Lean concepts Implementation on a case study

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Abstract

Crisis situations have always triggered progress in economic environments, challenging the resilience of companies faced with the unknown. Indeed, the automotive industry has always been present in revolutions, being a major player in the evolution of the use of practices and operations management tools. Furthermore, the robustness of this area within companies can determine the consolidation of financial structure and the sustainability of growth.

The issue presented in this Dissertation is inserted in the lower operating performance in the area of maintenance and repair of light vehicles of company ABC, leading representative of dealers and workshops in Portugal the brand XYZ. Hence, the limitations identified are based on material flow and resources management. Although the problem indicated is common to different units, in order to restrict the scope, the case study was limited to the workshop located in Alfragide, Lisboa

Furthermore, this Dissertation presents the results of the implementation of a range of selected tools, starting from the study of examples of the Literature Review. To this end, it was proceeded to the adaptation of the alternatives, starting from data collection and analysis made for a better effectiveness of the approach. As for the impacts resulting from the implementation of the proposed improvements include better productivity in 41%, as well as the increase in the average number of daily interventions recorded in 49%.

Keywords: Workshop, Muda, Productivity, Supply Flow, Continuous Improvement

1. Introduction

The European economic instability has influenced the enterprises'' performance, unveiling existing inefficiencies (Brandenburg, 2016). Therefore, the operations management companies' structure should mitigate the financial wane due to recession periods (Robbins & Pearce II,1992), ideally leading to an increase of production (Kliesen, 2003). In addition, the markets competitiveness growth and the change pacing customer needs urge for new management philosophies (Leite & Braz, 2016).

Furthermore, the Kaizen methodology is based on continuous improvement, promoting the sustainability growth by focusing on Quality, Cost, Service Level and employees Motivation. In addition, Imai (1986) reason that this methodology endorses the costumers' precedence, by eliminating the Muda activities, namely the non-added value processes.

Hence, the fundamental principles of the Kaizen methodologies are: Creating customer value; waste elimination on the customer point of view; Creating flow; pull flow system and continuous improvement (Hicks, et al., 2015).

Historically, the automotive sector has been a leading player on industrial revolutions, developing new tools and technologies for the operations management area. However, the after sales services are rarely studied by the scientific community, resulting on lack of support and embracing case studies out of the context desired.

Empresa ABC is the leading representative of dealers and workshops in Portugal for the automotive brand XYZ, with 25% of the market share. The company outstands for its experience and services reliability, assigning primary commitment to customers.

Despite the efforts, the performance on the workshop area is beyond the expected and is not

aligned with the company's vision and strategic objectives.
Therefore, the aim of this Paper is to present the implementation and results of a set of tools assembled in order to exceed the problem identified, based on the survey and data collection phase.
In the next section a brief review will be made to the available literature about the existing operations models that are or might be applied to the scope. On Section 3 it will present the methodology used. The section 4 introduces the case study, through its facilities description and process flow. On section 5 it will be described the selected tools adaptation and implementation, followed by section 6, where the results obtained are analysed. Finally, section 8 presents the conclusions and the proposed future actions.

2. Literature review

The results of the search of the existing literature and case studies on the after sales context are a restricted and scattered number of examples, moreover they are out of the scope intended (Dombrowski & Engel, 2014) Murali, et al. (2016).
As a result, firstly it must be understood if the processes of the case study are similar to product or services areas, in order to narrow the following operation models studied.
The differences of services and product are related to the intangibility of the output. For instance, the production of a service occurs at the same time as its consume, it cannot be stored and the quality assessment is subordinated to each client. In addition, this divergence of concepts implies different management structures, processes and organizational assessment. (Bowen & Ford, 2002).
Regarding this definition and considering that the perception of quality of the intervention of each vehicle follows an objective criteria established by the brand XYZ, the processes in study might be addressed similarly to the operations on a product area.
The leading product operations management models since Fordism have been changing from time to time, stressing out the one that can better adjust to the costumers' consumption pattern (Kenney & Florida, 1989).
On the recent years, the leading methodologies are the Lean Production(LM) and the Agile Production(AM) (Bartezzaghi, 1999). In addition, owing to the emerging technology trends to automate processes it must be highlighted the implementation of smart objects. (Musa, et al., 2014).

