick setup, uniform production level total quality management and total productive maintenance) have both positive and significant impact on both operational and sales performance.

Avelar-Sosa et al. (2018) use structural equation modeling framework to examine the effects of lean manufacturing practices; namely, total quality management, just in time and total productive maintenance, on the delivery time in a supply chain across different industries in Mexico. The sample comprises 225 respondents who are managers, purchasing and supplier planners, supervisors, directors of operations and engineers while the industries examined include Electronic, Automotive, Medical, Services, Plastics, Consumables, Metal, Packing and Communications. The results show that total quality management, just in time and total productive maintenance all have a direct and positive effect on delivery time, with just in time having the highest effect.

Nnadi and Ndu-Oko (2021) use a cross-sectional regression framework to examine the effect of lean inventory strategies on productivity and delivery performance of oil and gas companies in Rivers State, Nigeria. The study also considers the moderating role of organizational support in the relationship between lean inventory practices and firm performance. The sample consists of 96 senior employees from 10 selected oil and gas companies in Rivers State. The study measures lean inventory practices using two dimensions; namely, just in time and total quality management. The results show that both just in time and total quality management have positive and highly significant impact on both productivity and delivery performance. Both lean inventory strategies significantly account for approximately 72% and 67% of the variance of firm productivity and delivery performance respectively. However, for each performance measure, the magnitude of the effect of just in time is much higher than that of total quality management. The study also find that organizational support enhances the relationship between inventory leanness and firm performance.

## METHODOLOGY

### Data and Sample

This study uses cross-sectional data obtained through a structured questionnaire from 100 personnel representing 10 listed companies in the oil and gas sector of the Nigerian stock exchange. The companies are Total, Forte Oil, Japual Oil and Maritime Services, Eterna, MRS, Oando, Seplat, Rak Unity, Conoil, and Capital Oil. The respondents include senior managers, middle managers, or persons with satisfactory knowledge and/or relevant experience on lean inventory management and practices, and how they affect marketing performance. For each company in our sample, two (2) representatives are purposively selected from each of the six functional departments to include: marketing, procurement/purchasing, production, customer-service, and quality assurance departments.

### Measurement and Instrument

Data collection is based on questionnaire instrument structured in Likert format with 5 options. While the reliability of the instrument is determined based on the Cronbach Alpha method, content validity is based on opinions of two industry experts and two teaching professionals. For empirical analysis, the responses are converted into an interval scale using the SPSS variable transformation window. The descriptive analysis of the variables and their measures are shown in Table 1.

**Table 1: Descriptive Analysis**

| Item/Measure | Description | $\bar{x}$ | $\sigma$ | Remark |
|---|---|---|---|---|
| **Just in Time (JIT): Cronbach Alpha = 0.872** | | | | |
| JIT1 | Just in Time Production | 4.39 | 0.901 | Great Extent |
| JIT2 | Continuous process flow production | 3.93 | 0.871 | Great Extent |
| JIT3 | Pull Systems | 4.22 | 1.020 | Great Extent |
| JIT4 | Cycle-time reductions | 3.94 | 0.930 | Great Extent |
| JIT5 | Just in Time Purchasing | 4.19 | 0.896 | Great Extent |
| **Total Preventive Maintenance (TPM): Alpha = 0.850** | | | | |
| TPM1 | Autonomous maintenance | 3.79 | 0.534 | Great Extent |
| TPM2 | Planned maintenance | 3.75 | 0.564 | Great Extent |
| TPM3 | Safety, Health and Environment | 3.79 | 0.606 | Great Extent |
| TPM4 | Maintenance reduction | 3.77 | 0.639 | Great Extent |
| TPM5 | Employee Training | 3.79 | 0.629 | Great Extent |
| **Total Quality Management (TQM): Alpha = 0.859** | | | | |
| TQM1 | Competitive Benchmarking | 4.30 | 0.972 | Great Extent |
| TQM2 | Quality management programs | 4.18 | 1.057 | Great Extent |
| TQM3 | Process capability measurements | 4.31 | 1.088 | Great Extent |
| TQM4 | Formal continuous improvement program | 4.12 | 0.822 | Great Extent |
| TQM5 | Supplier quality management | 4.34 | 0.900 | Great Extent |
| **Operational Performance (OPP): Alpha = 0.859** | | | | |
| OPP1 | Implementing lean inventory practices has increased our labour productivity | 4.46 | 0.528 | Agree |
| OPP2 | Implementing lean inventory practices has increased the flexibility of our operations | 4.50 | 0.617 | Strongly Agree |
| OPP3 | Implementing lean inventory practices has led to cost saving | 4.54 | 0.514 | Strongly Agree |
| OPP4 | Implementing lean inventory practices has led to reduction in lead time production | 4.47 | 0.640 | Agree |
| OPP5 | Implementing lean inventory practices has led to reduction in inventory level | 4.53 | 0.515 | Strongly Agree |

**Empirical Model/Strategy**

To examine the effects of just in time, total preventive maintenance, and total quality management on firm operational performance, we specify the following cross-sectional regression model:

$$OPP_i = \alpha_0 + \alpha_1 JIT_i + \alpha_2 TPM_i + \alpha_3 TQM_i + \epsilon_i \quad (1)$$

Where $\alpha_0$ is the regression intercept which captures the average operational performance when all the right-hand side variables are jointly zero; $\alpha_1, \alpha_2$, and $\alpha_3$ are the main slope coefficients representing the individual effects of just in time, total preventive maintenance, and total quality management; and $\epsilon_i$ is the error term that represent factors that are not included in the model.

