

Article

Assessment of Lean Maturity Levels in Industries of the Luanda Region, Angola

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Abstract: Due to the context of market competitiveness and the economic and financial crisis, companies need to optimize their production systems, tracking the raw material from the suppliers until the final product arrives to the consumer. The Lean philosophy assumes a relevant role for today's industries through its concepts and tools, enabling optimization, increasing revenues, and having the principle of not expropriating the environment. This article aims to analyse the level of maturity reached by industries in Luanda regarding the practices and tools of the Lean philosophy. A Lean graphic model was built, measured by the Lean Enterprise Self-Assessment Tool (LESAT) maturity model through qualitative and quantitative research focusing on the statistics of 87 circumscribed industries at Viana Industrial Development Pole in the Economic Special Zone of Luanda region, Angola. Initially was conducted an analysis to see whether Lean practices and tools were used: 5S, OKJust-In-Time, Kanban, Bottleneck Analysis, Jidoka, Kaizen, Poka-Yoke, SMED, Gemba, Heijunka, Value Stream Mapping, Hoshin Kanri, and Andon. The next steps were to analyse the following: customer value analysis; value chain analysis; analysis of the use of the pulled production system; and analysis of the use of the continuous production flow analysis of continuous improvement. The result shows these industries using the Lean philosophy at a very low level of maturity. Only the 5S tool was known and used. The JIT, Kanban, and Bottleneck Analysis were moderately used. Only 50% of Lean practices were used.

Keywords: Lean philosophy; principles and dimensions of Lean philosophy; maturity of lean philosophy; industry; Angola



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1. Introduction

The economic development of all countries, both developed and emerging, was impacted by the global economic and financial crisis in 2011. This crisis disrupted market competitiveness and presented new challenges [1]. Consequently, economic recovery has occurred at varying speeds, as evidenced by the growth of gross domestic product (GDP) worldwide [2]. However, as noted in [3], growth in emerging markets is projected to increase modestly in the medium term. Angola finds itself within this context of economic challenges.

During the colonial period, Angola's economic activity was primarily driven by exports, with 65% consisting of rubber, supplemented by coffee, sisal, cotton, and fishery products. Subsequently, there was notable progress in extractive industries, particularly in diamonds, iron, and oil.

The manufacturing sector, encompassing food, textiles, beverages, and tobacco, contributed 64% to the total industry [3]. However, following the war, Angola's productive

infrastructure deteriorated significantly, leading to near paralysis in many traditional sectors. By 2014, 95% of exports were reliant on oil [4], and the international decline in oil prices resulted in reduced revenues for the country.

Presently, the Angolan government has implemented measures to counteract the impact of falling oil prices, focusing on two main strategies: increasing non-oil revenues (through taxes and equity) and diversifying the economy [4]. In this context, Decree-Law no. 5/04 of 7 September 2004, was enacted to promote industrial diversification [5]. This initiative involved state support for national and foreign investments linked to scientific development, emphasising training and the application of new technologies. The process of economic diversification had the following main objectives:

- Increase the national production;
- Reduce the national dependence on imports;
- Strengthen the Angolan enterprise;
- Promote job creation;
- Diversify sources of revenue and foreign exchange.

Therefore, several agreements have been reached with the International Monetary Fund (IMF). The latest report of the Angolan Ministry of Finance [6], bounded with the National Development Plan 2018–2022, reported, as main initiatives, the implementation of alternative management and exploitation modalities provided by article n° 6 of Public Business Sector Basic Law, as well as the restructuring of companies and the professionalisation of management teams [7].

This report indicated that, until 2018, the real business cycle of the economy showed a recessive behaviour, having registered a negative growth rate of around 1.1%, due to the low levels of oil production and the lower economic activity of the non-oil sector (spillover effect). However, it also pointed to an economic growth of 3.2% for 2021 [8].

Meanwhile, [1] indicated that inflation, which has been declining in recent quarters, may, until 2021, reach 7.9%. The current account will remain in deficit, resulting mainly from the increase in imports in the trade balance and growth in the payment of foreign interest, anticipates the government.

Specifically, the Angolan Ministry of Finance [8] states that the economic relevance of the public business sector is undeniable, because more than 80 companies in the main sectors of the economy, employing more than 50 thousand workers and holding a total of assets representing about 45% of the GDP. However, they were only in surplus due to the cross-subsidy system they received, and such a subsidy system is no longer viable [8].

Thus, after this initial diagnosis of the sector, strategic levers were identified for companies to survive without subsidies, one being to seek maturity in the industrial network. The word “Maturity” means that it can be extended to reflect the degree of improvement of things and to describe and measure the degree of comprehensive development of a thing or person [9,10].

Industrial maturity is a defined level of process evolution, and this level establishes a rational way to improve a process’s capability [11]. Therefore, the maturity levels assess and measure the development of an industry from its beginning to maturity and they are quantitative standards [10].

Seeking this maturity, seven priority clusters were defined in 2004 and rectified by [8], as shown in Figure 1. The seven clusters for diversifying the economy are Agriculture, Fisheries, Food, and Agro-Industry; Energy and Water; Extractive Activity; Housing; Leisure, Tourism, and Other Services; Oil and Natural Gas; and Transportation and Logistics. The clusters divided themselves into targeted programs (including the adoption of philosophy and the full range of Lean tools), integrating projects of investment and, for their part, speeding up economic diversification [12].



Figure 1. Priority clusters to speed up the economy’s diversification process (Adapted from [4]).

Therefore, the objective of this work was to analyse the maturity level of industries in Luanda regarding the Lean philosophy practices and tools; analysing whether the industries knew the 5S, Just-In-Time (JIT), Kanban, Bottleneck Analysis, Jidoka, Kaizen, Poka-Yoke, KPI, SMED, Gemba, Heijunka, Value Stream Mapping (VSM), Hoshin Kanri and Andon; whether such tools were used. In addition, an analysis was conducted of the implementation of the five Lean principles established by [13]: (a) Value; (b) Value Chain; (c) Continuous Flow; (d) Pull system; and (e) Pursuit of perfection [13]. This work also aims to propose practical implementation actions to contribute to the continuous improvement in companies’ productivity. The hypothesis raised states that the production practices implemented by the companies operating in the Angolan industrial fabric show an adequate level of maturity in accordance with the requirements of the Lean philosophy (LP) in view of the current challenges of this market.

2. Materials and Methods

The methodology was based on the criterion of accessibility, choosing 87 circumscribed industries in Luanda, on the Industrial Development Pole of Economic Special Zone (ESZ) in Viana, Luanda region, Angola, within the clusters (i) Agriculture, Fishing, Food, and AgroIndustry and (ii) Extractive Activity.

The directors of those industries were interviewed through a questionnaire validated through Cronbach’s Alpha and the Kaiser–Meyer–Olkin (KMO) values, which had questions that characterised the main branch of activity, legal classification, and size (according to Law No. 1/04 of 13 February 2011, where (a) small industries have up to 100 employees but with revenues of less than USD 3 million, (b) medium-sized industries, between 100

and 200 workers but with revenues between USD 3 and 10 million, and (c) large industries with more than 200 workers and more than 10 million USD in revenue).

Seven statistical analyses were performed: Analysis of knowledge of Lean practices and tools and whether they were used; customer value analysis (CV); value chain (VC) analysis; analysis of the use of the pulled production system (PPS); analysis of the use of the continuous production flow (CPF); analysis of continuous improvement (CI), and the maturity model of investigation chosen was that of Milan [1], which is a “simplified and tested model” of the Lean Enterprise Self-Assessment Tool (LESAT) [14].

This research followed a hypothetical deductive approach, showing that there are indeed gaps in the scientific knowledge about Lean practices applied in the Luanda region, Angola. This study emphasises the quantitative and qualitative approach based on applying a questionnaire to test the raised hypothesis and make a symbiosis with the LESAT model. To verify the hypothesis, the procedure adopted is exploratory, which is justified through the application of the questionnaire and statistical data analysis. The data processing method is inductive, consisting of analysing the data of each company to generalise conclusions [15,16].

The preparation of the questionnaire (Appendix A) was performed as described in Table 1.

The questions included in the questionnaire aim for answers related to the application of the LP principles. They were carefully chosen according to the most addressed, using a Likert scale, appropriate for the type of variables and the ease of the answer that is intended to be obtained. The LP tools were also carefully chosen according to the most prominent in the sources researched.

The questionnaire was validated to verify its quality as an instrument for data collection. The validity of the questionnaire obeys the use of several sources that make it possible to find evident and convergent contents, linked to the objectives of the study. For this purpose, the factor analysis method was used, the result of which is shown in Table 2.

Table 1. Process followed for the preparation of the questionnaire.

Step 1: Starting Aspects	
Matter	Assessment of Lean Maturity Levels in Industries of the Luanda Region, Angola
Objective	To make a diagnosis of the state of application of LP practices in companies operating in the industrial fabric of Angola.
Instructions	(1) All data collected will be treated with total anonymity and confidentiality in aggregate form and will only be used for this study.
	(2) Estimated time for completion is 15 min.
	(3) The questions should reflect your personal perception and opinion, so there are no right or wrong answers.
Step 2: Sample characterisation	
Objective	Characterise the requested companies in the aspects with the greatest impact on the results.
Instruction	The information requested in the following table aims to characterise the sample of the population participating in this study. Please fill in the box below as per the items requested.
Elements	(1) Main branch of activity.
	(2) Classification of the company as to size.
	(3) Legal classification of the company.
Step 3: General questions about the knowledge and application of LP practices	
Objective	Verify knowledge of LP practices and their application in the company.
Instruction	The questions that follow are to verify LP's practices in this company. Mark with “X” the answers that best suit your opinion.
Elements	• Knowledge of LP practices. • Application of LP practices in companies.
Step 4: Specific questions on following the LP principles	
Objective	Evaluate your company's compliance with the following principles.
Instruction	Evaluate your company's adherence to the following principles, knowing that the number 1 (one) means “not followed” and the number 5, “completely followed”. Indicate your answer with an “X”.

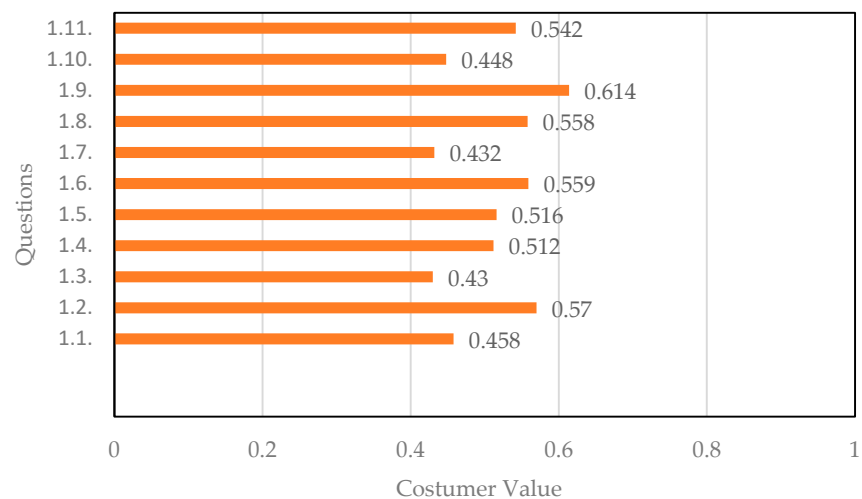
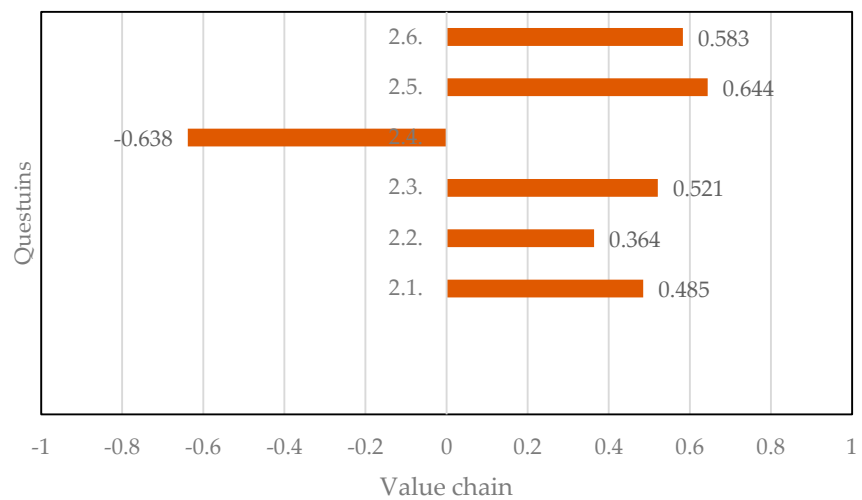
Table 1. Cont.

