# Collaborative supplier development for Lean implementation: a case study

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**Abstract**: Enterprises face numerous barriers when dealing with Lean implementation campaigns, especially if the companies' dimensions are small. Recent studies highlighted the struggles of small firms in dealing with Lean implementation barriers, but few discussed the importance of collaborative supply chain relationships to overcome these barriers. This article depicts a case study undertaken in a company that shows how a collaborative customer-supplier relationship can help small-medium enterprises enter the Lean philosophy. The methodology used in this paper is a case study carried out in one Italian mechanical company working mainly as a tier-two supplier in the automotive sector. The implementation of Lean in this firm was prompted and actively supported by a tier-one automotive firm settled in Italy. The outcome of this paper depicts a successful Lean implementation in an SME thanks to the use of Lean Thinking tools, the collaborative relationship between customer-supplier and the support given by the first to the latter. This research limit lies in using a single case study and the lack of a long-term study period. This paper can help managers, practitioners, and firms understand the potentiality and opportunities given by the collaboration between different supply chain actors, ensuring a successful Lean implementation.

**Keywords**: Lean manufacturing, Lean implementation, Supplier development, Collaborative supply chain

## I. Introduction

Lean Management has been studied as one of the most successful management paradigms in the last decades. Throughout the years, Lean has evolved and changed itself to keep up with the times and e aligned with the new technologies and phenomena that are changing the manufacturing and management environment. Even if Lean can be considered a mature topic, largely adopted by several firms both in manufacturing and not-manufacturing ones, it is still under study due to a different adoption grade, depending on firm size or sector.

Even if Lean is generally considered successful for manufacturing enterprises, it is not always like that. Numerous are the barriers that firms face, especially when dealing with first-time implementation and when they have to sustain the implementations already done. Suppose firms cannot deal with these barriers (Rafique et al., 2016). In that case, the implementation will lead to unsuccessful implementation, scarce results, and an overall failure of the whole implementation project.

Several barriers hinder the implementation of Lean thinking; among the others, some are very common and impact heavily on the success of Lean implementation campaigns.

These are mainly related to the lack of resources (Kumar and Kumar, 2014); lack of time (Wong et al., 2009); lack of methodology (Kumar, 2014), and lack of knowledge (Marchwinski, 2007; Kumar and Kumar 2014). Other studies have highlighted the influence of internal human factors such as resistance to change (Marchwinski 2007), lack of collaboration (Jadhav et al. 2014) and lack of innovative ideas (Kumar and Kumar 2014).

However, another external factor has been identified in some works as customer pressure (Cheah et al., 2012) or lack of collaboration with other supply chain players (Sharma et al., 2003). Related to this last point, one factor that could help companies face Lean implementation barriers is a collaborative relationship (Tortorella et al., 2017). Building customer-supplier relationship management can enhance firms performance both at the internal and at the supply chain level is the establishment of a customer-supplier relationship

All the previously cited barriers are common also for SMEs (small-medium enterprises). They are even more difficult to deal with due to the scarcity of resources, especially if compared to multinational firms. There are many examples of SMEs struggling toward Lean implementation and dealing with the highlighted barriers in literature (Horváth and Szabó, 2019).

Especially in this case, where resources are lacking, and the power is usually less than multinational enterprise, it would be extremely important to establish a strong relationship with larger enterprises across the supply chain to get help and improve the overall supply chain performance.

Historically born with Toyota, where supplier development was pioneered, Wagner, 2006 later defined supplier development as the set of practices and supporting actions towards the supplier to improve its capabilities and performance.

Among the supply chain management practices, various papers investigate the impact of supplier development and state the effectiveness of these practices for enhancing supply chain performance and success (Shokri et al., 2010).

Even though supplier development is embedded in the Lean philosophy, it is strictly related to the invention of the Toyota Productive System. Although supplier development has been studied alone and with Lean (Powell and Coughlan, 2020), showing its success, few are examples in the literature investigating the impact of supplier development on Lean implementation.

Apart from a few studies (Kim, 2015), few are the paper deepening the analysis on how developing supply chain relationships can help overcome traditional Lean barriers, thus leading to a successful implementation and an improved supply chain performance.

So, it would be interesting to know if and how supplier development or, more generally, creating customer-supplier relationships can help firms, in particular, is characterised by a small dimension in exceeding the barriers of Lean implementation.

Thus, this study's goal will be to address this research question, trying to show through a case study how a supplier development practice among two companies of very different dimensions can help reach a successful Lean implementation and which benefits can bring to both companies.

