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RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Testing the relationship between lean management practices and achieving excellence performance: A sample of workers in the electricity production sector in Illizi, Algeria

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Abstract

Purpose: This study aims to investigate the relationship between lean management practices and achieving excellence performance in the electricity production sector in the state of Illizi, Algeria, with a particular focus on identifying the most influential lean management tools. Method: The study is based on a sample of 180 workers, and data were collected through a structured questionnaire. The analysis was conducted using SPSS, applying Spearman's rank correlation coefficient and the Wilcoxon Single Sample Classification Test. Additionally, a Multi-Layer Perceptron (MLP) artificial neural network model was employed to evaluate the relative importance of lean management variables and assess prediction accuracy. Findings: The results indicate a statistically significant and positive relationship between lean management practices and excellence performance. A strong correlation was found between multi-functional workers and excellence performance (r = 0.747), while standardized work showed a moderate positive correlation (r = 0.629). The neural network model achieved an accuracy rate of 88.7%, with multi-functional workers identified as the most influential factor (100% importance), followed by standardized work (73.9%). Conclusion: The study contributes to the literature by demonstrating the critical role of lean management practices—particularly human-centered factors—in achieving excellence performance.

Keywords: Lean Management, Excellence Performance, Multi-functional Workers, Standardized Work, Continuous Improvement, Electricity Production Sector.

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1. Introduction

Today's business environment is characterized by intense competition and rapid change, along with a climate of uncertainty. This has led organizations to continuously strive to adopt effective management approaches that enhance efficiency, reduce waste, and achieve a sustainable competitive advantage. Lean management has emerged as one of the most influential management philosophies, aiming to maximize value while minimizing unnecessary processes and resources. Originating from the Toyota Production System, it is a management practice based on the philosophy of continuous improvement of processes by increasing value for the customer or reducing activities that do not create added value (Muda), process diversity (Mura), and eliminating poor working conditions (Muri). (Kelendar, 2020, p. 915)

In this context, achieving excellence performance is a strategic objective for organizations seeking long-term success. Excellence performance is reflected in improved productivity, enhanced output quality, increased customer satisfaction, innovation, and financial stability.

The relationship between lean management and excellence performance has garnered significant academic and practical attention due to the positive impact lean management principles have had on organizational outcomes by streamlining processes, enhancing operational efficiency, fostering a culture of continuous improvement, and encouraging employee empowerment.

Most studies that have addressed the topic of achieving excellence and good performance use analytical tools such as correlation, simple and multiple regression, and structural equations to determine the relationship between lean management and excellence performance. However, this study attempts to verify the relative importance of lean management tools in achieving excellence performance through lean management tools using artificial neural networks, in addition to analyzing the relationship using Spearman's correlation coefficient.

1.1.The Problem

What is the nature of the relationship between lean management practices and achieving excellence performance in the electricity sector in the state of Illizi, in Algeria? and Which lean management tool is most important in achieving excellence performance?

1.2. Hypotheses

H1: The level of implementation of lean management and achievement of excellence performance in the electricity production sector in the state of Illizi is an average level.

H2: There is a positive relationship between lean management practices and achieving excellence performance.

H3: Multi-skilled workers and standardized work are the most important lean management tools for achieving excellence performance.

1.3. Importance of the study

The study is of great importance because achieving excellence performance and outperforming competitors is a priority for business organizations in various fields. The services sector, especially the electricity sector, is a sensitive sector that is linked to meeting a need that the customer deals with on a daily basis and around the clock.

2. Literature Review

2.1. Lean Manufacturing

Womack, Jones, & Roos define lean production (a term coined by IMVP researcher John Krafcik) as production that uses less of everything compared to mass production. This system relies on using half the human labor in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product in half the time. It also requires keeping less than half the required inventory on-site, while producing fewer defects and a larger, more attractive product assortment (womack, Jones, & Roos, 1990, p. 13). They also add that lean or zero-waste production is a set of tools and methodologies focused on continuous process improvement, with the goal of eliminating all non-value-added activities and reducing waste within the organization (Benítez, López, & Real, 2018, p. 191). This definition focuses on the process aspect through the use of available resources and relies on a set of tools that achieve waste reduction while maintaining quality.

On the other hand, Eric Ries believes that lean manufacturing emerged in Toyota factories beginning in the 1950s at the hands of Taiichi Ohno and Shigeo Shingo. The lean philosophy radically transformed the management of supply chains and production systems. This methodology relies on valuing the skills and creativity of all employees, in addition to reducing production buffers, producing on time, reducing inventories, and accelerating the production cycle. This methodology has demonstrated to the entire world the difference between creating value and waste, and has also highlighted how quality can be incorporated throughout the various stages of product development (Ries, 2016, p. 26). With this definition, the researcher gives a philosophical dimension to lean manufacturing, with a focus on the human aspect represented by the creativity and skills of workers.

From the above, it can be said that the concepts of production and manufacturing refer to the same meaning, and that lean manufacturing or production expresses those tools and methods adopted by factories with the aim of managing production in a way that allows for reducing the use of various production factors and eliminating various activities that do not create value or cause waste, while maintaining quality in the various stages of the production or manufacturing processes.