2.2 Lean Manufacturing

The LM had its foundation in the management models developed by the Japanese companies after the second world war, particularly from the Toyota Motor Corporation (Hines, et al., 2004).
This methodology is based on the elimination of waste, which can be divided in seven categories (Womack & Jones, 2003):

- Wait;
- Transportation;
- Movement;
- Inventory;
- Errors;
- Overproduction
- Over processing;

Based on published examples, the tools from LM with major impact on operations analysis and productivity are:

- 5S- the aim of this tool is to increase procedures efficiency (Waldhausen, et al., 2010), maintaining a clean and organized workstation.
- Ishikawa diagrams (ID)- Jayswal, et al., (2011) use the ID in order to identify the limitations' root causes on a clear and objective manner.
- Continuous Improvement(CI)- CI furthers the sustainable growth using the Plan-Do-Check-Act cycle, not only by disruptive change, but mainly by incremental improvements (de Lange-Ros & Boer, 2001).
- Standardize- according to Womack & Jones (2003), processes standardization reduces the production and quality variabilty by ensure the best practises are used.
- Kanban- to reduce replenishment lead time and products inventory, the Kanban supports the supply management by working on a pull system (Naufal, et al.,2012).
- Leveling- in furtherance of reducing out of stock situations or improve the rate of capacity used, this tool objective is to reduce the chain variability (Hopp e Spearman, 2008).

- Mizusumashi- this line supply model, originated from the Toyota Production System, reduces line stops as well as line inventory. Nowadays, the Mizusumashi represents one key element on the automotive sector (Emde, et al., 2012).

Melton (2005) identifies as one of the major difficulties on the LM tools implementations is the lack of resilience on companies.

2.3 Agile Manufacturing

In 1991, a group of researchers from the Iaccoca Institute among other company managers presented a new production management model to support the American organizations. The core of this new methodology is to provide companies with high flexibility in order to keep up with the customers' demands (Yusuf, et al., 1999).

In comparison with the LM, AM is not focused by the implementation of tools with certain purpose, but a new business vision (Gunasekaran, 1999).

Yusuf, et al., (1999) describe the drivers of this model as:

- Automation;
- Increase the customers' range of choice and expectations;
- Competitive priorities;
- Integration and initiatives;
- Target production synergies

In addition, it has ten domain targets to work in: processes integration; team building; technology; change; education; skills; quality; partnerships; welfare; market.

In the case of McCullen & Towill (2001), the integration of processes, partnerships through the chain and the reduction of planning cycles reduced the variability and inventory by 45%. On the other hand, in OPEL Spain by the standardization of operations, Total Quality Management (TQM), virtual integration and new partnerships, it was achieved the lowest lead time for new models on the entire company. Moreover,

The implementation of Kanban, TQM and processes redesign on Iberian John Deere resulted in better quality and service to the customers (Vázquez-Bustelo & Lucía, 2006).

Nevertheless, due to the difficulty to distinguish concepts, on the implementation assessment might not be possible to differentiate the results (Leite & Braz, 2016).

2.4 Smart Objects

The concept of "smart product" is the key concept for the integration of products on the information system and communication with other products, processes and stakeholders (Putnik, et al., 2015). Hence, it increases the coordination, flexibility, efficiency and productivity of the value chain (Musa, et al., 2014).

One of the earliest methods to introduce information on products and data recognition through the organization was the bar code, which are low-priced and easily adapted (Manthou & Vlachopoulou, 2001). Furthermore, Desforges & Archimede, (2006) introduce the implementation of smart sensors in order to identify, monitor and adapt the production and reduce redundant operations. Additionally, Radio Frequency Identification (RFID) systems support the management and tracking of products (Huang, et al., 2008).