Description of LP Principles	3.1. Customer Value	1.1. Valuing customer needs.
		1.2. Production according to customer orders.
		1.3. Conducting customer satisfaction surveys.
		1.4. Existence of a register of complaints.
		1.5. Existence of a complaint handling procedure;.
		1.6. Produce giving priority to product quality.
		1.7. Compliance with the delivery deadline.
		1.8. Distribution of products to customers by the company.
		1.9. Holding meetings with customers.
		1.10. Adjustment of prices to the customer’s purchasing power.
		1.11. Availability of company and product information.
	3.2. Chain Value	2.1. Valuing the activities of the production process that add value.
		2.2. Registration of the existence of the product in stock.
		2.3. Calculation of the product’s processing time.
		2.4. Identification of the time it takes to carry out the activities.
		2.5. Graphic representation of the production process.
		2.6. Tracking of the process from the supplier to the distribution of the product to the customer.
	3.3. Pull System	3.1. Produce according to customer demand.
		3.2. Daily production plan.
		3.3. Supply of raw material to the warehouse according to needs.
		3.4. Levelling of production according to demand.
		3.5. Specific location for stock.
		3.6. Visual devices that identify problems in production.
		3.7. Production control using automatic systems for detecting anomalies or quality problems.
	3.4. Continuous Production Flow	4.1. Interconnection of the stages of the process.
		4.2. Sequencing of operations.
		4.3. Processing per unit.
		4.4. Production according to plan.
		4.5. Organisation of the machines according to the sequence of the process.
		4.6. Uninterrupted processes.
4.7. Processes without delay in carrying out activities.		
3.5. Continuous Improvement	5.1. Existence of programs for monitoring, evaluation, and development of employees’ skills.	
	5.2. Autonomy of officials in solving personal problems.	
	5.3. Dissemination of evaluation and productivity results.	
	5.4. Involvement of employees in the preparation of the continuous improvement program.	
	5.5. Training of officials in continuous improvements.	
	5.6. Dissemination of production strategies to all employees of the company.	
	5.7. Cleaning, tidiness, organisation, discipline, and safety procedures.	
	5.8. Implementation of improvement per part or machine.	
Step 5: Questions about knowledge of LP tools		
Objective	Verify knowledge of LP practices in companies.	
Instruction	The questions that follow are to verify LP’s practices in this company. Mark with “X” the answer that best suits your opinion.	
LP tools	5S, JIT, Kanban, Bottleneck Analysis, Jidoka, Kaizen, Poka-Yoke, KPI, SMED, Gemba, Heijunka, VSM, Hoshin Kanri and Andon	
Step 6: Question about the organisational model with a continuous production system		
Objective	To verify if the company uses the production system with continuous flow.	
Instruction	Answer with “YES” if the answer about the production system used is with continuous production flow.	
Elements	Continuous flow production system.	

Table 2. Result of the factor analysis obtained from SPSS.

Principles of the Lean Philosophy (PLP)									
Dimensions	Customer Value (CV)	Dimensions	Value Chain (VC)	Dimensions	Pull Production System (PPS)	Dimensions	Continuous Production Flow (CPF)	Dimensions	Continuous Improvement (CI)
1.1.	0.458	2.1.	0.485	3.1.	0.592	4.1.	0.505	5.1.	0.730
1.2.	0.570	2.2.	0.364	3.2.	0.487	4.2.	0.580	5.2.	0.486
1.3.	0.430	2.3.	0.521	3.3.	0.489	4.3.	0.543	5.3.	0.715
1.4.	0.512	2.4.	−0.638	3.4.	0.501	4.4.	0.423	5.4.	0.730
1.5.	0.516	2.5.	0.644	3.5.	0.475	4.5.	0.456	5.5.	0.640
1.6.	0.559	2.6.	0.583	3.6.	0.405	4.6.	0.448	5.6.	0.593
1.7.	0.432			3.7.	0.624			5.7.	0.424
1.8.	0.558							5.8.	−0.463
1.9.	0.614								
1.10.	0.448								
1.11.	0.542								

The results presented in Table 2 are better interpreted in Figures 2–6.

**Figure 2.** Customer value.**Figure 3.** Value chain.

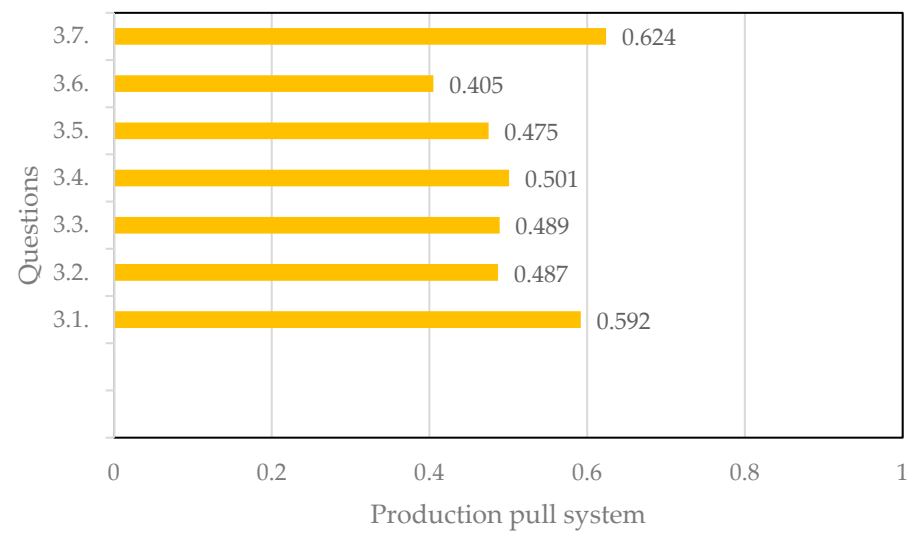


Figure 4. Production pull system.

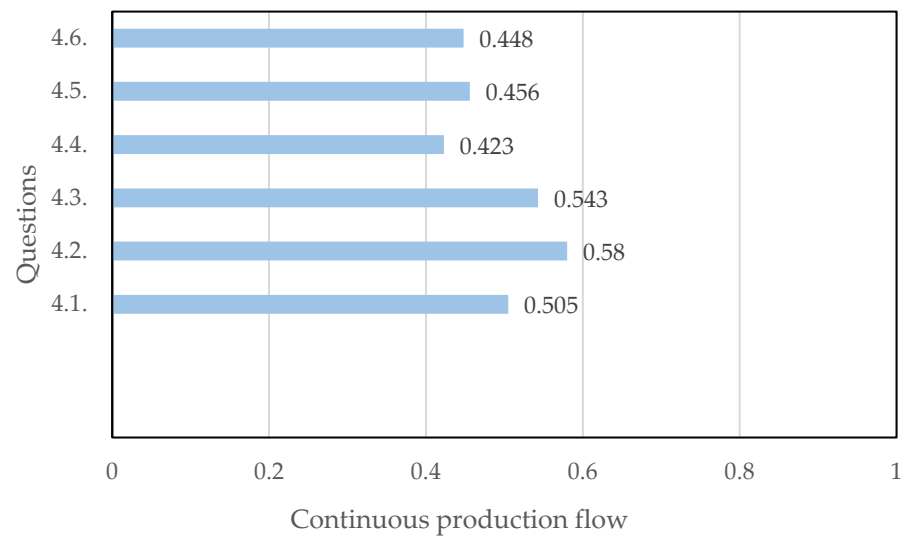


Figure 5. Continuous production flow.

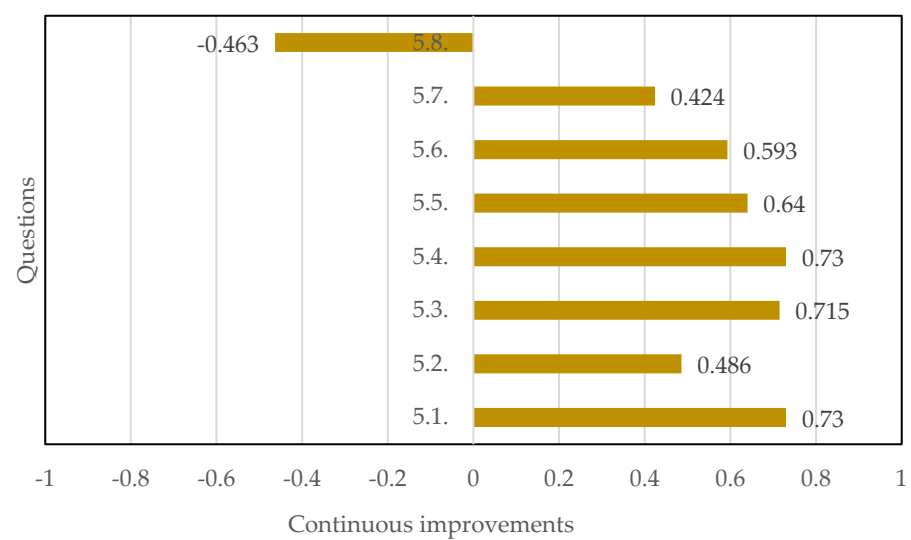


Figure 6. Continuous improvements.

The result of the statistical method of factor analysis confirms the dimensions to be measured and the factor load of the items, and only the dimensions that have a factor load above 0.50 are accepted.

To evaluate the reliability of the questionnaire, Cronbach's alpha method was chosen, suitable for measuring internal consistency with the Likert scale and interpreted according to the results of the Kaiser–Meyer–Olkin (KMO) test [17], being from 1 to 0.90 very good; 0.80 to 0.90 good; 0.70 to 0.80 average; 0.60 to 0.70 reasonable; 0.50 to 0.60 bad; and less than 0.50 unacceptable [18]. The test results are mirrored in Table 3.

Table 3. Cronbach's alpha result, processed in SPSS.

Cronbach's Alpha	Cronbach's Alpha Based on Standardised Items	N of Items
0.921	0.923	49

Table 3 shows that Cronbach's alpha is 0.921, a higher value than Cronbach's alpha of 0.70 which is allowed for the acceptance of the consistency of the data collection instrument [19]. In this case, it was not necessary to exclude any dimension due to the fact that they are all correlated and contribute to good consistency.