## II. METHODOLOGY

The methodology used for this study is the analysis of a case study. This has been decided for several reasons, but the most relevant ones are:

The case study has flexibility in design and application (Merriam and Tisdell, 2015).

It is useful for testing existing theories and providing a baseline for the application of solutions to business issues (Gijo et al., 2018).

The case study methodology is widely used to test the effectiveness of programs like Lean implementation ones (Zhang et al., 2015; Sunder et al., 2019).

However, according to Welsh and Lyons (2001), the outcomes from a single case study are not statistically relevant and generalisable. Still, the possibility to confirm and apply theories, in this case, the effectiveness of the collaboration among different supply-chain players to implement Lean, mitigates this weakness.

In fact, according to (Sunder et al., 2020), a single case study can add new knowledge for future practitioners and researchers, and it is still valid for this purpose.

Generally, articles focused on operations management tend to extend existing theories or use them to explain phenomena (Karlsson, 2016, Amrani and Ducq, 2020). These authors explain two research axes: exploratory studies and confirmatory studies. This article lies in the confirmatory one. As in this case, the author has an idea "a priori" about the relationship between the variables under investigation in confirmatory research. In this approach, the researcher tries to see if a theory, specified as a hypothesis, is supported by evidence and data.

Using a case study methodology has allowed the direct observation of the processes and the interactions with workers at different levels, from shop-floor level to managerial one.

From the literature analysis, the best outcome that is possible to say is the scarce paper presence talking about Lean implementation through collaborative relationships for supplier development. Thus, this work aims to understand how a collaborative relationship between supplier and customer can help the smaller company join the Lean philosophy. To this extent, the single case study approach (Yin, 2018) fits perfectly with the scope of this paper. It favours a thorough knowledge of how a collaborative supply can help small and medium enterprises overcome traditional barriers and successfully introduce Lean management.

### *A. Case study context*

This research was developed thanks to two companies' commitment, being in a customer-supplier relationship and acting mainly in the automotive supply chain. The two firms will be called Company A for the customer, while Company B is the customer. From an overall automotive supply-chain perspective, Company A belongs to tier 1 while Company B to tier 2.

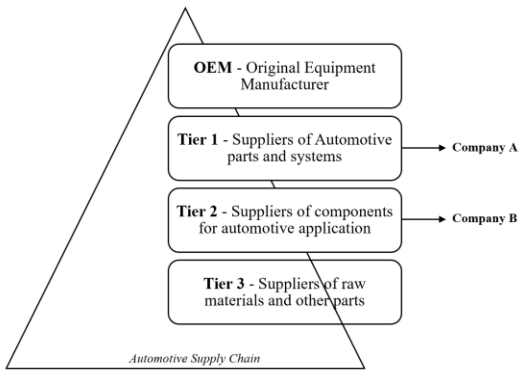


Fig. 1. Automotive supply chain with Company A and B positioning

Company A is a firm that belongs to one of the biggest groups, which acts as a supplier of several components for the automotive industry. It can be considered a Multinational Enterprise (from now on, MNE).

Company A is located in northern Italy and, for 25 years, has been part of one of the biggest groups acting in the Mobility Solutions sector, especially in the automotive industry. It is an industrial company that works in the vacuum and hydraulics fields, with products destined for the international automotive market. Its main products are vacuum pumps, for which the company represents the worldwide competence centre for the group. The product portfolio ranges from vacuum pumps to oil pumps (both mechanical and electrical), combined pumps, and fuel pumps.

Company A's group acts on various types of business sectors solutions for mobility, which consists of the overall 60% of the group, and Industrial Technology, Energy & Building Tech and Consumer Goods. The overall group has revenues of more than 50 billion per year and has hundreds of productive plants spread in Europe, Asia, and the Americas.

Company B is a supplier of Company A. It is a small Italian mechanical processing enterprise working previously in the Italian market. Company A is one of the most important customers. Company B is also a supplier of other important companies in different sectors. The Automotive one is the main business, but it also produces for customers active in the electronics and the industrial plants.

Company B's main process is bar turning, a technology in which the company is specialised. In this production process, the firm has diversified its offer by investing in a wide range of machines that allow it to choose the best technology according to the product's characteristics. The production is divided into three departments: CNC single-bar lathes, mechanical single-bar lathes and multi-spindle lathes that allow it to process production batches ranging from a few hundred pieces up to several million, and it is very flexible also in manufacturing different products in terms of shape, material, and dimension.