Although the term Lean has been widely known and widespread since the 1990s, and has become common in many sectors of activity, providing a synthetic and appropriate definition for it is still difficult, as this term has little control among companies, starting from its appearance in Toyota in the 1950s, despite the wide scope of documentation and study of this term, and despite the many trainings that this field has known by various companies, and perhaps the difficulty of defining its concept is due primarily to the nature of Lean, which is characterized by precision and depth, despite its reputation for being based on common sense principles (Hohmann, 2012, p. 11).

From this standpoint, Shah & Ward see Lean as a business philosophy that defines the means of improvement in the production system with a focus on identifying and eliminating all types of waste, and reducing or minimizing the variance from demand to supply (Benítez, López, & Real, 2018, p. 190). Here, researchers focus on the aspect of thinking in defining Lean as a means of improving production. In the same context, (Duc et all) adds that Lean depends on a culture that has a special mentality and behaviors that are considered the basis upon which methods and tools are based for improving performance by eliminating waste (Duc, Fantaine, Hoenen, & Wellhoff, 2020).

Sherehy believes that Lean is the necessary capabilities through which the organization achieves Flexibility, which makes it more responsive to market trends, in addition to providing quality goods and services quickly and at lower costs than competitors. Lean management and lean thinking are two intertwined concepts, as described by Womak & Jones as the ideal combination for eliminating waste. This combination aims to continuously improve processes and their outputs and the endless search for perfection, relying primarily on what is known as Kaizen (Fresno, 2012, p. 91).

From the previous definitions, it becomes clear that Lean is a modern term in the field of business management. It expresses a set of actions and behaviors based on a philosophy and mentality that aims to achieve effectiveness by relying on reducing waste in resources while responding to customer requests.

2.2. Types of waste

Field observers, led by Taiichi Ohno, realized that with any value-creating activity comes an activity that adds cost, consumes resources, time, energy, etc., but without adding value. This is known as " Muda." (Hohmann, 2012, p. 17).

Taiichi Ohno, the father of the Toyota Production System, identified seven types of waste (Muda): Overproduction, Waiting, Transportation, Inventory, Motion, Overprocessing, and Defects. Later, the eighth waste of non-utilized talent (Skills) was added to the original seven. (Overproduction, Waiting, Transportation, Inventory, Motion, Overprocessing, Defects). Liker adds another form of waste : unused employee creativity, i.e., skills, ideas, time, improvements, and learning opportunities wasted by not engaging or listening to employees. Womack & Jones adds an additional source of waste : designing products that don't meet customer needs (Kelendar, 2020, p. 917).

2.3. Principles of lean management

In their book on lean management, Womack and Jones presented five principles of lean management, which are as follows :

- **Defining Value :** Value is the starting point of the lean management approach, and value is determined by the end customer. The producer is responsible for creating the value that fulfills and satisfies customer desires, which is extremely difficult (Womack & Jones, 2009, p. 4).
- **Value Chain :** The value chain represents the set of necessary activities involved in the various stages of a product, whether it is a good, a service, or both. This chain includes three stages: problem-solving, information management, and physical transformation (Womack & Jones, 2009, pp. 8-9).
- **Obtaining Flows :** After accurately identifying value and establishing the value chain for products and their various stages, the various stages that create value are organized to obtain the required flows (Womack & Jones, 2009, p. 11).
- **Adopting a Pull System :** Unlike the prevalent batch production system, which relied on a push system, the production process in lean management relies on a pull system, where the process is driven by customer demand (Womack & Jones, 2009, p. 14).
- **Pursuit of perfection :** After completing the various previous stages, the organization aims for perfection by offering a product that meets customer expectations. This perfection makes all stakeholders in the various stages of the production process pay attention to everything that goes into the process, from time and cost to work space and effort, to achieve customer satisfaction (Womack & Jones, 2009, pp. 15-16).

2.4. Lean Management Pillars

Ohno described the Toyota Production System, (which later became Lean Manufacturing and then Lean Management), as a set of techniques designed to reduce costs and eliminate waste. This system was built on two basic pillars : Just In Time, which means production on time, and Jidoka, which expresses automation (Wilson, 2010, pp. 11-12).

The Toyota System initially relied on two basic pillars, each of which comprised a set of tools. However, over time and the spread of the Lean Management philosophy, many models emerged. In this regard. Stewart adds that over the years, he observed many different types of Lean Houses within the Toyota System (TPS). Many of these houses were complex and intertwined with many different threads. At the heart of all the houses used to represent the TPS system were the same basic elements. However, many people always added additional elements (stewart, 2011, p. 26).

Researchers have presented many models for lean management Pillars, but there has been no agreement on which of these lean management tools is the main Pillars. The following are the most important of these Pillars (Alzrooq, Bounehas, 2025):

- **Continuous improvement(Kaizen) :** Kaizen is a philosophy and practice that views productivity improvement as a gradual and systematic process. It is a Japanese term meaning "change for the better." The concept of Kaizen encompasses a broad range of ideas and includes making the workplace more efficient and effective by creating a team atmosphere, improving daily procedures, ensuring employee satisfaction, and making work more satisfying, less stressful, and safer (Punna Rao, Nallusamy, & Narayanan, 2017, p. 366).