It should be noted that, for this study, it was possible to estimate the size of the population surveyed through on-site findings in the field research: 98 factories in operation. Companies that are closed are not considered, and the sample for this study is 87 companies that represent 89% of the population.

For data collection, the plan presented in Table 4 was performed, depending on the geographic location of the companies, the date, and the hours of operation. According to [20], data collection is the phase of the investigation whose objective is to obtain real information. Initially, a visit was made to request and schedule the date, and the objective was to identify the total population of the companies, the number of workers, and the volume of business. The data collection plan is presented in Table 4.

Table 4. Data collection plan.

Criteria	Description	Justification
Local	Special economic zone, Viana industrial pole	Geographical location, organisation of space, centralised management direction, proximity to factories.
Questioned	Directors and/or deputy directors of the production area	Knowledge and experience of the activities carried out.
Timetable	Morning (9:00–11:00 a.m.)	According to the availability of the respondents.
Instrument	Questionnaire with closed questions	Suitable for a sample of 87 companies and the type of investigation.
Verification of clarity and seriousness in the data collection process	Explanatory method	Initial meetings with the company's management to clarify the objectives of the research, presentation of the documentation of guidance for carrying out the research, and identification of the researcher.
Questionnaire application	Data collection	Face-to-face completion after careful reading of the questionnaire and clarification of doubts.

The objective was to cover all companies because it is a population with few companies; at the time of application of the questionnaire, 11 companies were unavailable and some still did not operate. All companies in the industrial sector of Viana, ESZ, are presented in Table 5.

Table 5. List of companies in the industrial sector of Viana.

N. ^{er}	Industrial Sector	N. ^{er}	Industrial Sector	N. ^{er}	Industrial Sector
1	Vegetable oil plant	37	Pipes, rails, and profiles	73	Electrical materials and equipment
2	Construction material	38	Articles of synthetic fibres	74	Cement
3	Medical gas producers	39	Plastic tubes	75	Pharmacy products
4	Miscellaneous products	40	Tubes	76	Bottled and bulk LPG gas
5	Miscellaneous mattresses	41	Tanks	77	Chemicals
6	Construction	42	Electroplating industrial unit	78	Plastic
7	Building material factory	43	Chemical products	79	Drinks
8	Bottling of water and juice	44	Concrete	80	Food industry
9	Fiber optic cables	45	Chemicals	81	Blocks and bricks
10	Metalworking	46	Plates	82	Wood processing
11	Plastic recycling	47	Construction	83	Soap factory
12	Pasta kiamo	48	Furniture industry	84	Marble and granite
13	Furnishings	49	Wood material	85	Vehicle maintenance consumables equipment
14	Lubricants	50	Paints and varnishes	86	Domestic paper products
15	Blocks	51	Plastics production	87	Prefabricated buildings
16	Blocks and cement	52	Hardware	88	Kitchen, school, and office furniture design
17	Manufacture of water pumps	53	Construction	89	Plastic
18	Drinks	54	Metalworking	90	Gas
19	Wines and waiters	55	Printing industry	91	Radiators
20	Construction and real estate	56	Electrical materials industry	92	Glass and crystals
21	Construction	57	Correction of automotive parts to produce street furniture	93	False ceilings
22	Cement and blocks	58	Vinegar, sauces, and dressings	94	Bakery and pastry shop
23	Rolling parts and equipment	59	Chemicals	95	Wood shredder machines
24	Automobile commercialisation	60	Detergents	96	Metal tiles
25	Automobile assembly industry	61	Cement glue	97	Paints and chemicals
26	Construction	62	Satellite dishes, antennas, and furniture	98	Paints
27	Bridges	63	Uniforms	99	Paints
28	Tires	64	Oil industry	100	Paints
29	Metalwork and metalworking	65	Ink	101	Plastic industry
30	Plates	66	Mattresses	102	Systems for aluminium frames
31	Plastic bag recycling	67	Compound feed	103	Drinks
32	Beverage	68	Granite, limestone, marble, and slate	104	Metallurgical
33	Beverage	69	Cement	105	Fences
34	Aluminium and iron lacquering	70	Pipes, seals, and wires	106	Pipes, seals, and wires
35	Manufacture of building materials and industrial buildings	71	Agricultural irrigation pivots	107	Tractor and bus assemblies
36	Machinery and articles for the food industry	72	Production of plastic utensils	108	Block and construction material

The companies are located in the ESZ, in the municipality of Viana, as shown in Figure 7.

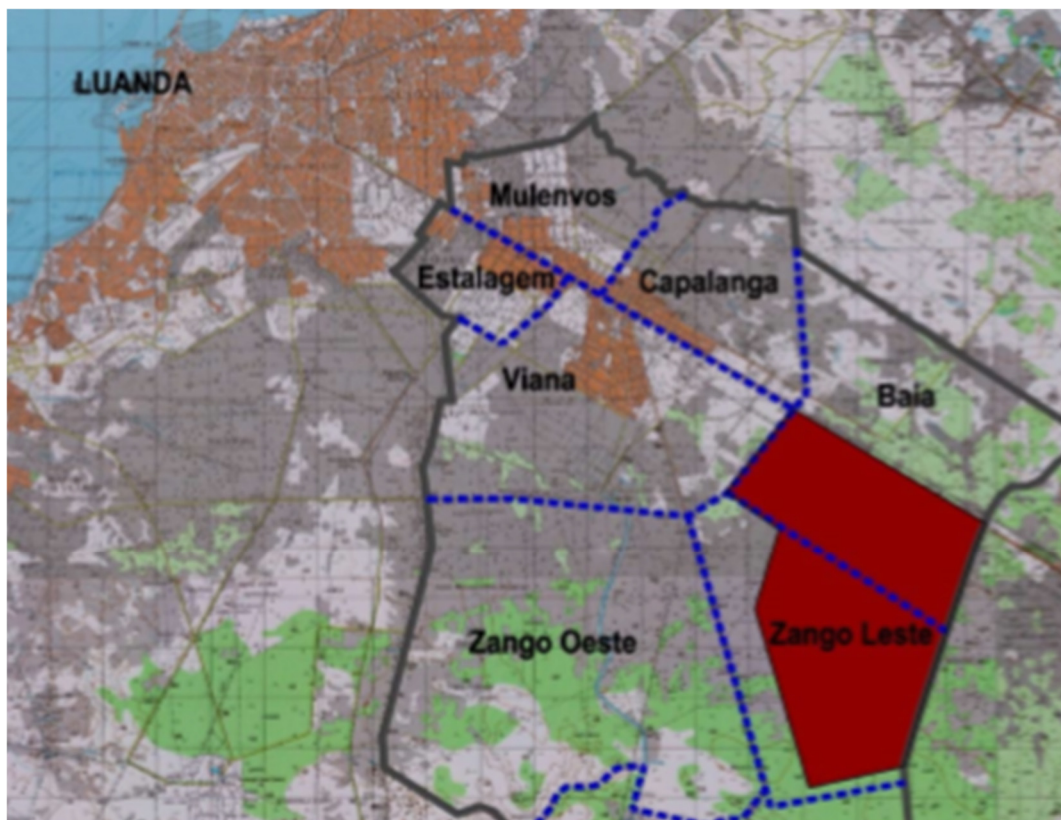


Figure 7. Geographical location of the ESZ, Luanda (obtained from Google Maps).

Figure 8 shows the exact area occupied by the companies in the ESZ.

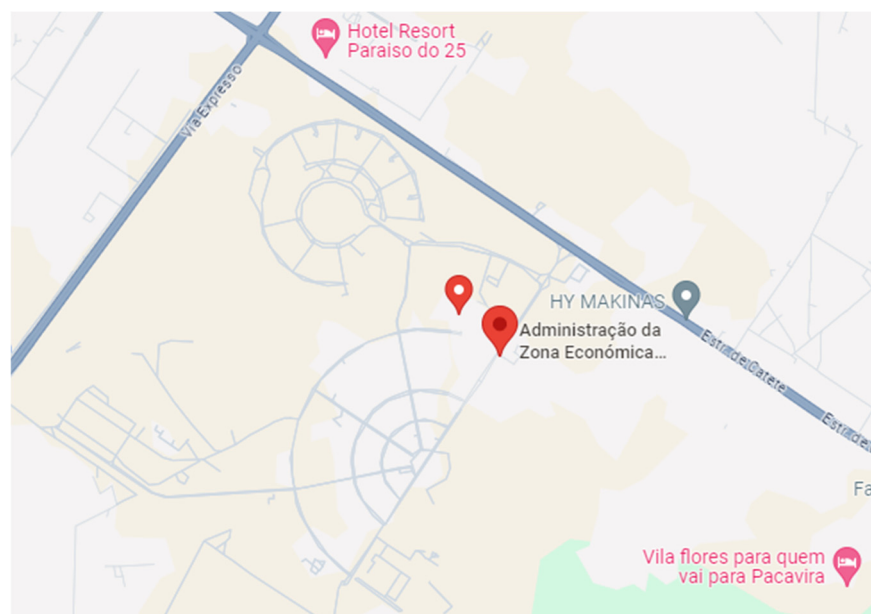


Figure 8. Illustration of the area occupied by the ESZ, Luanda (obtained from Google Maps).

The location of the ESZ is close to national roads and urban areas, such as the city of Viana at kilometre 28 and the new centralities of Zango, Kilamba Kiaksi, and Cacuaco (Figure 8) and the future facilities of the international airport and railways. These infrastructures constitute competitive advantages in terms of production strategies with ease of logistics operations.

Table 6 shows the classification of the companies by size and legal classification.

Table 6. Classification of companies.

Rating the Company by Size	Legal Classification of the Company			Total
	Private	Public	Mixed	
Small	6	1	1	8
	7.9%	20.0%	16.7%	9.2%
Average	44	3	3	50
	57.9%	60.0%	50.0%	57.5%
large	26	1	2	29
	34.2%	20.0%	33.3%	33.3%
Total	76	5	6	87
				100.0%

Thus, it can be stated that this study is characterised mostly by medium-sized companies, and from the private sector, which is better illustrated in Figure 9.

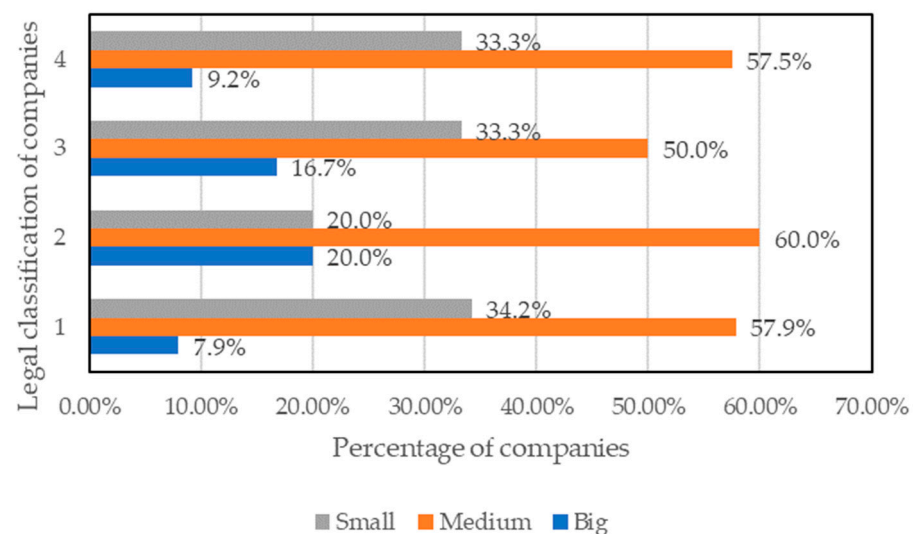


Figure 9. Classification of companies according to size (%) (1—Private, 2—State, 3—Mixed, 4—Total).