Companies A and B have a long and solid relationship reinforced by representing key players for both firms. Company A certainly occupies a prominent place among Company B's customers since it represents more than 20% of the yearly revenues. On the other hand, Company B represents 4.5% of Company A's purchase budget, positioning itself as the seventh supplier out of more than 90.

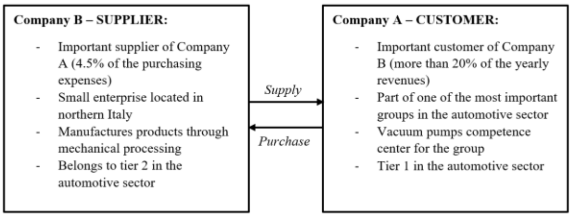


Fig. 2. Companies A and B's relationship

It was increasingly important for both firms to integrate processes in the best possible way to ensure good production flexibility to cope with demand variability, thus optimising the entire supply chain toward the end customer.

To continue and strengthen this collaboration, a project was undertaken to improve and optimise the activities carried out in Company B, using a Lean approach. In fact, in recent times, this firm has tried to implement Lean but has faced troubles and clashed with the traditional barriers. Despite those attempts to make some changes and standardise some procedures, Company B desired to deepen the analysis and do it through a rigorous methodology. Company B was aware of numerous barriers such as lack of resources, expertise and time.

Thanks to Company A's extensive wisdom and experience in these kinds of projects and the need to bring the Lean Thinking as a structured method to be replicated in the future have led the two companies to collaborate to improve their performance at the internal and supply chain levels. The help from the bigger company was functional to overcome the barriers.

Thanks to these facts, a pilot project has been carried out in the supplier plant, and after a brief analysis of the scenario, the starting area has been identified. The decision was made based on strategic importance, inefficiencies to tackle, and project replicability; thus, the bar turning department has been defined as the starting point.

### *B. Case study deployment*

As previously mentioned, the general idea of the project was not only to optimise the upstream player of the supply chain. The scope was to help the upstream companies with resources coming from the downstream one, which was bigger and more powerful in terms of resources, to give them the possibility to develop a pilot project that could be easily replicated in the future.

So after having identified the area, based on strategic importance, replicability and the possibility to easily tackle inefficiencies, which consisted of being the turning department, the focus was on the two most important families of products: pistons and valve holders.

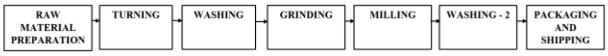


Fig. 3. Piston flow chart

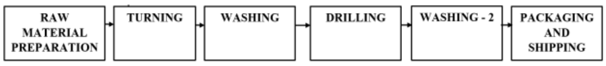


Fig. 4. Valve Holder flow chart

Then the team was jointly defined: Company A decided to fully dedicate a person from their purchasing department to the shop floor of Company B, to bring his experience in continuous improvement projects to the supplier. This one was placed side by side with the Operations Manager of Company B to discuss the objectives and move forward with the study together.

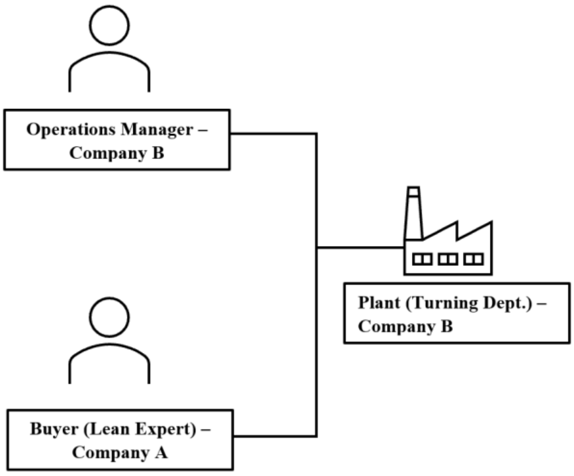


Fig. 5. Resources mainly involved in the project

As the last thing before starting with the study, according to the need for a structured method and replicability, it has been decided to follow the A3 methodology. Developed based on Toyota's problem-solving approach (Rother and Shook, 1999), among the other Lean tools, the A3 model has been widely used to conduct continuous improvement projects to introduce Lean thinking into companies (Torri et al., 2021, Rossini et al., 2019)

It is very helpful because it helps companies act in a structured way, tackle the root causes that are provoking the issues, and share the success of the projects to be replied to in other areas (Sobek and Jimmerson, 2004). Moreover, its easiness in the implementation, learning and its peculiarity of being visual made it perfect for the scope of this case study. As can be seen in figure 6, it is based on eight subsequential steps; each of these belongs to one phase of the famous PDCA (Plan-Do-Check-Act) cycle.