- **5s way :** The term "5S" refers to an approach whose acronym stands for the five actions (Seiri, Seiton, Seiso, Seiketsu, Shitsuke) that all begin with the letter "S" (Hohmann, 2010, p. 3).
- **Standardized work:** According to (Lu et al. 2015), standardized work within the lean management concept ensures improved organizational efficiency, increased productivity, and reduced order processing time. It also allows employees to increase their creativity by generating improvement proposals, in addition to improving employee discipline and increasing commitment (Ratter & Nader, 2022, p. 362). Stewart adds that standardized work applies to products, processes, systems, and procedures, as standardization must be achieved before any improvement can occur. Without standardization within an organization, it is like building a house on sand (stewart, 2011, p. 27).

2.5. Definition of Business excellence

Business excellence can be defined as "excellence in strategies, business practices and performance results related to stakeholders that are validated through assessments using proven business excellence models." (Mohammad, Mann, Grigg, & Wagner, 2011) It is a systematic and continuous approach to improving an organization's performance to achieve exceptional results, including sustainable growth, customer satisfaction, and operational efficiency. This includes implementing best practices, leveraging excellence models, and integrating continuous improvement principles into the company's culture to create value for all stakeholders.

2.6. International Models of Excellence

There are many international models of excellence that have been created, and the following are the three most important international models:

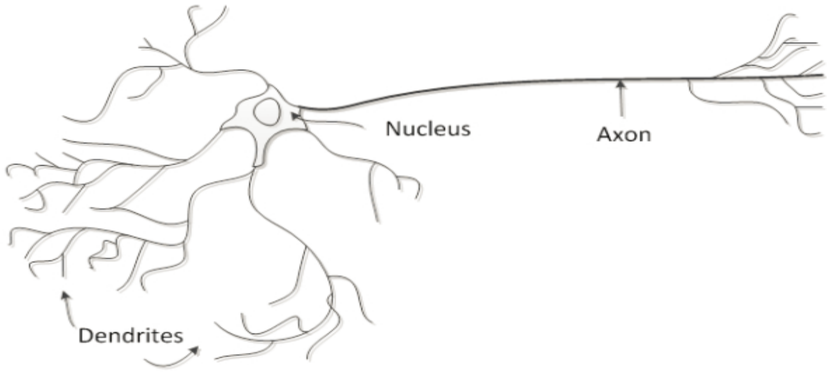
- **The Deming Prize:** The Deming Prize was established in 1951 by the Union of Japanese Scientists and Engineers (JUSE) in honor of W. Edwards Deming's legendary influence on Japanese industry. The award recognizes excellence in implementing quality control at the company level (Porter & Tanner, 2004, p. 7).
- **The EFQM Excellence Model:** The EFQM Excellence Model is the most well-known and widely used reference in Europe for improving the Total Quality Management system. This model defines the organization's strategy and allows managers to understand the cause-and-effect relationships between the criteria of enabling factors (enablers) and the results they achieve (outcome criteria). The EFQM Excellence Model aims to support organizations in achieving business excellence through continuous improvement, learning, and innovation. This is done using a mixed methodology that includes self-assessment and external evaluation processes (carried out by independent experts). This provides confirmation of the initial diagnosis conducted by the organization itself. Information is obtained about what the organization is doing to achieve its goals, how it is developing its plans, programs, and planned operations, what resources and alliances it has to reach its goals, as well as the impact its actions have had on key stakeholders (Mora, García, & Cristobal, 2015, p. 1639).
- **The MBNQA model :** The American model is named in memory of Malcolm Baldrige, who served as U.S. Secretary of Commerce from 1981 until his untimely death in a rodeo accident in 1987. Malcolm Baldrige was instrumental in the long-term prosperity of the American economy. The Malcolm Baldrige National Quality Award was launched in 1988. The award framework is the most well-known excellence award model and the world's most widely used excellence framework for self-assessment. The annual award was originally used to honor U.S. private sector companies for business excellence and quality. In 1999, education and healthcare categories were introduced (Porter & Tanner, 2004, p. 7).

2.7. Artificial neural networks

Artificial neural networks are computer algorithms capable of solving complex problems by simulating brain processes in a simplified way (Zacharis, 2016, p. 18).An artificial neural network is designed to mimic the structure of a natural neuron, and therefore resembles the human brain. (Dung, Thomas, &

Oyerinde, 2023, p. 2), it has the same structure: it consists of a nucleus (the processing unit), dendrites (the input), and an axon (the output) (Dung, Thomas, & Oyerinde, 2023, p. 2).

Figure 1: Natural Neuron.