It should be noted that cluster analysis was performed to verify the homogeneity of the answers given regarding the dimensions of the LP that guide the recommended objective. The obtained result is presented in Tables 7–11.

Table 7. Cluster constitution of the dimensions of the LP-CV principle.

Dimensions	3 Clusters
1:1	1
2:2	2
3:3	3
4:4	1
5:5	2
6:6	1
7:7	1
8:8	2
9:9	3
10:10	2
11:11	1

Table 8. Cluster constitution of the dimensions of the LP-VC principle.

Dimensions	3 Clusters
1:1	1
2:2	2
3:3	1
4:4	3
5:5	1
6:6	1

Table 9. Cluster constitution of the dimensions of the LP-PPS principle.

Dimensions	3 Clusters
1:1	1
2:2	2
3:3	3
4:4	1
5:5	1
6:6	2
7:7	2

Table 10. Cluster constitution of the dimensions of the LP-CPF principle.

Dimensions	3 Clusters
1:1	1
2:2	1
3:3	2
4:4	1
5:5	1
6:6	3
7:7	3

Table 11. Cluster constitution of the dimensions of the LP-CI principle.

Dimensions	3 Clusters
1:1	1
2:2	1
3:3	2
4:4	2
5:5	2
6:6	1
7:7	3
8:8	1

The results shown in the previous tables were obtained through SPSS and are reflected in the following dendrogram graphs, Figures 10–14.

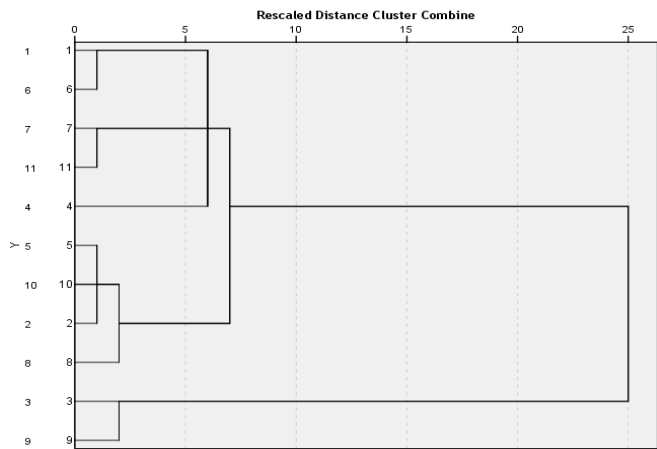


Figure 10. Costumer Value dendrogram.

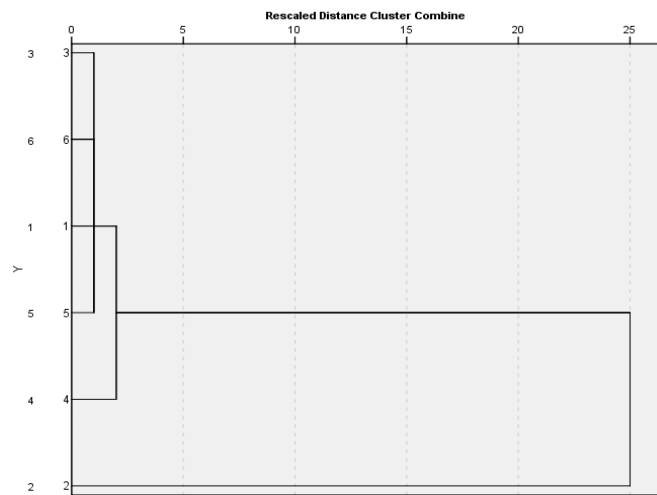


Figure 11. Value Chain dendrogram.

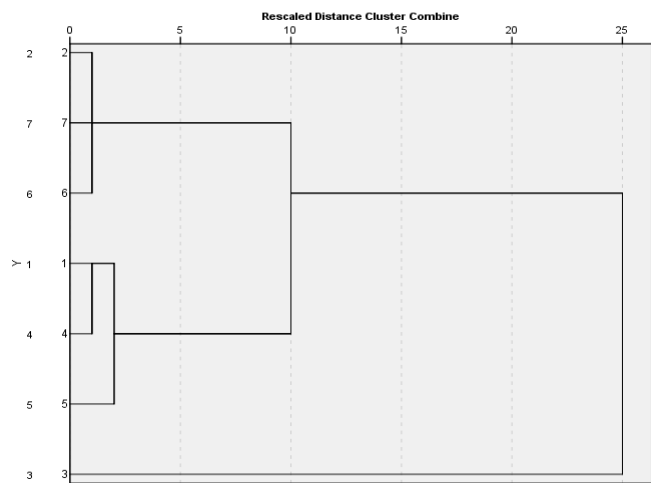


Figure 12. Production Pull System dendrogram.

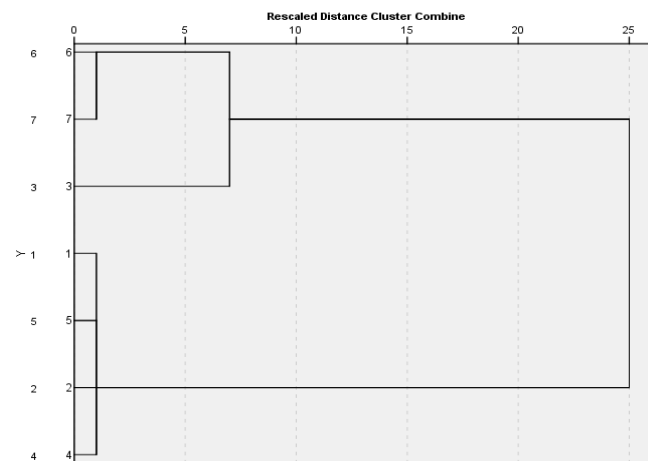


Figure 13. Continuous Production Flow dendrogram.

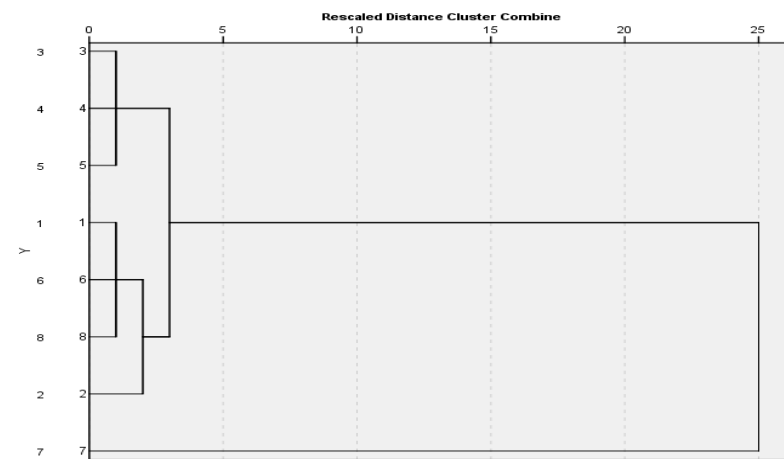


Figure 14. Continuous Improvement dendrogram.

The results show a certain association between the evaluated dimensions.

3. Importance of Implementing Lean Philosophy in Industries

There is a significant amount of evidence regarding the advantages of the application of LP in the industrial sector in general. Only the year 2024 can be considered as a reference. According to the research on the scientific database B-on, analysed by peers, in the sources of academic journals, several publications are found, such as the study conducted by [21] that states that LP practices are a solution to improve business performance in industries. This result was verified in Mexico. Other studies that show the importance of Lean practices in the industries, such as [22], present advantages in their application in the red ceramics industry and state that this tool is the solution that can contribute to visualise the current state of the production process and help eliminate layoffs. They applied the VSM tool.

The study on the production process applying the VSM tool in the plastics industry also shows the advantages of this tool in the identification of waste, as shown by [23].

We can also highlight studies conducted on the subject related to the assessment of Lean maturity levels in industries performed by [24]. This study was applied to the manufacturing sector of Pakistan. The applied model provides the ease of integrating two main paradigms of Lean manufacturing and Industry 4.0 and allows companies to make their assessment. The study on the Lean circular maturity model (LCMM) for companies' self-assessment in terms of process, product, and life cycle thinking proposed by [25] focuses on the self-assessment of companies in terms of Lean thinking applied in the production process and in the product life cycle. The study on the maturity model for assessing Digital Green Lean leadership and culture implementation in manufacturing

companies developed by [26] contributes to providing tools that help compare and develop action plans in the context of Industry 4.0, circular economy, culture, and Lean leadership as part of the new Digital Green Lean [27,28].

These types of studies were not found in the B-on database in Angola; thus, this research is innovative and relevant for companies that are in this region and sector, as it shows the advantages of the application of LP in productivity, the current state of maturity as well as its gaps, and presents a simple model that will help in the assessment of the state of maturity of the LP in this business sector or another with similar characteristics.

4. Brief Contextualisation of Lean and Maturity Philosophy

The development of industries in any country is a signal and a mechanism for leveraging the growth of economies. The Angolan economy faces great challenges due to the fall in the price of oil on which it depends. Therefore, companies can no longer be subsidised, and so they are committed to becoming competitive and one of the possible ways to achieve this is to adopt and apply Lean practices and tools.

In the 90s, Lean was seen as a set of productive practices, which worked by establishing a rapid cost reduction in production processes. At the beginning of the 21st century, the system started to be seen as a Lean management model [16]. These authors claim that Lean manufacturing (LM) is implemented by a sequence of steps, usually starting with tools and practices, after a period of diagnosis. LM is recognised, in this way, as a philosophy that helps the management of an organisation, and this philosophy is guided by some principles that seek total customer satisfaction. It is the customer who receives the products indicating the corresponding value, and according to [13], there are five principles, as follows:

1. Value: Generally, when referring to a product that you buy, you risk using the designation value when evaluating. When there is satisfaction, we affirm that it has reached the expected value.
2. Value Chain: The next step is to identify the value chain. This is a process or a set of process steps that each product must go through to be completed.
3. Continuous Flow: The flow is conducted throughout the value chain, and must be continuous, which means that no problems should exist to stop or reduce an operation.
4. Pull System: The principle of the pull system follows the creation's flow and production start only if the customer requests it.
5. Pursuit the perfection: It comes by continuous improvement.

In this sense, a Lean culture or philosophy is created, which adopts Lean tools with practices in a system aimed at eliminating everything that does not add value, reducing inventories, adopting principles of participative management, and focusing on the constant search for problem-solving, standardisation, cost reduction, and innovation, and therefore, continuous improvement.

However, there is a strong differentiation between the different stages of Lean implementation, from the beginning, which is the knowledge and implementation of tools until it becomes a system that flows automatically because it has already become an active, operating system, as shown in Figure 2. Thus, the evolution of Lean involves three areas covering the overall concepts of Lean culture and philosophy, the focus of Lean systems, and how Lean tools and practices can be accomplished.