**EMPIRICAL ANALYSIS**

Table 2 presents the regression results for the relationship between just in time and operational performance. Panel A presents the model estimates while Panel B reports the goodness of fit statistics and diagnostic tests. The estimation is based on Huber-White standard errors which are consistent and robust even in the presence of heteroskedasticity.

**Table 2: Regression Results (DV = Operational Performance)**

| Variable | Coefficient | P-value |
|---|---|---|
| **Panel A: Model Estimates** | | |
| Intercept ($\alpha_0$) | -1.7942*** | 0.0006 |
| JIT ($\alpha_1$) | 0.1420** | 0.0345 |
| TPM ($\alpha_2$) | 0.1734 | 0.1572 |
| TQM ($\alpha_3$) | 0.2723*** | 0.0045 |
| **Panel B: Goodness of Fit Statistics** | | |
| $R^2$ | 0.3026 | – |
| $\bar{R}^2$ | 0.2865 | – |
| $F$-statistic | 18.808*** | 0.0000 |
| $DW$ statistic | 1.5809 | – |
| LM Statistic (Serial Correlation) | 4.5979 | 1.0004 |

****indicates significance at 0.05 level**
*****indicates significance at 0.01 level**

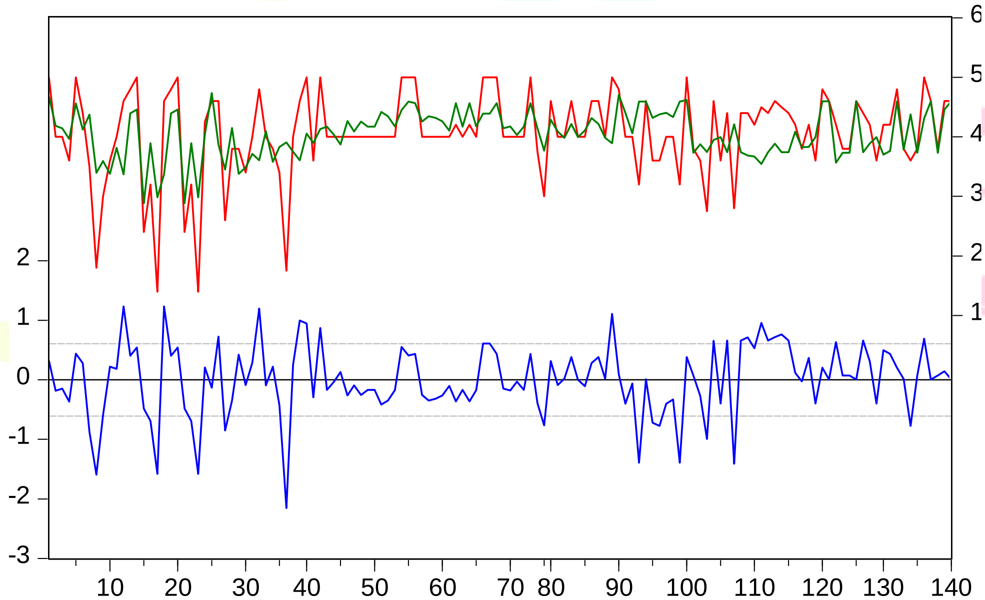


**Figure 1: Regression Residuals**

From Panel B of Table 2, the $\bar{R}^2$ of 0.2865 indicates that the regression model is poorly explained as approximately 29% of the model variation are due to the combined effects of the regressors. In other words, firm operational performance responds much more to factors not included in the specified regression model than the included explanatory variables. However, the p-value of the F-statistic is almost zero, and indication that the estimated model is highly statistically significant. Further, although, the Durbin-Watson ($DW = 1.5809$) is below its ideal value of 2, it is very much greater than the $R^2 (= 0.3026)$, indicating that our estimation results are not spurious in the sense of Granger and Newbold (1974). Also, the LM statistic has a p-value of 1.0004, and hence fails to reject the null hypothesis of no serial correlation in the data. Finally, as shown in Figure 1, the regression residuals exhibits stationarity features, hence, the fitted model is a plausible description of our cross-sectional data.