Source: Dung, Thomas, & Oyerinde, 2023, p. 2

The theoretical foundation of artificial neural networks was laid in 1943. Artificial neural networks, which mimic the workings of the human brain, have become an increasingly influential tool in machine learning and data analysis. However, due to hardware limitations, their development in the 20th century was largely theoretical. With the increasing processing power of computers and the availability of memory, artificial neural networks have become a widespread tool for data analysis. Since the late 2000s. (Weiss, Karimijafarbigloo, Roggenbuck, & Rödiger, 2022, p. 2)Artificial neural networks are non-parametric mathematical models consisting of an interconnected set of processing units called "neurons," which are adaptable, trainable, and contain empirical knowledge (Aryadoust & Goh, 2014, p. 4).

Artificial neural networks, regardless of their type, all share the following characteristics (Adam, Gamal El-Din, & Mohammed, 2020, p. 90).

- Distributed Representation .
- Local Processing
- Non Linear Processing

Compared to traditional statistical models for prediction and classification, artificial neural networks (ANNs) offer several important advantages: They are highly adaptable and do not impose any assumptions on the relationships between dependent and independent variables, such as normality, linearity, homogeneity of variance, and error independence—preconditions for, for example, multiple linear regression. Therefore, if the relationship between variables is linear, the ANNs learn the linear structure and converge on the linear regression; if the relationship is nonlinear, the ANNs search for the best nonlinear structure to fit the data (Aryadoust & Goh, 2014, p. 4).

2.8. Multi-Layer Perceptron MLP (Ainous, 2022, p. 342)

The multi-layer Perceptron network is one of the most widely used neural networks in the field of prediction, The idea of this network is to use previous values as inputs to the network, and to collect the values of weights in the layer For hidden inputs, the Sigmoid transfer function is used. As for the output layer of this network, it receives the outputs of the hidden layer and applies them to it Linear function transformation, where the predicted values in the time series are produced. The model used in forecasting using MLP models is calculated with the following relationship :

$$Xu^{\wedge} = W_0 + \sum_{j=1}^{h} W_i f_j \left[\sum_{i=1}^{n} W_{ij}\, x(k-1)\right] + W_{j0} \text{ ..... (1)}$$

Whereas:

h: is the number of hidden layer units.

n: the weights between the input and the hidden layer

wij: the weights between the hidden layer and the output layer

Fj: stimulus function in hidden units

3. Methodology

This article relies on the descriptive approach, The correlation was also tested using Spearman's rank correlation coefficient, in addition to conducting a logistic regression test. And The Multi-Layer Receiver (MLP) module of IBM SPSS 27 was used to build the neural network model and test its accuracy. The MLP neural network employs a backpropagation learning algorithm, which uses a gradient of origins to weights to minimize functional error.

3.1. Sample

The study sample consisted of 288 employees in the electricity sector in the Illizi province of Algeria. A random sample of 200 questionnaires was distributed, and 180 were deemed valid for analysis.

3.2. Variables

The independent variable comprises four lean management tools: workplace organization, continuous improvement, cross-functional employees, and standardized work. These variables are assigned a five-point scale ranging from strongly disagree to strongly agree.

The dependent variable is excellence performance, which encompasses the performance of several elements, including Strategic Excellence, Leadership Excellence, Human resource excellence, Operational Excellence, Resources and Partners Excellence. The analysis relied on the average responses provided by employees regarding outstanding performance. Averages of four (4)or higher represent a high level of outstanding performance, while averages below four (4) represent a lower level. Therefore, the result is (1 = outstanding performance, 0 = lower performance).

3.3. Questionnaire Reliability

Table 1: Reliability test.

Variables	Number of items	Cronbach's Alpha
Organizing the workplace	5	0,736
Continuous improvement	5	0,753
Multi-functional workers	5	0,700
Standardized work	5	0,805
Elements of lean management h	20	0,904
Strategic Excellence	4	0,871
Leadership Excellence	5	0,828
Human resource excellence	5	0,762
Operational Excellence	5	0,695
Resources and Partners Excellence	6	0,763
Excellence Performance	25	0,929
Tolal	45	0,953

Source : Based on the outputs of Spss.

In order to verify the validity of the study instrument, the reliability coefficient of Cronbach's alpha was used. The table above shows the reliability coefficient for the various dimensions of the questionnaire (Abdelali, Djamel 2026). For the elements of lean management, the reliability coefficient reached 0,904, which is a strong coefficient that proves the reliability of the statements in this dimension. The reliability coefficient for the dimensions of this variable ranged between 0,700 and 0.805. As for the dimension of Exellence performance, its percentage reached 0.929, and the reliability coefficient for the dimensions of this variable ranged between 0.695 and 0.871. On the other hand, the overall reliability coefficient reached 0.953, which is an excellent percentage to express the strength of the questionnaire. Internal consistency of questionnaire items.

4.Test results

4.1. Diagnostic tests

Before conducting the necessary tests, it will be confirmed that the data follows a normal distribution, as shown in the following table:

Table 2: Normal distribution test**.**

	Kolmogorov-Smirnov		Shapiro-Wilk	
Variables	Statistic	Sig	Statistic	Sig
X1	0,202	0,000	0,938	0,000
X2	0,095	0,000	0,974	0,002
X3	0,136	0,000	0,964	0,000
X4	0,166	0,000	0,925	0,000
y	0,120	0,000	0,955	0,000

Source : Based on the outputs of Spss.