The building of a Lean culture is not just an isolated application of a tool or adopting this or that practice (Area I), but it is about organising the practices and tools to create a moving system (Area II). Once this system is incorporated into the minds of employees, causing the analysis of continuous improvement and pursuit of perfection, there is the Lean philosophy (Area III). Thus, we observe that the basic principles proposed by Womack remain the same but are updated according to the context and needs. The main tools or practices of the Lean philosophy identified in Figure 15 are described in Table 12.

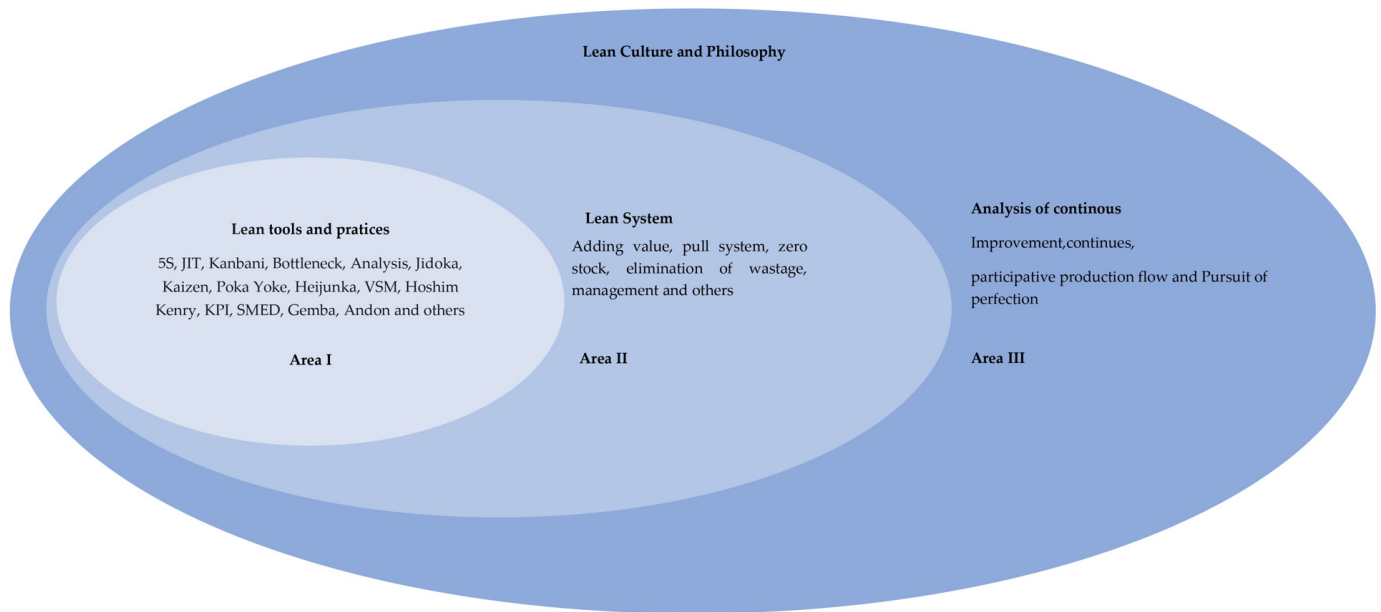


Figure 15. Lean’s graphic model: evolution—tools and practices; system; Lean culture or philosophy.

Table 12. Main tools or practices of Lean philosophy.

Tools	Description
5S	These are vital work environment practices for visual management, cleanliness, and organisation: Seiri: organisation, separating the necessary from the unnecessary; Seiton: storage, putting everything in its place; Seiso: clean and care for the work environment; Seiketsu: normalisation, making the work environment healthy; Shitsuke: self-discipline, standardise the application of previous S.
JIT	It consists of producing, only, what is necessary at the necessary time, avoiding any kind of waste.
Kanban	Visual control of production and materials is more used where there is pulled production, which authorises instructions for production or product withdrawals.
Bottleneck Analysis	It is a technique used to identify and locate the bottleneck in the production process.
Jidoka	It makes it possible to separate the workers from the machine operation and offers a better visibility of anomalies.
Kaizen	It is a process of continuous improvement that can be applied in any activity, to eliminate or reduce waste, creating more value through the workers, processes, time, and technology [29].
POKA–YOKE	Protection mechanism in the manufacturing process that helps to avoid/prevent human errors.
KPI	“Key performance indicators” are goals and objectives seen as key performance indicators that guide resources in executing the strategy [29].
SMED	Single Minute Exchange of Die, in approximate translation “quick tool change”, is used in the industry to reduce the time of the setup process (preparation of machines, equipment, and production lines).
Gemba	It is a tool that aims to get closer to the process [30].
Heijunka	Relates to grade production and aims to seek the stability of the process, reduce the quantity of stock, reduce costs, and decrease labour and the production lead time [31].
VSM	Used for mapping process activities by drawing a flowchart.
Hoshin Kanri	It is the method of management, planning, or even establishing the company’s policy [32].
Andon	It is a way of sight management that informs the status of production to the entire organisation, displaying on boards, and lamps, audible or visual indications of anomalies and allows for corrective actions to be taken immediately [33].

These tools, among others, when developed and used, provide industries with a competitive advantage. The constant act of using tools and routines transforms individual use into a Lean system and, later, with the more mature industry, a level of culture, or Lean philosophy, is reached. With the increasing use of Lean practices, a high level of transformation is reached, which we call maturity.

Maturity models [14] are used to measure the degree of Lean maturity in organisations. A company's maturity level can be understood as the extent to which processes are explicitly defined, managed, measured, controlled, efficient, and effective [6].

In this sense [14], we can divide the models into (i) qualitative ones like the Shingo Prize and the Lai Enterprise Self-Assessment Tool (LESAT) and (ii) quantitative ones that, for the most part, are based on fuzzy logic [34].

The LESAT, according to Table 13, presents three sections of analysis, and in each section, there are five levels of Lean maturity. Its application has already been tested in more than 20 companies in England and the USA, which have demonstrated the usefulness of the instrument, its effectiveness, and ease of use [6].

Table 13. LESAT sections and variables (adapted from [2]).

Section I—Enterprise Transformation/Leadership		Section II—Lifecycle Processes	
(a)	Determine Strategic Imperative (3 enterprise practices)	(a)	Acquire, Develop, and Leverage Enterprise Capabilities
(b)	Engage Enterprise Leadership in Transformation	(b)	Optimise Network-Wide Performance
(c)	Understand the Current Enterprise State	(c)	Incorporate Downstream Customer Value into Enterprise Value Chain
(d)	Envision and Design Future Enterprise	(d)	Actively Engage Upstream Stakeholders to Maximise Value Creation
(e)	Develop Enterprise Structure and Behaviour	(e)	Provide Capability to Monitor and Manage Risk and Performance
(f)	Create Transformation Plan	Section III—Enabling Infrastructure	
(g)	Implement and Coordinate Transformation Plan	(a)	Organisational Enablers
(h)	Nurture Transformation and Embed Enterprise Thinking	(b)	Process Enablers

LESAT is more than a measurement model for Lean maturity because, by using every model, industries can see where they can and if they need to make improvements [6,9] when evaluating the implementation of Lean concepts in the process of developing new products, using a model extracted, simplified, and tested from LESAT, as shown in Table 14 [6].

Table 14. Lean maturity levels—LESAT/MIT (Adapted from [6]).

Levels	Designation	Detailed Features of Each Lean Maturity Level	
1	Informal (None or initial process) (Area I—Figure 2)	- Basic activities are generally carried out, but there is a lack of greater rigor in the planning and execution of activities. - Performance of activities can be confusing, unpredictable, and inconsistent and result in low-quality products, uncertainties regarding delivery times, and increased budgets and costs compared to what was projected. - Performance depends on individual skills and dedication (“heroes” and “firefighters” make a difference).	
2	Organised (structured and standardised process) (Area I—Figure 2)	- Products according to specified standards and requirements. - The execution of the main processes is planned, managed, and progressively evolves into well-structured processes. - The results of the processes are predictable. - The relationship between specific processes and macro-processes is not well defined.	
3	Well structured (institutionalised processes and organisational standards) (Area II—Figure 2)	- Basic activities are performed according to well-defined processes (well structured), following standards adopted by the entire company. - Subprocesses and activities are also defined. - The relationships between processes and macro-processes are defined. - Start using measurements to help with process management. - The organisation is focused on process management. - Detailed performance measurements are collected and analysed, supporting decision-making processes.	
4	Managed (managed processes) (Area II—Figure 2)	- Knowledge of the capacity of the processes. - Good margin of accuracy in performance or results forecasts. - Greater objectivity in managing performance or results. - Product quality is quantified. - The main difference from Level 3 is that, at this level, the performance of processes is quantitatively known, controlled, and managed.	

Table 14. Cont.

Levels	Designation	Detailed Features of Each Lean Maturity Level
5	Optimised (optimised processes) (Area III—Figure 2)	- Performance goals based on business objectives are quantitatively established. - Systematic measurements to provide feedback on the performance or results of processes and to guide improvement and innovation actions. - The main difference to Level 4 is that, at this level, there is a permanent action for improvement and refinement of methods, oriented towards the organisation's guiding objectives.

The maturity level means steps towards improvement in project management. These steps are associated with the application of tools, processes, methodologies, knowledge, and skills applied to projects to achieve organisational objectives. They range from the lowest levels (not able) to the highest levels (solid; in continuous improvement).

Thus, Ref. [35] states that level 5 of maturity, or full maturity, would be synonymous with perfection, something that is fully developed and has reached its highest level. Therefore, the simple application of Lean tools (considered a good practice that can provide satisfactory results in the identification and elimination of waste) is an initial level of maturity (Area I seen in Figure 2), having some tools and practices in place (Area II seen in Figure 2) and having a whole system in place, working with organisational routines and automatic in the employees' mind, is a much higher level of maturity (Area III seen in Figure 2), that is, it reached the Lean culture or philosophy.

The maturity scale of the Lean philosophy is resumed in three areas, as shown in Figure 16, in which the first represents a low maturity, and adopts very simple Lean tools, and the second is medium maturity. In this phase, Lean is put into operation as a system and the third corresponds to high maturity, which requires the application of culture based on philosophy.

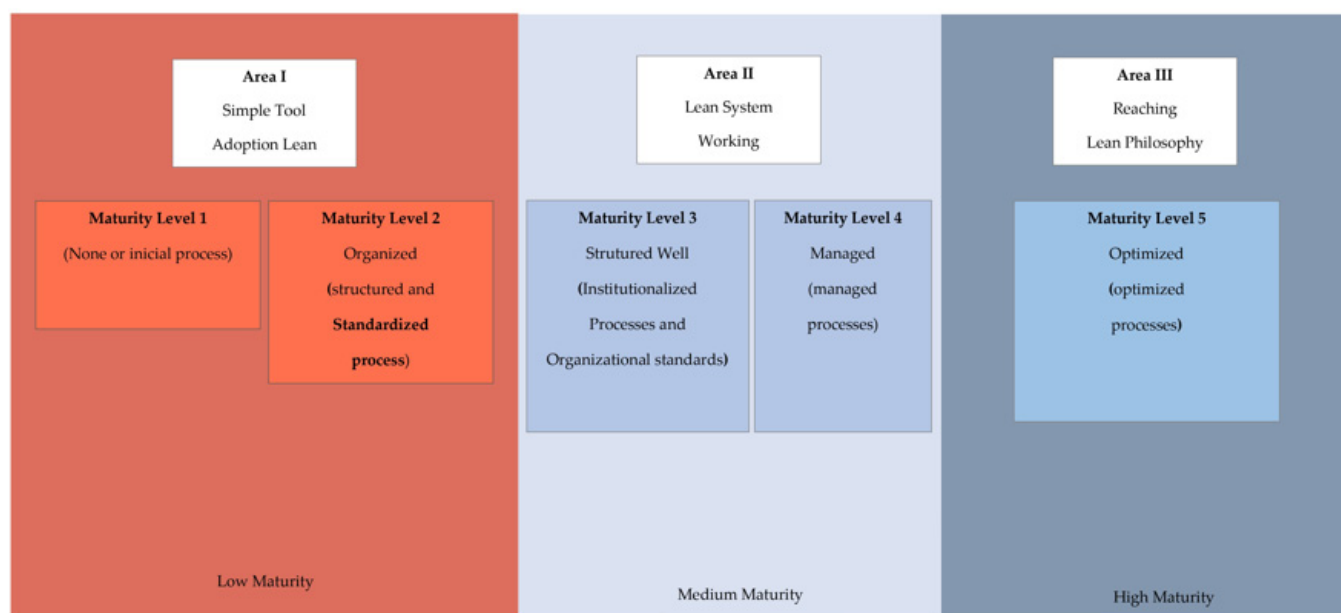


Figure 16. Proposed lean maturity scale.