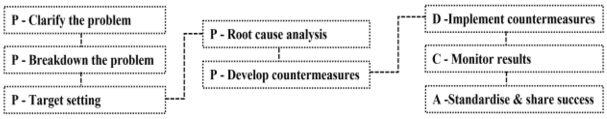


Fig. 6. A3 8 steps model

*C. Lean implementation*

Following the A3 model, the first step was understanding which was the problem, why it was relevant for the firm and in which area it was located. For the previously mentioned motivations, the case study started from the turning department, focusing mainly on two families of products: pistons and valve holders. After interviews and data gathering, a clearer overview of the process was obtained and why improving the AS-IS condition was fundamental.

Firstly, regarding the relevance for both companies of the products examined, they are strategical and relevant for the hydraulics application. These components represent approximately 15% of the value of Company B products in Company A's purchase budget. In contrast, they represent 15% of the turnover relating to Company A and 3.5% of the overall yearly turnover of Company B side.

Then, these components are produced on the mechanical lathes, using the machines for about 50% of the calendar hours. For the remaining hours, the machines are used by other turned components. The setup times required in turning machines currently account for more than 9% of the yearly calendar hours, thus making it costly to change from one code to another. This, therefore, entails a very high machine downtime, which can reach up to more than 230 hours a year, thus also lowering the productivity and flexibility of the plant. All of this is reflected in the company's ability to respond promptly to the demand of its customers, including Company A, and to deal with changes in demand.

Also, knowing that setup time constitutes almost 19% of the total downtime, which also includes the time without the operator to carry out the tooling, the waiting time for approval at the start of production and finally, other stops, it was clear that one of Company B's main problems was dealing with setups in the turning department for the specified products.

As suggested by the second step of the A3 methodology, more data were gathered once the problem area was defined. A clearer overview of the complete analysis area was obtained using flow charts, Pareto analysis, and analysis gathered data. In particular, it was understood that the setup could be divided into four different clusters, as reported in table 1. Setup time and variability are represented concerning the fastest component change, thus from Valve holder to Valve holder (i.e., Piston-Piston changeover time is 1,14 longer than Valve Holder-Valve Holder one).

TABLE I
SETUP CLUSTERS

| Component Change | Average setup time | Average setup variability |
|---|---|---|
| Piston – Piston | 1,14 | 1,28 |
| Valve holder – Valve Holder | 1 | 1 |
| Piston – Valve Holder | 1,11 | 1,33 |
| Valve Holder – Piston | 1,21 | 1,04 |

After that, the targets were set to reduce setup times and variability in realising them. Then, the root causes were analysed through the use of Gantt charts: they were drawn to depict the activities carried out while doing a setup; in this way, all the inefficiencies, NVA (non-value added) and external activities (i.e., activities that can be done without a machine stoppage) were highlighted. Also, these tools were functional for the forthcoming steps, where countermeasures were deployed and Lean tools implemented. After this fourth step, everything was ready to develop and implement the countermeasures and apply the right Lean tools. In this specific case, it was chosen to use the SMED (single minute exchange of die), one of the most recognised among Lean methodologies, to optimise the setup activities through the externalisation of some activities. Then the other countermeasures were related to standardising activities and building new procedures. These last two were identifiable in the 5S methodology, another among the various Lean tools.

Then, following the last steps of the A3 model, the last activities to be done were monitoring the process and the results, and in case of a positive outcome, standardise and sharing success. Results one will discuss this last part in the following section.

## III. RESULTS

After implementing the previously mentioned countermeasures, a monitoring period started, assessing results. In particular, the "new" setup time for the four clusters identified was measured and the variability related to these changeovers.

TABLE II
IMPROVEMENTS IN SETUP TIME AND VARIABILITY

| Component Change | Average savings (time) | Average savings (variability) |
|---|---|---|
| Piston – Piston | 36% | 66% |
| Valve holder – Valve Holder | 32% | 57% |
| Piston – Valve Holder | 30% | 68% |
| Valve Holder – Piston | 37% | 69% |

The results obtained are outstanding, given the strategic importance of these products and their frequent production in the machines. They reduce setup time and variability, enhancing predictability and control over processes while doing changeover and bringing some side effects.

These other effects are very important for the company and of the utmost importance for the customer firm (Company A) who dedicated resources to this improvement study. Through these results will obtain benefits. Among the others, the benefits brought by this implementation are:

- Possibility to change the product mix more frequently thanks to shorter machine downtimes.
- Possibility to have a shorter customer lead time thanks to the time saved during changeovers.
- Possibility to change the batching policy from a few large batches to several smaller ones.