In normality hypotheses, the null hypothesis (H_0) is that the data follow a normal distribution, while the alternative hypothesis is that the data do not follow a normal distribution. From the table, it is clear to us that the data related to the study variables do not follow a normal distribution, as the level of statistical significance is less than 5% in both the Kolmogorov-Smirnov and Shapiro-Wilk statistics, which means rejecting the null hypothesis and accepting the alternative hypothesis. For this reason, the appropriate tests in this study are non-parametric tests.

4.2. Testing the level of variables

Table 3: Summary of the Wilcoxon Single Sample Classification Test.

Variables	Wilcoxon statistic	Standard error	Standardized test statistics	Sig	Hypothetical median	observed median
X1	15735,000	691,686	11,103	0,000	3	4
X2	14026,000	641,187	10,541	0,000	3	4
X3	13580,000	640,826	9,851	0,000	3	4
X4	13739,000	657,333	9,453	0,000	3	4
y	14802,500	676,316	10,372	0,000	3	3.92

Source : Based on the outputs of Spss.

The table above shows the Wilcoxon Single Sample Classification Test, which aims to determine the degree of the variables before conducting the relationship test between them. This test is the non-parametric alternative to the one-t-test. In this study, the median was set at 3 points and the variable classification test was performed. As shown in the table, all tests are statistically significant, which means rejecting the null hypotheses. The classification of the variables was greater than the median by 1 for the independent variables and by 0.92 for the dependent variable, which explains the presence of lean management practices and achieving excellence performance to a high degree.

4.3. Studying the Relationship

Table 4: Spearman'sCorrelation coefficient

Variables	Correlation coefficient	Sig
Organizing the workplace	0,471**	0,000
Continuous improvement	0,596**	0,000
Multi-functional workers	0,747**	0,000
Standardized work	0,629**	0,000
** : The correlation is significant at the level 0.01		

Source : Based on the outputs of Spss.

To determine the relationship between lean management practices and excellence performance, Spearman's correlation coefficient was used. The table shows the value of the correlation coefficient between the independent and dependent variables. The correlation coefficient between the workplace organization dimension and excellence performance was estimated at 0.471, which is a lower than average coefficient. As for the continuous improvement dimension, its correlation coefficient was estimated at 0.596, which indicates a moderate correlation between the two variables. Meanwhile, the correlation coefficient between the multi-functional workers variable and excellence performance was estimated at 0.747, which indicates a high correlation between the variables. Finally, the correlation coefficient between the standard work dimension and excellence performance was estimated at 0.629, which indicates a moderate correlation between the two variables. All the coefficients were statistically significant and positive, which means that there is a direct relationship between the independent variables, represented by lean management practices, and the dependent variable, which is excellence performance.

4.4. Results of Multilayer Perceptron Neural Network

4.4.1. Summary of Model

This study aims to investigate the possibility of using a multi-layer neural network (MLP) to determine the accuracy of predicting the performance of the electricity sector in the state of Illizi, through the analysis of data collected from the questionnaire. In Table 2, we find information about the datasets used in building the artificial neural network model.

Table 5: Summary of observation processing

		N	Percent
Sample	**Training**	127	70,6%
	Testing	53	29,4%
Valid		180	100%
Excluded		0	
Total		180	100%

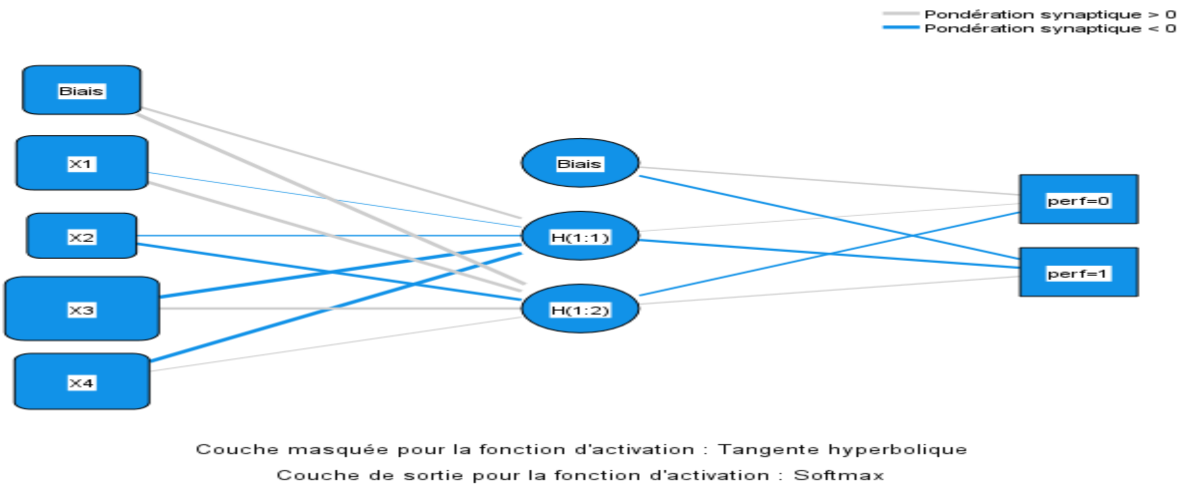
Source: Based on the outputs of Spss.