This model measures the Lean maturity of industries and can provide the optimisation of time, material resources, human effort, and productivity gains, as well as for proportional improvements in products and services.

5. The Application of Lean Philosophy in the Angolan Industrial Fabric

In view of the evolution challenges of the Angolan economy already presented, it is necessary to increase the competitiveness of the industries to consequently increase the

competitiveness of the economy. One of the possible strategies to increase the competitiveness of these companies may be to increase the implementation of the Lean philosophy (LP) at the business level, that is, to add greater value to customers using fewer resources [36].

Although LP is not a new topic, it is a relevant topic of maturity in many of the emerging countries, such as Angola. The organisational model is a novelty, arousing great interest in the application of LP, which has the potential to minimise risks in the business development process, by presenting solutions in terms of identification and waste reduction, optimisation of resources, and maximisation of productivity [27]. Thus, LP has established itself as one of the most efficient production strategies in developed countries [36,37], in which the results are evidently satisfactory, judging by the wide range of scientific publications in the area.

Specifically, the Angolan industrial fabric (composed of about 7000 factories) faces numerous problems in the industrialisation process that can have several origins, namely financial, energetic, human resources, infrastructure, distribution and product management, basic materials, among others [38]. In fact, about 14% are paralyzed and 2% semi-paralyzed, due to different constraints, financial problems, supply difficulties, and in some cases, poor management.

Even in this context of difficulties, some projects are being implemented, through strategies adopted by [38], aimed at the development of industrialisation projects, the most addressed of which are listed in Table 15.

Table 15. Industrial development programs (adapted from [8]).

Program	Description
PROFIR	It is a program to promote small rural industries, which aims to install small factory units to produce manioc (corn and bombó) in the municipalities; animal feed; general electromechanical workshops; etc.
PROPÃO	Bakery and pastry program. It is a program aimed at improving the competitiveness of the Angolan bakery and pastry sector.
RNPDI	National network of industrial development hubs, which consists of planning, coordinating activities aimed at the installation of hubs at the level of Angola, and their subsequent management.

Therefore, there is an intention to seek competitiveness in the industries of Luanda and, among these current projects and industrial plants, many seek maturity, and for that they use Lean tools to achieve efficiency and survival, but they are seemingly still at the first stage (Area I seen in Figure 2).

6. Analysis of Lean Maturity in the Industrial Sector of Angola

This analysis will be performed through the search for principles of Lean philosophy via the analysis of the following:

- 5.1—Analysis of knowledge of tools.
- 5.2—Analysis of the use of tools.
- 5.3—Customer value (CV).
- 5.4—Value chain (VC).
- 5.5—Use of the pull production system (PPS).
- 5.6—Use of continuous production flow (CPF).
- 5.7—Continuous improvement analysis (CI).

6.1. Analysis of Knowledge of Lean Philosophy Tools

Figure 17 shows the results in the percentage of knowledge of the main Lean tools in the industrial sector of Luanda.

The survey results show that, of the 14 tools presented, only the 5S, JIT, Bottleneck Analysis, and Kaizen tools (28.5%) were known by the companies, and the only tool that was known by 60% of the companies was the 5S technique.

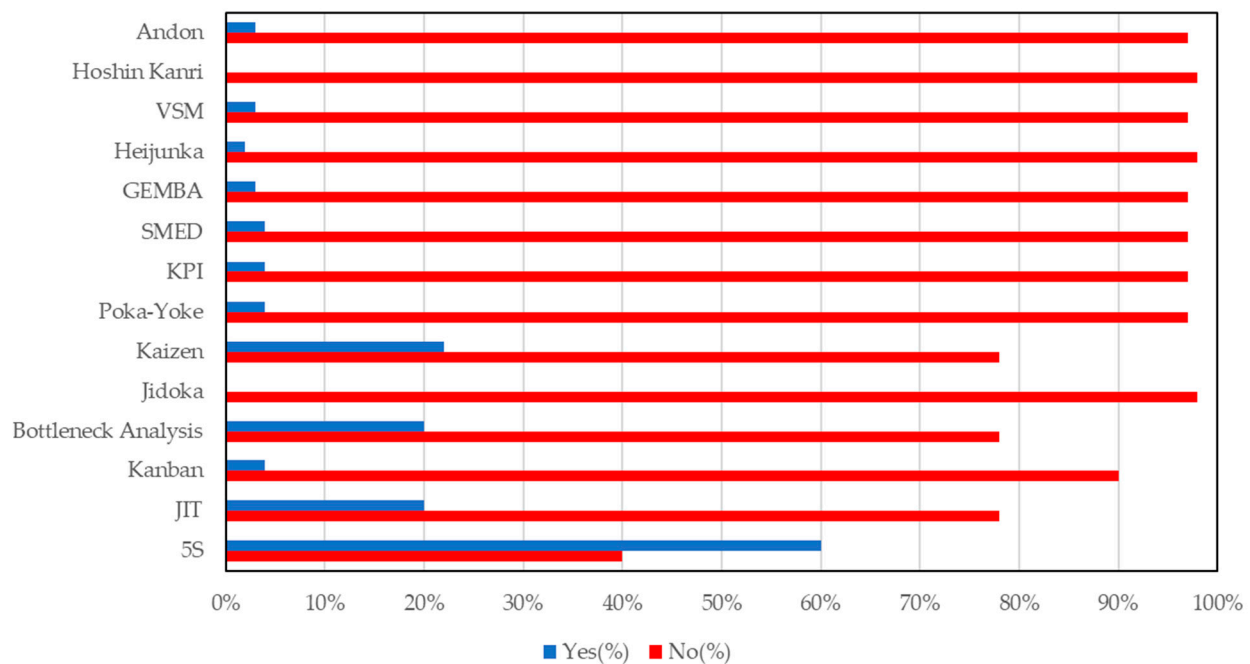


Figure 17. Frequency of responses regarding knowledge of Lean tools.

6.2. Analysis of the Use of Lean Tools

Considering the set of 87 industries, 14 Lean tools were verified, that is, among the 1218 possibilities of using or not the tools, only the answer “yes, we use this tool” occurred 132 times, at 10.8%. Given this result, a stratification was made among the 87 companies investigated between small (8), medium (51), and large (28) companies to know whether the size influenced the use of the tools. It was found that, among the large industries, 50% of them used 5S, with 46% using another tool, but 39% did not use any Lean tool; medium-sized industries: 53% used 5S, with 40% using at least one other tool, but 60% did not use any Lean tools; and small industries: 50% used 5S and just another tool and 50% did not use any Lean tools. Figure 18 shows the results of the frequency of using Lean tools in Luanda’s industries, according to their size.

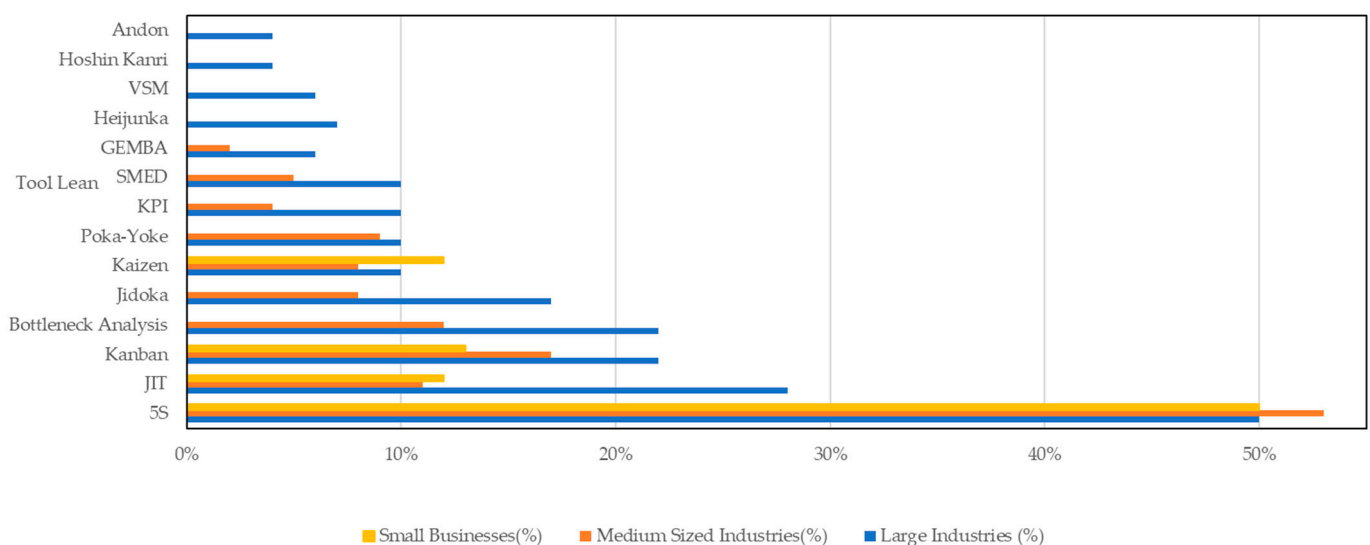


Figure 18. Frequency of responses regarding the use of Lean philosophy tools.

As can be seen, the pattern of use followed only by the 5S tool is better known and used; even so it reaches an use average of 52%.

6.3. Search for the Lean Principle via Analysis of “Customer Value (CV)”

The results of the analysis of the responses regarding the value given to the customer are presented in means and standard deviation in Table 16.

Table 16. Mean and standard deviation of the PLP-CV dimensions.

PLP-CV Dimensions	Mean	Std. Deviation
1.1. Valuing customer needs.	4.49	0.697
1.2. Production according to customer orders.	3.49	1.731
1.3. Conducting customer satisfaction surveys.	2.33	1.452
1.4. Existence of registration of complaints.	3.82	1.596
1.5. Existence of complaints handling procedure.	3.39	1.505
1.6. Produce based on product quality.	4.47	0.745
1.7. Compliance with delivery deadline.	4.18	0.922
1.8. Distribution of products to customers by the company.	3.15	1.709
1.9. Meetings with customers.	2.51	1.478
1.10. Adjustment of prices to the customer’s purchasing power.	3.33	1.236
1.11. Availability of company and product information.	4.11	1.214

Dimensions 1.1 (evaluation of customer needs), 1.4 (existence of registration of complaints), 1.6 (produce based on product quality), 1.7 (delivery deadline), and 1.11 (availability of information about the company and the product) are followed to the extent that the mean values are greater than 4, according to the Likert scale, and also the standard deviation values, in the referred dimensions, are those that show less dispersion. The analysis carried out at this point allows us to conclude that 45.4% of the dimensions of the Lean philosophy “customer value” are followed by the surveyed companies.