Not only the data capture is relevant, but also the integration and analysis. Thus, organizations use Enterprise Resource Planning and Manufacturing Execution Systems software to ground management decisions. Hence, most systems are customized accordingly to each company requirements (Putnik, et al., 2015).

3. Methodology

The methodology used on the development of the study assents on the Melton's proposed structure in order to apply Lean Thinking (Figure 1).

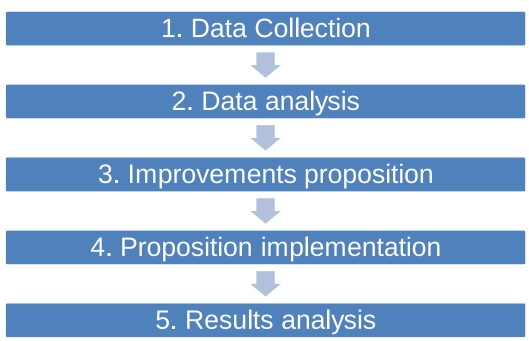

Figure 1 – Lean Thinking Structure
Font: Melton, 2005

Initially it is proceeded to the collection of the relevant data that bears further analysis and decisions (1). Moreover, the information gathered is analyzed, identifying the difficulties and problems (2). Therefore, it is formulated a proposition of improvements (3). The forth step is to implement the proponed alternatives (4), followed by the results assessment and discussion.

4. Case-study

To narrow the scope, the study on hand was elaborate on the central workshop of Empresa ABC, particularly on the maintenance and repair operations. However, it was not included the accidents repair area.

4.1 Facilities

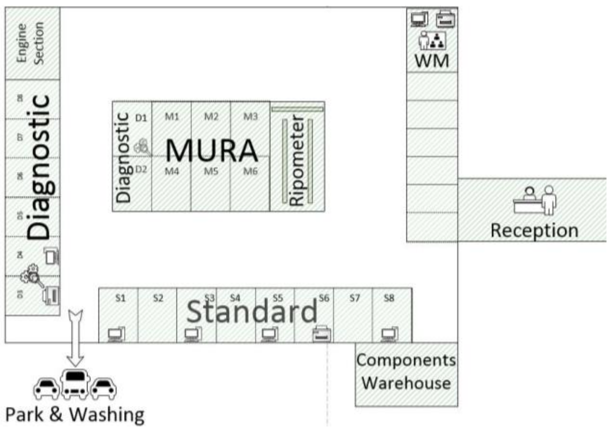

Figure 2 – Workshop layout

As represented in Figure 2, the workshop in study is divided in 9 areas, separated according to the procedures that take place. On the reception area it is made the first approach to the costumer by the client managers. In addition, it is also made a preliminary diagnosis.

Furthermore, the ripometer equipment measures the peak force and the steering alignment. The components warehouse is the inventory of all material and parts needed for the interventions. The WM zone is the organization station for the workshop manager. Moreover, it is on the standard area that take place all the maintenance procedures, which regularly take less than 2 hours. Furthermore, the extensive mechanical procedures, namely the interventions that are expected to take more than 2 hours, take place on the Mura zone. The electrical repairs and the diagnosis assessments, in case the preliminary diagnosis is inconclusive, occur on the diagnostic zone. Finally, there is the vehicles park and the washing operations.

4.2 Interventions differences

Brand XYZ has 16 different light vehicles models, with hundreds of different combinations of specifications each, among engine, brake system, electrical system, gears and others. For instance, we have different procedures for the same type of intervention for the same vehicle model and perform the same procedure for different models, regarding the vehicle features. For better understanding, Table 1 represents an example of different intervention operations for 2 different combination of specifications.

Table 1 – intervention differences example

Model				
Brake Type	A	B	B	A
Fuel	Diesel	Gasoline	Diesel	Gasoline
Pads change operation	1	2	2	1
Fuel Filtre change operation	1	2	1	2

Resuming, the type and sequence of operations for each vehicle intervention is highly variable.