The table shows the sample division between training and testing, with 70,6% allocated to the training group and 29,4% to the testing group. and The program did not exclude any values from the studied sample.

4.4.2. Artificial Neural Network Diagram

The figure 02 illustrates the network diagram extracted from SPSS software to predict performance outcomes in the electricity sector of Illizi province. This prediction relies, as shown, on four inputs representing the four input nodes: workplace organization, continuous improvement, Multi-functional workers, and standard work. The diagram also reveals two hidden nodes and two output nodes representing performance.

Figure 2: Network diagram.



Source : Based on the outputs of Spss.

As shown in Table 3, the information relates to the training and sample testing results. The entropy error (Errer d'entropie) decreases during the training phase, with the small value of 35.21 indicating the model's strength in predicting the training outcome. According to this table, the percentage of incorrect predictions based on the sample training and testing is small, at 8.7% and 11.3%, respectively.

Table 6: Summary of models.

Training	**Cross Entropy error**	**35,210**
	Percent Incorrect Predictions	8,7%
Testing	Cross Entropy error	14,865
	Percent Incorrect Predictions	11,3%

Source : Based on the outputs of Spss.

A prediction matrix table is presented for the categorical dependent outcome variable, by segmentation and total. In each case, the predicted outcome is defined as excellence performance if the probability of prediction is greater than 0.5. The network of MLP correctly classified 116 out of 127 individuals in the training sample and 47 out of 52 individuals in the test sample. Overall, 91.3% of the training cases were correctly classified in the training sample and 88.7% in the test sample.

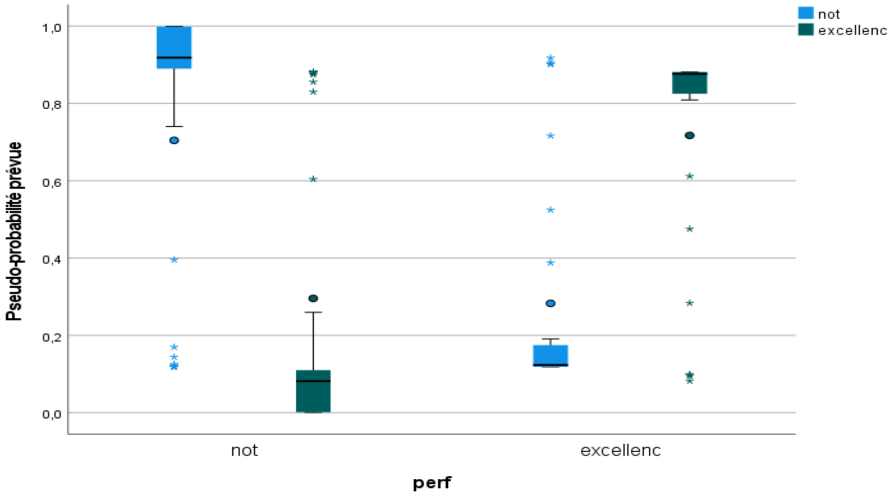
Table 7: Prediction matrix.

Sample	**Observed**	**predicted**		
		Failure	**success**	**Percent correct**
Training	not	67	8	89,3%
	excellence	3	49	94,2%
	Overall Percent	55,1%	44,9%	**91,3%**
Testing	not	23	3	88,5%
	excellence	3	24	88,9%
	Overall Percent	49,1%	50,9%	**88,7%**

Source : Based on the outputs of Spss.

To further illustrate, the figure shows the box plots of the predicted false probabilities for the dependent variable based on the complete dataset. In each box plot, values greater than 0.5 indicate correct predictions

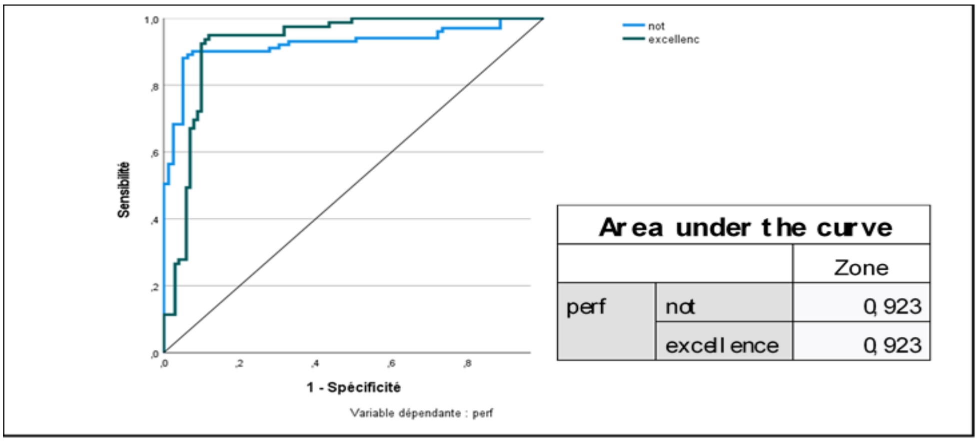
Figure 3: Predicted Classification Probabilities for Performance Categories



Source : Based on the outputs of Spss.