6.4. Search for the Lean Principle via Analysis of the “Value Chain (VC)”

This value refers to all activities that are carried out to conceive a product, manufactured and delivered to the customer, including activities that do not add value. Thus, the VSM is a Lean tool that helps to understand the material and information needed for production and helps in identifying opportunities for improvement. The results are shown in Table 17.

Table 17. Mean and standard deviation of the PLP-VC dimensions.

Dimension of PLP-VC	Mean	Std. Deviation
2.1. Valuing activities that add value.	4.20	1.010
2.2. Record of existence of the product in stock.	4.68	0.770
2.3. Calculation of product processing time.	3.94	1.288
2.4. Identification of the delay time in the execution of activities.	2.23	1.282
2.5. Graphical representation of the production process.	3.15	1.702
2.6. Process tracking from the supplier to product distribution to the customer.	3.79	1.313

The dimensions 2.1—valuations of the activities of the production process that add value, 2.2—records of the existence of the product in stock, and 2.3—calculation of the product’s processing time, are concentrated around 4, constituting the set with greater emphasis on the results. Even so, the correlation of dimensions will be analysed to verify the consistency of the answers. The analysis carried out at this point allows us to conclude that 50% of the dimensions of the Lean philosophy “Value Chain” principle are followed by the surveyed companies.

6.5. Search for the Lean Principle Using the “Pull Production System (PPS)”

The level of application of the Lean principle is analysed regarding the pulled production system (PPS). The results are shown in Table 18.

Table 18. Mean and standard deviation of the PLP-PPS dimensions.

PLP-PPS Dimensions	Mean	Std. Deviation
3.1. Produce according to customer demand.	4.16	1.397
3.2. Daily production planning.	2.99	1.688
3.3. Supply of raw material warehouse according to demand.	1.86	1.424
3.4. Level production according to demand.	3.95	1.200
3.5. Specific stock location.	4.48	1.066
3.6. Visual devices that identify problems in production.	3.32	1.559
3.7. Production control through anomaly detection systems.	2.98	1.649

The analysis shows that the three dimensions most followed by the company considering the average and the standard deviation are 3.1—producing according to customer demand, 3.4—levelling production according to demand, and 3.5—specific location for stock, which represents that 42.8% of the dimensions are followed by the surveyed companies.

6.6. Search for the Lean Principle Using the “Continuous Production Flow (CPF)”

The behaviour of the Lean principle continuous production flow is shown in Table 19 through the mean average and standard deviation of its dimensions.

Table 19. Mean and standard deviation of the PLP-CPF dimensions.

PLP-CPF Dimensions	Mean	Std. Deviation
4.1. Interconnection of process steps.	4.80	0.487
4.2. Sequencing of operations.	4.71	0.762
4.3. Unit processing.	3.58	1.729
4.4. Production according to plan.	4.56	0.898
4.5. Organisation of machines according to the process sequence.	4.84	0.601
4.6. Processes without interruption during production.	2.65	1.022
4.7. Processes without delay in carrying out activities.	2.64	1.144

From the analysis of the previous table, the dimensions 4.1—interconnection of the process steps, 4.2—sequencing of operations, 4.4—production according to plan, and 4.5—organisation of the machines according to the process sequence present a high average and low dispersion, as these dimensions represent 57.2% of those followed by the surveyed companies.

6.7. Search for the Lean Principle via Analysis of “Continuous Improvement (CI)”

The behaviour of the Lean CI principle is shown in Table 20 through the mean average and standard deviation of its dimensions.

Table 20. Mean and standard deviation of PLP-CI dimensions.

PLP-CI Dimensions	Mean	Std. Deviation
5.1. Existence of a monitoring program, employee skills assessment.	2.75	1.519
5.2. Employee autonomy in solving specific problems.	3.05	1.210
5.3. Dissemination of evaluation and productivity results.	2.26	1.458
5.4. Employee involvement in developing the continuous improvement program.	2.26	1.316
5.5. Training of employees on continuous improvement.	2.22	1.350
5.6. Disclosure of production strategies to all company employees.	2.84	1.462
5.7. Cleaning, tidiness, organisation, discipline and safety (C.T.O.D.S.) procedure.	4.28	0.949
5.8. Improvement implementation by part or machine.	2.56	1.300

From the analysis of the results shown in Table 20, the dimensions 5.2 and 5.7 present a high average and low dispersion.

7. Summary of the Analysis of Maturity of Luanda's Region Industries

To summarise the results of the analysis, the responses were the following:

- (a) Simple table of the percentages when the dimension reached 4 or more.
- (b) Analysis of the probability of the responses being lower than the centre of the scale and classification of the group's response:
 - (i) Density curves of the responses of the items by individual dimension, but summarised in Figure 18 with the overlap of all density curves.
 - (ii) Overlapping the cumulative distribution curves of responses by dimension (see Figure 19).
- (c) Analysis in Table 21 of the percentages when the dimension reached 4 or more. Table 21 shows that knowledge (28.5%), use of Lean tools (10.8%), and the practice of continuous improvement (12.5%) are very low. The other four practices, namely customer value, value chain, use of pulled production, and continuous flow, gave average results between 42 and 57%, showing that, in fact, the value of maturity is very low. The median value of these four practices was affected by the big industries, which raised the numerical value.

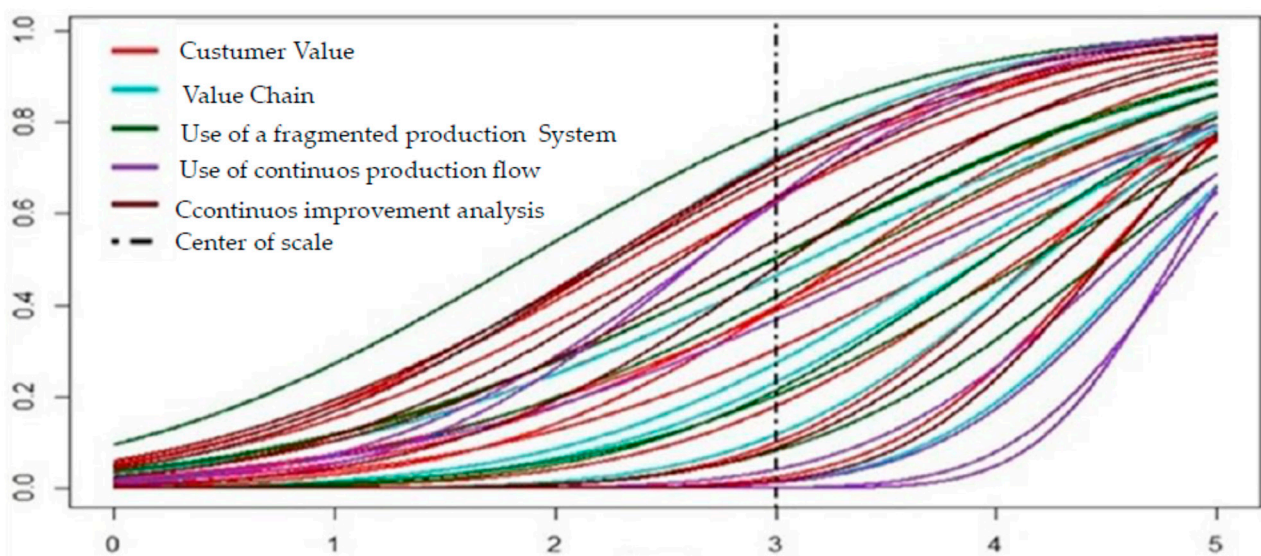


Figure 19. Overlapping density curves for item responses by dimension.

Table 21. Percentages when the dimension reached 4 or more.

Analysis Performed	Compatibility Percentage
4.1—Tool knowledge analysis.	28.5%
4.2—Tools analysis of use.	10.8%
4.3—Value to the client (VC).	45.4%
4.4—Customer value (CV).	50.0%
4.5—Use of the pull production system (PPS).	42.8%
4.6—Use of continuous production flow (CPF).	57.2%
4.7—Continuous improvement analysis (CI).	12.5%

Figures 19 and 20 and Table 22 show that, of the 39 variables analysed, 25 are highly likely to be correct, so Figure 21 can be presented.

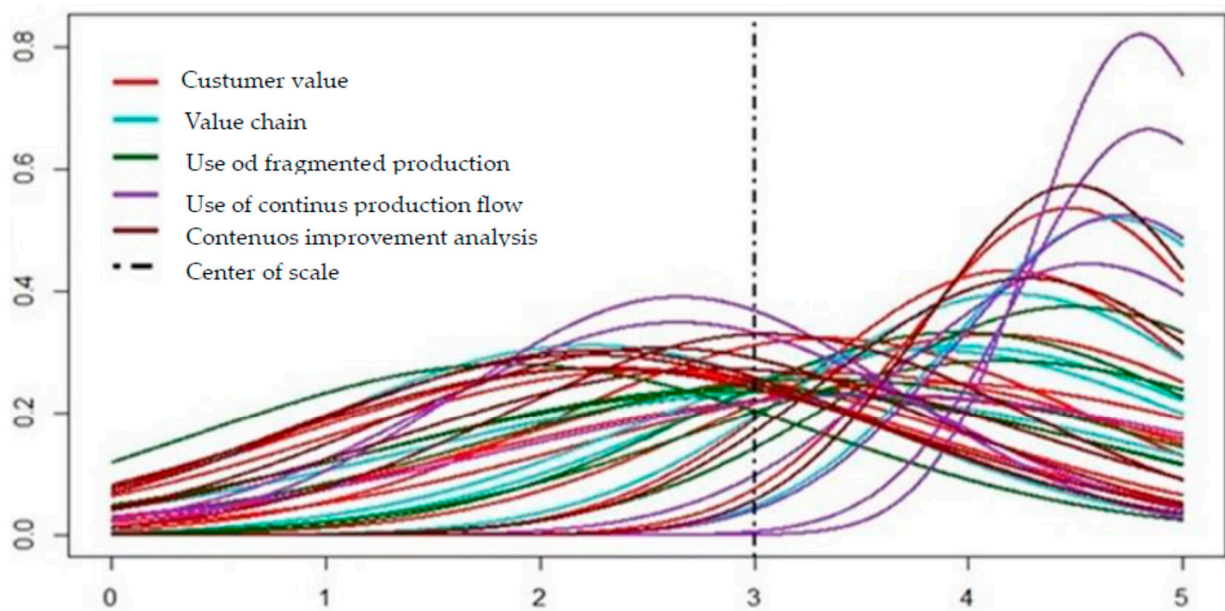


Figure 20. Overlapping the cumulative distribution curves of responses by dimension.

Table 22. Probability of responses being lower than the centre of the scale and classification of the group's response.