4.3 Human Resources

The workshop technical team is featured by 1 workshop manager(WM), 12 technicians, 2 quality controllers (QC) and 1 technical responsible. The WM manages all operations in the workshop, namely assign priorities, assign vehicles, review extra procedures estimates and give technical support. Furthermore, the technicians are responsible for executing the interventions. The quality controllers perform the quality assessment according to the requirements set by the brand. Finally, the technical responsible follow all diagnosis operations and gives technical support. In addition, in case of the WM absence assumes the role of workshop manager.

4.4 Vehicle Flow

Figure 3 represents the cycle of the vehicle flow through the intervention process.

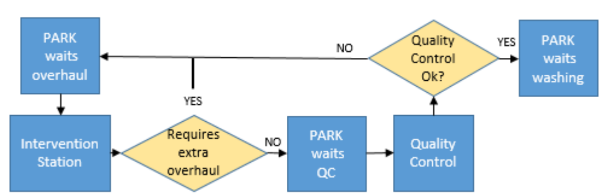

Figure 3 – Vehicle flow

On the first stage, one technician directs the vehicle from the park to a free station and goes to the warehouse in order to collect the materials needed. Afterwards the operator starts the procedure. In case there is an anomaly, the technician registers a new intervention estimate and the automobile re-enters in the cycle. Then the operator drives the vehicle back to the park. The fourth stage is the quality control. Finally, if the assessment is ok, it leaves the cycle, otherwise restarts the cycle from stage 1.

4.5 Performance description

The workshop registers about 25,6 interventions per day, with an average duration of 2.97 hours each. Furthermore, 18% of the vehicles fail on the quality control assessment.

Moreover, the main key performance indicator is the productivity, which is the relation of the invoiced hours and the hours worked by the technicians. In other words, it can be calculated as it is shown by Equation 1.

$$Productivity = \frac{Nº\ of\ hours\ invoiced}{Nº\ of\ hours\ worked} \qquad (1)$$

In addition, the productivity is the weighted result of the efficiency of operations and the occupation rate. On one hand, the efficiency is the relation of the hours' invoice with the duration of the interventions, while on the other the occupation rate is the relation of the duration of the interventions and the hours worked by the technical team. In fact, the hours invoiced are established by the brand depending on the type of operation. For the year of 2015 the overall productivity was 54.2%.

Additionally, for each cycle, the technicians take 30 minutes on tasks besides executing the intervention, such as collecting materials and positioning the vehicle at the workstation.

Further, not all interventions are scheduled in advance. Thus, there is a mark unbalanced workload through the week, where the first and the last days are quiet comparing to the third and fourth days.

Finally, generally speaking, based on the questionnaires elaborated, the team motivation was classified as "medium".

4.6 Limitations

In conclusion, regarding the performance description, there are 4 major limitations on the workshop:

- Low occupation rate;
- Low efficiency;
- High quality control fail rate;
- Low team motivation level;

A deepen analysis using the Ishikawa diagrams unveiled the root causes of the difficulties mentioned. Respecting the occupation rate, the motives identified are the seasonality, the waiting while collecting the components and the process of positioning the vehicle at the workstation. Furthermore, regarding the efficiency it was pinpointed the workshop disorganization of the equipment placement and the lack of technical skills. Moreover, the fail rate diagnosed is due to the lack of technical skills and incorrect procedure execution. At last, on behalf of the motivation level, it was identified the lack of openness for communication and appreciation from the top managers.