As shown in the diagram, the first box plot, on the left, Illustrates the probability of excellence performance being classified as not excellence. The second box plot shows the probability of performance being classified as not excellence even though it was actually excellence. The third box plot, for results depicted as excellence, shows the probability of them being classified as not excellence. The right-hand box plot shows the probability of excellence performance actually being classified as excellence.

Figure 4: Receiver Operating Characteristic (ROC) Curve and Area Under the Curve (AUC) for Performance Classification



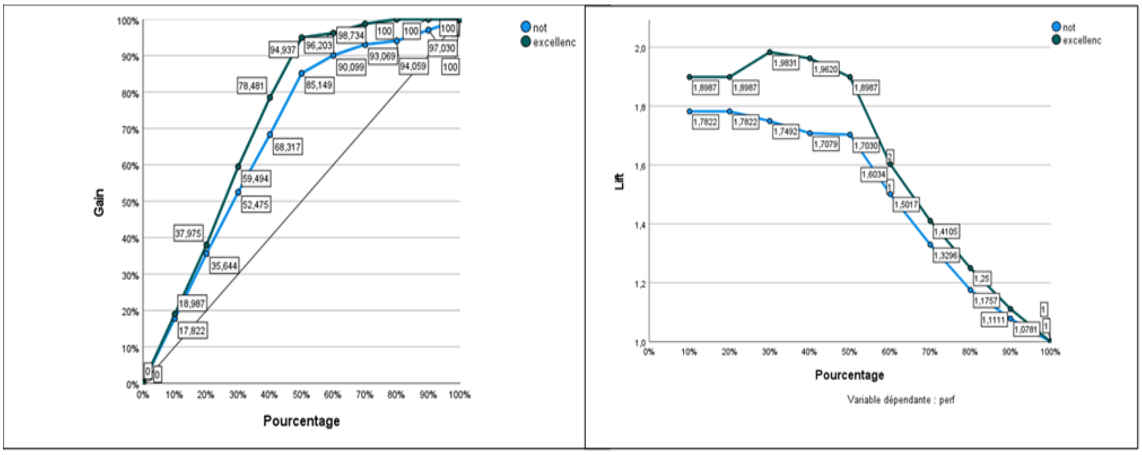
Source : Based on the outputs of Spss.

The figure 04 represents the ROC curve, a sensitivity-specificity graph showing the classification performance across all possible threshold values. The 45-degree diagonal line from the upper right corner of the graph to the lower left corner represents a random guessing scenario for the class.

The further the curve deviates by 45 degrees from the baseline, the greater the classification accuracy.

The area under the ROC curve indicates that if the performance category is chosen at random from the good category and the performance category is not excellence, the probability that the model-predicted pseudo-probability of the first performance being expected to be in the excellence category is higher than the approximate probability of the second performance being expected to be in the excellence category is 0,923.

Figure 5: Cumulative Gain and Lift Charts for Model Performance Evaluation

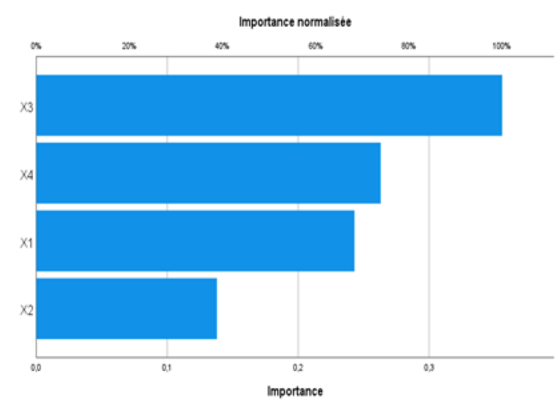


Source : Based on the outputs of Spss.

Lift and gain charts are visual tools for evaluating the performance of classification models. Unlike a confusion matrix, which evaluates models across the entire set, a gain or leverage chart assesses a model's performance within a portion of the set. The leverage chart uses a segment of the dataset to provide a clearer picture of the benefits of using the model compared to not using it. Here, values from the gain chart are used to calculate the leverage factor, which is equal to the percentage divided by the gain.

The graph in Figure 05 illustrates the cumulative gain, which is the proportion of correct classifications obtained by the artificial neural network model compared to the correct classifications that would occur by chance. For example, the fourth point on the failure category curve is approximately (40%, 80%), meaning that if the network evaluates a dataset and sorts all cases according to the pseudo-predictable probability of failure, the top 40% is expected to contain approximately 78,5% of all cases that actually fall into the failure category. Selecting 100% of the evaluated dataset would result in all observed failures within the dataset. The gain is a measure of the classification model's effectiveness and is calculated as the percentage of correct predictions obtained using the model compared to the percentage of correct predictions obtained without a model (the baseline). The higher the curve is above the baseline, the greater the gain. A higher overall gain indicates better performance (Zacharis, 2016).