**Just in Time and Operational Performance**

Our first objective is to determine the extent to which just in time practices can influence firm operational performance. Literature suggests that just in time has a positive relationship with firm performance. According to Cua et al. (2001) just in time practices such as set-up time reduction and pull system production, require employees to be trained to perform multiple tasks and to be involved in the improvement efforts, can help address two major forms of waste: namely, work-in-process inventory and unnecessary delays in flow time. Similarly, Gunasekaran and Lyu (1997) opined that just in time is a system that produces the required items at the time and in the quantities needed. All these imply that implementing just in time strategy can increase productivity and lead to higher operational performance. Therefore, we expected, *apriori*, that the JIT coefficient in the operational performance model would be positive and highly significant.

Consistent with our expectation, *apriori*, we find that just in time strategy has a positive and significant effect on operational performance. As evident in Panel A of Table 2, the coefficient on JIT is 0.1420 showing that just in time and operational performance move in the same direction. Also, the estimated JIT coefficient is sizable and associated with a p-value of 0.0345 indicating that the effect of just in time on operational performance is both statistically and economically significant. This implies that implementing just in time strategies would lead to higher operational performance in terms of labour productivity, flexibility of operations, cost saving, lead time reduction and reduction in inventory level. This has also confirmed the widely held view that just in time is a continuous improvement strategy that focuses on the identification and elimination of all forms of waste, including excess inventories, material movements, production steps, scrap losses, rejects and rework within the production function (Brox & Fader, 2002). This finding also agrees with several previous studies including Shaw and Ward (2003), who find that lean bundles including just in time practices significantly affect operational performance of US manufacturing firms, Demeter and Matyusz (2011), who find that just in time practices are powerful lean manufacturing tools for improving inventory turnover, and Bon and Garai (2011), who find that just in time practice enhances inventory management through reduction of inventory level.

**Total Preventive Maintenance and Operational Performance**

Our second objective is to determine the extent to which total preventive maintenance can influence firm operational performance. Literature suggests that total preventive maintenance is among the lean practices that can improve operational performance through waste and accident reduction (Panwar et al. 2017). According to Shaw and Ward (2003), total preventive maintenance is a combination practices that are primarily designed to optimize the effectiveness of equipment. Thus, implementing total preventive maintenance strategy can lead to higher operational performance. Therefore, we expected, *apriori*, that the TPM coefficient in the operational performance model would be positive and highly significant.

Our finding shows that although, total preventive maintenance has the expected positive relationship with operational performance, its effect is not statistically significant. This is evident in Panel A of Table 2, which shows that the coefficient on TPM is estimated at 0.1734 with a p-value of 0.1572, which is much higher than all conventional significance levels. However, the size of this coefficient is appreciable, suggesting that it is economically significant. This implies that implementing total preventive maintenance strategies would improve operational performance (in terms of labour productivity, flexibility of operations, cost saving, lead time reduction and reduction in inventory level) but only in economic sense. This finding also agrees with several previous studies including Cua et al. (2001) and Shaw and Ward (2003). While Cua et al. (2001) found that implementing total productive maintenance leads to higher operational performance, Shaw and Ward (2003) found that lean bundles which include amongst others total preventive maintenance significantly explain approximately 23% of the variance of operational performance of US manufacturing plants.

**Total Quality Management and Operational Performance**

Our third objective is to determine the extent to which total quality management can influence firm operational performance. Literature suggests that total quality management is among the lean practices that can improve operational performance through waste reduction. According to Shaw and Ward (2003), total quality management is a combination of quality processes and products that enhance inventory management. Thus, implementing total quality management strategy can lead to higher operational performance. Therefore, we expected, *apriori*, that the TQM coefficient in the operational performance model would be positive and highly significant.

Consistent with our expectation, *apriori*, our regression results show that total quality management strategy has a positive and highly significant effect on operational performance. As shown in Panel A of Table 2, the coefficient on TQM is 0.2723 showing that total quality management and operational performance move in the same direction. Also, the estimated TQM coefficient is associated with a p-value of 0.0045 indicating that the effect of total quality management on operational performance is statistically significant at less than 1% level. Further, the size of the TQM coefficient suggests that the positive effect of total quality management is also economically significant. This implies that implementing total quality management strategies would lead to higher operational performance in terms of labour productivity, flexibility of operations, cost saving, lead time reduction and reduction in inventory level. This finding also agrees with several previous studies including Baird et al. (2011), Dal Pont, Furlan and Vinelli (2008) and Nnadi and Ndu Oko (2019). Their findings suggest that total quality management can lead to higher operational performance.

**CONCLUSION**

The aim of this study is to examine the effects of just in time, total preventive maintenance, and total quality management on firm operational performance. The cross-sectional regression results based on survey data collected from 100 managers representing 10 listed oil and gas companies in Nigeria lead to the following conclusions:

There is evidence that just in time, total preventive maintenance, and total quality management all have a positive relationship with firm operational performance. However, the effect total quality management is much higher in magnitude while the effect of total preventive maintenance is not statistically significant. The combined effect of the three lean inventory strategies significantly explains about 29% of the total variation in firm operational performance. Therefore, we contend that integration of lean inventory strategies in the existing business model would significantly enhance the operational performance of oil and gas companies in Nigeria. However, more emphasis should be placed on total quality management and just in time strategies.

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