5. Proposition implementation

5.1 Implementation structure

The implementation of the improvements proposed was structured in 5 stages, prioritizing according to their entailed disruptiveness and objective. Therefore, the stages are the following:

- Stage 1 – Supply flow – the implementation of mizusumashi and the creation of a sequencer supported by bar codes will reduced the periods that the technicians are not executing an intervention.
- Stage 2 – Workshop organization – the 5S, Kanban system and process standardization will reduce the time the team is looking for equipments and will help reduce the errors in procedures.
- Stage 3 – Scheduling – in order to mitigate the seasonality through the week, leveling the interventions scheduled will balance the workload.
- Stage 4 – Team Management – creating a continuous improvement program will increase the resources flexibility, communication quality and team motivation.
- Stage 5 – Individual improvement – introducing a coaching and feedback programs will increase the motivation and resources flexibility, as well as reduced the errors occurred.

The implementation of each tool occurred in 3 phases: 1) Test the tool; 2) Verify if it is adapted effectively to the case study, otherwise modify and repeat phase 1; 3) Follow up if the tool is updated according to the workshop features.

5.2 Stage 1 – Supply flow

Owing to the experience and the investment on coaching sessions, each technician has great value for the company. Therefore, for the mizusumashi implementation it was necessary to introduce a new operator to the team, which from then on was responsible for the material supply and vehicles positioning. In addition, it was relocated one warehouse worker to the WM zone. By this, the mentioned operator has the role to do the inventory administrative management and to beforehand separate the materials for each intervention and place them by the WM area.

The trigger for the beginning of mizusumashi cycle is when a technician places a pin in front of the vehicle, representing the end of operation. Hence, the mizusumashi takes the vehicle to the WM area, where collects the intervention sheet, the keys and the parts needed for the next vehicle. Moreover, the supply operator drives the automobile to the park and swaps to the next. Further, the mizusumashi position the new vehicle on the empty workstation.

On the other hand, for the sequencer there are two different cycles, one for mizusumashi and another for the technicians. The first, at the same step of collecting the intervention sheet, the mizusumashi introduces the data regarding the vehicle and the workstation it will be positioned at. For this, he uses the bar code labels identifying each station and the bar code on the sheet. On the technicians' cycle, after an intervention is concluded, the operator opens the sequencer software and it is shown the next vehicle to be intervencioned. In addition, there is a display page that display on time the situation of each intervention.

5.3 Stage 2 – Workshop organization

As presented by the 5S methodology, the first step stands for sort. Therefore, it was identified the equipments that are frequently used, the seldom used and the obsolete. Further, on the second step, straighten, the equipments were placed accordingly to the procedures and area they are applied. The transversal equipment's were placed on a sharing area. Moreover, it was defined the cleanliness standard on the third step. Furthermore, on the standard step, each equipment is identified, as well as its location. For the last step, it was created an audits system to guarantee the maintenance of the new organizational configuration.

Besides, it was implemented a Kanban system for the consumables easy replenishment, such as lubricants and cleaning sprays. This way, the technicians do not have to go to the warehouse for substitution. At the end of the day one of the warehouse operator supplies the Kanban inventory in case of need.

Finally, it was created operations standards for the key procedures to support proper execution and reduce errors. Afterwards, the norms were placed on key locations for easy access.

5.4 Stage 3 – Scheduling

On stage 3 it was implemented the leveling of workload by focusing on the interventions appointments. Initially, the process of scheduling had no priority or capacity management. Therefore, it was created a procedure to narrow to the appointments to the first or last days of the week. Additionally, it was created a form explaining the benefits, namely the lead time and the service quality, to persuaded the customer's choice.

5.5 Stage 4 – Team Management

At the beginning of each day the WM conducted a briefing meeting with the technical team. However, it did not follow a defined structure. Hence, the continuous improvement program was infused in this session.

As a result, it was created a meeting board, which includes an agenda, the team key performance indicators, and a PDCA cycle, that promotes new improvement designs for the operation. In addition, each day a top manager from the company takes part in the reunion. By this, it is achieved an open and effective communication on preparation for the rest of the day.

5.6 Stage 5 – Individual Improvement

In order to transmit a clear assessment, it was placed at the meeting board the individual indicators as well. In addition, it was created a difficulties and errors table, identifying the most common problems and their countermeasures, contributing for a problem-solving discussion during the team meeting.