Figure 6: Importance of independent variables



	Importance	Importance normalisée
X1	0, 243	68, 3 %
X2	0, 138	38, 8 %
X3	0, 356	100, 0 %
X4	0, 263	73, 9 %

Source : Based on the outputs of Spss.

The figure 06 illustrates the importance of the independent variables, ranked from most to least important by percentage. Variable X_3 ranked first with 100% importance, representing the human element through multi-functional employees. Variable X_4 ranked second, explaining 73.9% of the results and representing standard work. Variable X_1 ranked third, explaining 68.3% of the results and representing workplace organization. Variable X_2, representing continuous improvement, ranked fourth with 38.8% importance.

These results demonstrate the crucial role of the human element in achieving excellence performance, alongside the procedures involved in executing operations. Human factors are among the most important contributors to minimizing waste in activity and, consequently, achieving excellence performance.

4.5. Discussion of Results

The results of the Wilcoxon test demonstrated a high degree of implementation of lean management toolsand achievement of excellence performance in the organization under study, contradicting the first hypothesis, which stated that the level of implementation of lean management and achievement of excellence performance in the electricity production sector in the state of Illizi is an average level. The second hypothesis was confirmed, as all correlation coefficients were positive and statistically significant, indicating a positive relationship between lean management practices and achieving excellence performance. The third hypothesis was also confirmed, as the artificial neural network results showed that multi-skilled workers and standardized work are the most important lean management tools for achieving excellence performance.

The relative importance of lean management tools, which highlights the significance of the human element, stems from various factors. Electricity production necessitates highly skilled workers with broad knowledge across different fields, as the process involves diverse technical specializations including electronics, mechanics, hydrocarbons, and transportation. Furthermore, electricity production units in the stqte of Illizi rely on one or two production methods, with the exception of one unit that employs three. This also allows for the mobility of workers between different units and departments. Additionally, the inherent risks of electricity production necessitate well-organized workplaces to prevent accidents and maintain safety and security. The electricity production units in Illizi are equipped with relatively modern equipment, and their production capacity meets the needs of the region, which is characterized by a lower population density compared to northern regions. This explains the relatively low importance of the continuous improvement variable, as the equipment does not require constant upgrades, This would then rely on a radical improvement of the equipment in case of malfunction.

5. Conclusion

This study aimed to examine the relationship between lean management practices and performance excellence. Spearman's rank correlation coefficient was used to analyze the relationship, and the effectiveness of artificial neural networks was tested to determine the relative importance of lean management practices in achieving performance excellence in the electricity production sector in the state of Illizi in Algeria. Data were collected through a questionnaire distributed to employees in this sector. Appropriate tests were then conducted to examine the relationship between lean management and performance excellence. A multi-layered neural network was trained using a backpropagation algorithm to determine the relative importance of lean management practices in contributing to the sector's performance excellence. The results showed that the level of implementation of lean management practices was high, with a score of 4, corresponding to a high level on the five-point Likert scale. Performance excellence also reached a high level, with a score of 3.92. The results also showed a positive correlation between lean management practices and performance excellence. The correlation coefficient for the independent variable, "multi-functional workers," was 0.747, followed by the variable "standard work" with a correlation coefficient of 0.629. The correlation coefficient for the "continuous improvement" variable was 0.596, while the correlation coefficient between organization the workplace and the dependent variable was 0.471.

The accuracy of classifying variables using the artificial neural network was 88.7%. The results showed that the strongest predictive indicator was the multitasking worker index, followed by the standard work index, and then the workplace organization index. The continuous improvement index came in fourth place. This study demonstrates the effectiveness of using artificial neural networks in predicting excellence performance in electricity production units in the Illizi, This is because the application of lean management practices. It also opens avenues for future research to understand the relationship between lean management and excellence performance in other sectors in Algeria.

Statments

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Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethics Approval

This study was conducted in accordance with recognized ethical standards for social science research. As the research involved human participants (employees in the electricity sector), informed consent was obtained from all respondents prior to data collection. Participation was voluntary, and respondents were assured of anonymity and confidentiality. No personal identifying information was collected or disclosed. The study complied with institutional and international ethical guidelines for research involving human participants.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request. Due to privacy and confidentiality considerations, raw data are not publicly accessible.

Author Contributions

• Othmane Blal: Conceptualization, methodology, data collection, formal analysis, writing – original draft.

• Abdellah Bendob: Supervision, validation, statistical analysis support, writing – review and editing.

All authors have read and approved the final version of the manuscript.

Artificial Intelligence Use Statement

The authors declare that no artificial intelligence (AI) tools were used in the generation of the research content, data analysis, or interpretation of results. AI-assisted tools may have been used solely for language editing and formatting purposes, without influencing the scientific integrity of the study.

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