All these factors lead to an increase in flexibility and the ability to cope with demand variability. Thus, it means greater responsiveness to customer demand (i.e., to Company A). At the same time, Company A will be more flexible and be able to satisfy the demand of the final customer better. The management of the fluctuations of the final demand will be improved.

Even though these results are very good, they will impact positively on company performance and can also confirm the power of Lean tools like SMED and 5S. The goal of this paper was not to evaluate the impact of the techniques applied but how the collaboration among different players in the supply chain can help overcome traditional barriers and successfully implement Lean. This part will be discussed in the following section, the Discussion one.

## IV. DISCUSSION

Understanding if these results were relevant and thus the implementations successful was understanding if these results are similar to the literature. So, looking at the previous years' case studies, is it possible to observe different improvements in setup time, thanks to SMED:

- Amrani and Ducq, 2020: 40% of change over time.
- Yazici et al., 2020: achieved a 48% improvement thanks to SMED and FMEA.
- Escobar et al., 2019: reduction from 32% to 50% set up time reduction.

So, if we look at this study, the results are comparable, and thus it is possible to conclude that the implementation was successfully done.

Thanks to the resources deployed by Company A, the customer is much bigger than Company B; it has been possible to reach the objective of overcoming the barriers of the lack of time (Kumar and Kumar, 2014; Wong et al., 2009) and resources (Kumar and Kumar, 2014).

Moreover, the greater expertise in Lean projects of Company A has brought a rigorous method to implement Lean management, also overcoming, in this case, the lack of knowledge (Kumar and Kumar, 2014; Marchwinski, 2015) and methodology (Kumar, 2014)

Moreover, the collaborative aspect of this implementation has led to an enhanced collaboration because it brought an innovative condition to the shop floor, thus solving the lack of innovative ideas highlighted by Kumar and Kumar, 2014 and through this enhanced the collaboration (Jadhav et al., 2014), thus reducing the resistance to change (Bhasin, 2012; Kumar, 2014; Marchwinski, 2015)

Also, this fact avoided the possibility of raising another barrier to the proper implementation, the one coming from customer pressure, as highlighted by Cheah et al., 2012.

Due to the collaborative approach adopted, the smaller company has benefited from a resource point of view and improvements in processes. On the other hand, the bigger one that employs resources, in this particular case, the human workforce, will benefit from the flexibility of suppliers, reduction of lead times, and a more reliable upstream supply chain. Also, the final customer, as the two companies, will benefit from an optimised supply chain.

Lastly, thanks to the replicability embedded in this project, thanks to the use of the A3 model, is it possible also to do the same in other areas of the enterprise or extend to other products or machines, thus leading to further improvements that will pay back the efforts of Company A, and will enhance even more the overall advantages.

## V. CONCLUSION, LIMITATIONS AND FUTURE RESEARCH

To conclude, it is possible to state that the case study shows success in implementing Lean through collaborative supplier development. The traditional barriers to Lean implementation, especially for small enterprises (Kassem and Portioli, 2019), have been overcome. Moreover, this paper showed how the downstream supply chain would gain benefits. An overall increase in inefficiency will repay the efforts made by the "promoter" company.

On the other hand, the limitations of this work must be highlighted. This paper has, in fact, its weaknesses:

- Firstly, it has explained in the Methodology section that it is based on a single case study. However, it can contribute to enriching the actual knowledge on the topic.
- Another weak point is the focus on a specific area and company products; it would need an extension to other parts of the company to have a clear overview.
- Lastly is the absence of a long-term vision, the case study is based only on the current results, but there is a lack of monitoring in the future, where the results could be improved or worse than now.

The last thing to be analysed is the possibility of widening this research. For instance, future improvements to deepen the outcomes from this paper could be:

- Evaluating the long-term effects of this project.
- Extend the project to other products or areas and evaluate if the effects are confirmed.
- Do similar single case studies in other companies, environments, or sectors.
- Conduct a multi-case-study analysis to generalise the outcomes, if any, deriving from this study.

Moreover, the research topic could also be extended to implementing Lean 4.0 tools (Rossini et al., 2021). The barriers to implementation are even higher for small enterprises than for Lean stand-alone. So future research could also be:

- How can collaborative supplier development can help in the implementation of Lean 4.0 tools.
- How the supply chain can benefit from adopting the previously mentioned tools.
- How the supply chain can benefit from implementing Lean 4.0 tools, also using a collaborative approach regarding data, information and thus visibility.

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