Dimensions	Item	p (Answer < 3)	Evaluation (Cut off = 0.5)
Customer Value	1.1. Customer needs.	0.0163	High
	1.2. Order production.	0.3886	High
	1.3. Satisfaction survey.	0.6778	Low
	1.4. Registration of complaints.	0.3037	High
	1.5. Handle complaints.	0.3978	High
	1.6. Produce by quality.	0.0242	High
	1.7. Accomplish deadlines.	0.1003	High
	1.8. Distribute products.	0.4650	High
	1.9. Meetings with customers.	0.6299	Low
	1.10. Adjustment to purchasing power.	0.3947	High
	1.11. Providing information.	0.1803	High
Value Chain	2.1. Valuing activities of value.	0.1174	High
	2.2. Stock registration.	0.0146	High
	2.3. Process time calculation.	0.2328	High
	2.4. Identify delay time.	0.7260	Low
	2.5. Graphing the process.	0.4649	High
	2.6. Track the entire process.	0.2737	High
Pull Production System	3.1. Produce by demand.	0.2032	High
	3.2. Plan daily production.	0.5024	Low
	3.3. Supply MP warehouse.	0.7883	Low
	3.4. Level production by demand.	0.2143	High
	3.5. Stock location.	0.0825	High
	3.6. Visual production devices.	0.4187	High
	3.7. Anomaly detection control.	0.5048	Low
Continuous Production Flow	4.1. Interconnection in the process.	0.0001	High
	4.2. Sequencing operations.	0.0124	High
	4.3. Process by unit.	0.3686	High
	4.4. Produce as planned.	0.0412	High
	4.5. Sort machines by sequence.	0.0011	High
	4.6. Absence of interruptions.	0.6340	Low
	4.7. Absence of delays.	0.6235	Low

Table 22. Cont.

Dimensions	Item	<i>p</i> (Answer < 3)	Evaluation (Cut off = 0.5)
Continuous Improvement	5.1. Programs to accompany employees.	0.5654	Low
	5.2. Employee autonomy.	0.4835	High
	5.3. Disseminate evaluation results.	0.6941	Low
	5.4. Engage employees in improvement.	0.7130	Low
	5.5. Improving employee training.	0.7183	Low
	5.6. Disseminate production strategies.	0.5436	Low
	5.7. C.T.O.D.S. procedure.	0.0887	High
	5.8. Improve by part and by machine.	0.6325	Low

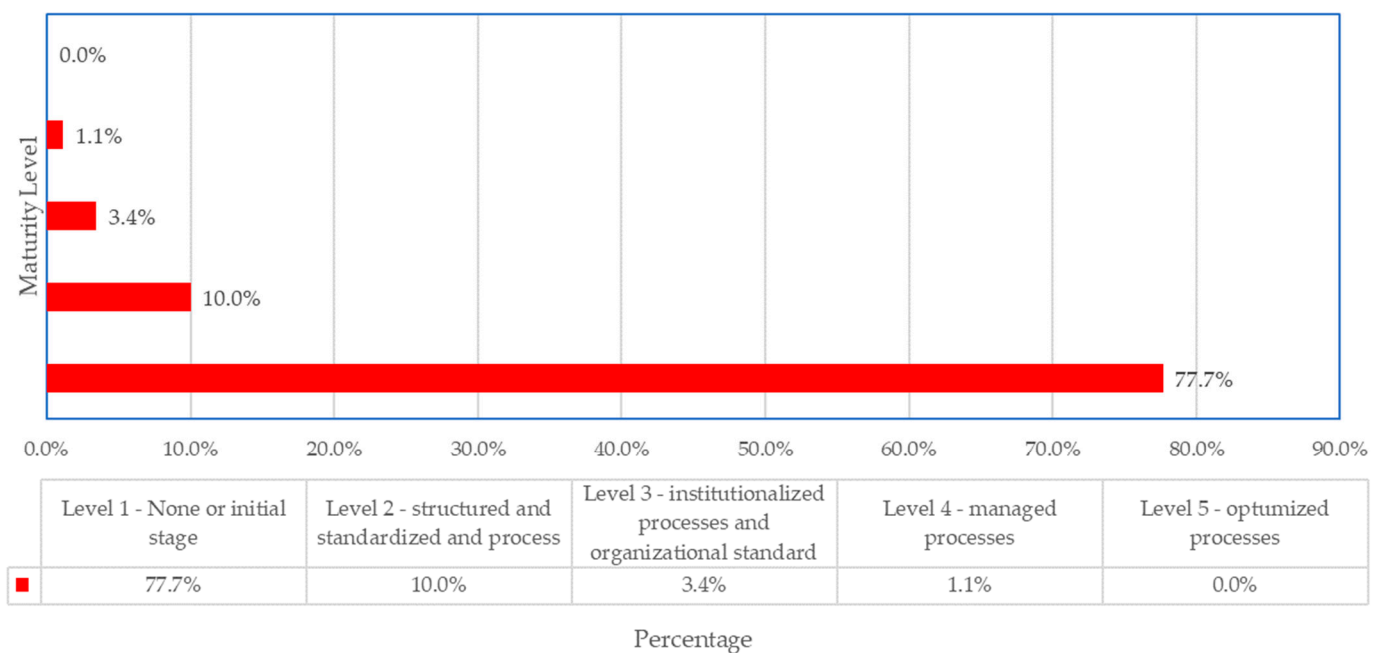


Figure 21. Frequency of responses regarding the maturity of Lean practices in industries in Luanda.

The survey data show that 87% of the industries in Luanda are in the initial levels of low Lean maturity, 4.5% at medium maturity, and none at high maturity.

8. Conclusions

The research was conducted on 87 industries located in Luanda, and it was evaluated whether these companies used Lean concepts, tools, and practices, that is, whether they applied the Lean manufacturing model to measure maturity [34].

Thus, Lean philosophy approaches were discussed in organisations with a focus on practices and tools [34]. A questionnaire survey of factories that are based in the industrial fabric of Luanda was used, specifically in the industrial development pole and in the special economic zone, both located in the municipality of Viana.

It was necessary to outline (in Figure 2) the limits of what was just the application of Lean tools, which in themselves do not establish the concept of Lean philosophy (and would be the initial level of maturity), to add the concept of Lean practices establishing the concept of a Lean system (intermediate level of maturity), which added to the “analysis of continuous improvement and pursuit of perfection” and may help reach the last stage, a holistic view of the system, called Lean philosophy (higher level of maturity). It was necessary to consider that Lean is a model that has a great number of peculiarities and understandings that allow for variations in the implantation sequence, which determine maturity.

These maturity levels were measured according to the Maturity model designed by Milan [6,28], which was already a simplification of LESAT developed by MIT. After a statistical analysis of the questionnaire answers, it was concluded that the level of Lean maturity in such industries is very low. This result cannot be generalised for all industries in Luanda, because the criterion for choosing industrial companies was accessibility, preferably within the industrial pole. However, there is a very strong expectation that, when expanding the research sample (which we recommend as future work), the result should be worse regarding the implementation of Lean practices, since such industries, on average, are most established.

For future research, it is recommended for the state of maturity of the FL in service companies in Angola to be investigated. As it is the most comprehensive sector, it may certainly contribute to their performance in maximising production.

Investigating the state of maturity of FL in the universities of Angola may help find solutions related to the training of individuals with knowledge of Lean philosophy.

Finally, taking into account the high number of companies that do not know the practices of FL, it would be pertinent to delve deeper into the barriers and drivers to the implementation of FL in this sector. This would also complement this research.

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Appendix A

Appendix A.1. Sample Characterisation

The information requested in the following table aims to characterise the sample of the population participating in this study. Please fill in the box below as per the items requested.

Main Activity Branch		
(A) Classification of the company as to Size		
(a.1) Small	(a.2) Average	(a.3) Big
(B) Legal classification of the company (Ownership)		
(b.1) Private	(b.2) State-owned	(b.3) Mixed
Company Country of Origin		

Appendix A.2. Instructions for Filling in the General Questions on Knowledge and Application of Principles of Lean Philosophy

The questions that follow are to verify the practices of the lean philosophy in this company. Mark with “X” the answers that best suit your opinion.

- Does the company know the practices of the Lean philosophy? YES ☐ NO ☐
- Does the company apply the practices of the Lean philosophy? YES ☐ NO ☐

Appendix A.3. Instructions for Filling in the Specific Questions on the Application of the Principles of the Lean Philosophy (LP)

How are the following principles of the lean philosophy followed in the company? Evaluate your company's adherence to the following principles, knowing that the number 1 (one) means "not followed", 2 "little followed", 3 "reasonably followed", 4 "very followed", and the number 5 "completely followed". Indicate your answer with an "X."

3.1. Customer Value					
Customer Value Practices	1	2	3	4	5
3.1.1. Valuing customer needs.					
3.1.2. Production according to customer orders.					
3.1.3. Conducting customer satisfaction surveys.					
3.1.4. Existence of a register of complaints.					
3.1.5. Existence of a complaint handling procedure.					
3.1.6. Produce based on product quality.					
3.1.7. Compliance with the delivery deadline.					
3.1.8. Distribution of products to customers by the company.					
3.1.9. Holding meetings with customers.					
3.1.10. Adjustment of prices to the customer's purchasing power.					
3.1.11. Availability of company and product information.					
3.2. Value Chain					
Value chain practices	1	2	3	4	5
3.2.1. Valuing the activities of the production process that add value					
3.2.2. Registration of the existence of the product in stock					
3.2.3. Calculation of product processing time					
3.2.4. Identification of the time it takes to perform the activities					
Value chain practices	1	2	3	4	5
3.2.5. Graphic representation of the production process					
3.2.6. Tracking of the process from the supplier to the distribution of the product to the customer					
3.3. Pull Production System					
Pull Production System Practices	1	2	3	4	5
3.3.1. Produce according to customer demand					
3.3.2. Plan production daily					
3.3.3. Supply of raw material from the warehouse in function of needs					
3.3.4. Levelling of production according to demand					
3.3.5. Specific location for stock					
3.3.6. Visual devices that identify problems in production					
3.3.7. Production control by means of automatic systems for detecting anomalies or quality problems					
3.4. Continuous Production Flow					
Continuous Production Flow Practices	1	2	3	4	5
3.4.1. Interconnection of the stages of the process					
3.4.2. Sequencing of operations					
3.4.3. Processing per unit					
3.4.4. Production according to plan					
3.4.5. Organisation of the machines according to the sequence of the process					
3.4.6. Interrupted processes					
3.4.7. Processes without delay in carrying out activities					
3.5. Continuous Improvement					
Continuous Improvement Practices	1	2	3	4	5
3.5.1. Existence of programmes for monitoring, evaluation, and development of employee skills					
3.5.2. Autonomy of employees in solving specific problems					
3.5.3. Dissemination of evaluation and productivity results					

3.5.4. Employee involvement in the design of the continuous improvement programme					
3.5.5. Training of employees in matters of continuous improvement					
3.5.6. Dissemination of production strategies to all employees of the company					
3.5.7. Cleaning, tidiness, organisation, discipline, and safety procedures					
3.5.8. Implementation of improvement per part or per machine					

Appendix A.4. Instructions for Filling in the Questions on the Knowledge of the Tools of Lean Philosophy Practices

The questions that follow are to verify the practices of the Lean Philosophy in this company. Mark with “X” the answer that best suits your opinion.

Does the company know the following tools of the Lean Philosophy?

Lean Philosophy Tools	Answers	
	YES	NO
5 S		
Andon		
Bottleneck Analysis		
Gemba		
Heijunka		
Hoshin Kanri		
Jidoka		
Kaizen		
Kanban		
KPI		
PDCA		
Poka-Yoke		
SMED		
VSM		
JIT		

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