Moreover, to support the preparation of the coaching program it was elaborated a skills matrix of the technical team regarding the experience and knowledge on each process. However, due to its strategic and long-term scope, the elaboration of the program is not part of the paper presented, thereby it will not be taken in consideration on the following section.

6. Results assessment

The results assessment takes in consideration the 15 weeks' duration of the proposition implementation. As well, it concerns the indicators previously defined.

Analysing the evolution of the quality control fail rate indicator is not possible to identify clearly which implementation stages had an impact. Despite, it was since the stage 2 implementation that the fail rate started declining continuously, registering 16.6% at week 15, from the 18% of the initial state. Hence, the benefits of the proposed alternatives might not be obtained immediately, but on mid term.

In contrast, as it is shown on Figure 4, the productivity KPI had significant variability over the implementation period.

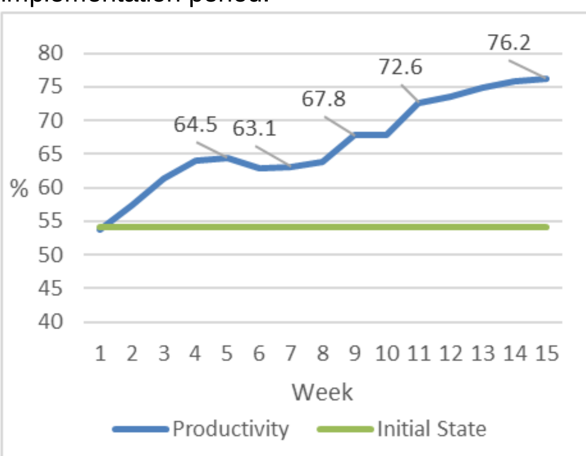

Figure 4 – Productivity indicator evolution

In spite of at week four there is a peak of an improvement of 10%, it is followed by a wane down to 63%. This evolution is due to stage 1, that raised the occupation rate up to 20% increasing the existing capacity. Yet, it also increased the sazonality impact, since it boosted the workload on peak days, but not through the rest of the week. Furthermore, at week 9 there is a new rise of the indicator owing to stage 2. The implementation of 5S, Kanban and processes standardization enhanced the efficiency index, registering 87.3% comparing with the initial 79.9%. Moreover, stage 3 reduced the difference amplitude of workload through the week on 58%. Thus, leading to the improvement indicated on week 11 on Figure 4.

During the last four weeks of the implementation period there was an incremental growth on the productivity, however it was not possible determine effectively the reason. Nevertheless, it is not expected that stages 4 and 5 to burst the workshop performance, but to sustain the improvements achieved.

Despite of the productivity growth analysed, it was included a new member on the technical team that does not execute intervencions, therefore his productivity indicator is 0%. Figure 5 represents the KPI progress including Mizusumashi.

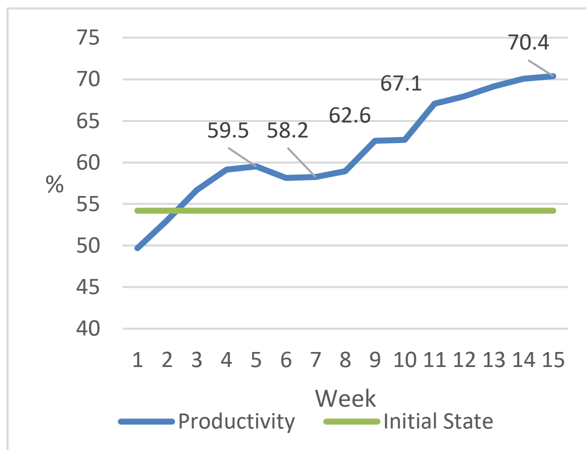

Figure 5 – Productivity indicator evolution including Mizusumashi

As shown by Figure 5,

7. Conclusions

8. References

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