IV. AN EMPIRICAL STUDY ABOUT THE EFFECTIVENESS OF LEAN EMPOWERMENT IN WAREHOUSES

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Abstract

Lean Management is well established in production environments. Some empirical evidences are available which suggest that in production systems lean management achieves positive results. For warehousing, some works have already been done, which deal with the application and adaption of lean tools for usage in warehousing. In order to answer the question, whether the application of lean tools leads to a better performance however, no study is available today. Therefore, an empirical study has been conducted, where the effectiveness of lean empowerment has been tested and compared to the performance of warehouse, who continued to work as before.

1 Lean Warehousing and Situation at the Outset

Lean warehousing in this contribution is defined as the application of lean management techniques and tools in warehousing operations. Lean empowerment refers to the teaching and promotion of lean management techniques and tools in the warehouse. This will be described in chapter 2.

The Robert Bosch (RB) Company has considered a lean empowerment program for its warehouses, which partially are operated by RB personnel and partially by logistic service providers. Having good experiences with a lean empowerment program in manufacturing, called Bosch Production System (BPS) (see [1] and [2]), it was discussed, that warehousing operations should undergo the same makeover of management style. However, it was unclear whether lean management could have the same positive effects in warehousing as in manufacturing. Some noticeable difference between manufacturing and warehousing are:

Table 1: Differences between manufacturing and warehousing

Area	Manufacturing	Warehousing
Number of employees per site	Usually between 100 and a few thousand	Between 10 and a few hundred
Education level	Medium to High	Low to Medium
Processes and processing times	Standardized	Usually not standardized
Lot sizes	Usually larger than one	Usually1 (unique orders)
Degrees of freedom concerning layout of processes	Low – limited by machines or assembly lines	High
Density of people on shop floor	High	Low

Therefore, the starting point for lean management is noticeably different. Standardized work is far less common in warehouses and the qualification and presence of managers in the warehouse is usually lower, due to the fact that the number of employees per site is much smaller than in manufacturing and the education level is lower.

Therefore, an experiment has been set up, where 16 warehouses have undergone a lean empowerment program and 56 have been monitored but continued to work as before.

1.1 Selection of warehouses

The observation group that includes the 16 warehouses was chosen randomly and consisted of 16 warehouses located in seven countries. These were comprised of six distribution warehouses, seven plant warehouses, and three raw material warehouses. These 16 warehouses handle three different kind of businesses. The different businesses are automotive technology goods, industrial technology and consumer goods, and building technology. Fourteen warehouses out of the 16 warehouses are single user warehouses and handle one business. Two of the 16 warehouses are multi-user warehouses and each of them handle two different businesses. In total, two are involved in industrial technology, 10 warehouses handle automotive technology, and six deal with consumer goods and building technology. Eight of the warehouses were operated by Bosch and another eight by logistics service providers. These included three of the five largest logistics service providers in the world as measured by turnover.

The control group that includes the 56 warehouses was also selected randomly. They were located across 16 countries. They were comprised of 38 distribution warehouses and 18 plant warehouses. Thirty-seven warehouses are in the automotive business, 6 in industrial technology, and 13 in consumer goods and building technology. Twenty-seven of the warehouses are operated by Bosch and 29 by logistics service providers. This included three of the five largest logistics service providers in the world as measured by turnover. The control group was not influenced by an empowerment program or by milestones that they had to achieve. All other detailed structural information can be read in [3] on page 138 and 140.

1.2 Assessment of Lean empowerment success – Lean Maturity Index

In order to measure the effectiveness of a lean empowerment program it is necessary to establish a metric which is able to recognize a change of the lean maturity. Therefore, a lean management assessment for a warehouse environment was necessary.

More than 70 maturity assessments were identified by reviewing and researching three scientific databases and the internet and by questioning experts. Seventeen maturity assessments remained after those assessments that did not focus on the lean approach were eliminated. These 17 lean maturity assessments were evaluated against each other by using five minimum criteria:

- Lean focus
  How much does the assessment focus on lean?
- Verified execution
  Does the maturity assessment verify the execution of lean tools or just ask if a standard is available in written form?
- Not survey based
  The data is more reliable and objective if it is not survey based.
- Warehouse focus
  Has the focus been on warehouse operations?
- Tested in practice
  Was the assessment tested in practice?

Unfortunately, none of the existing lean maturity assessments that focus on warehouses were adequate to fulfil the desired minimum criteria. The Bosch Production System Assessment V. 3.1 has the best match with before mentioned criteria and it is a representative of a new generation of assessments. The restriction by these assessments is that it focuses on production and only covers some of the warehouse processes as mentioned before. An adaption of this assessment for the warehouse environment would fulfil the desired criteria and enable further studies within this subject.

The Bosch Production System Assessment V. 3.1 was adapted for the warehouse environment and transformed into the Bosch Logistics Warehouse Assessment (BLWA). The BLWA was developed in several steps. In the first step, the key literature for the lean approach was re-evaluated. The main components of the lean approach that needed to be assessed in the warehouse assessment were identified based on the defined requirements.

The existing lean maturity assessments that focused on the warehouse environments were also analyzed. The goal was to find the components that could be used for Bosch Logistics Warehouse Assessment.

The second step involved the creation of a new structure. The Bosch Production System Assessment V. 3.1 only focused on some warehouse operations. The warehouse processes that were not covered by the processes in the Bosch Production System Assessment V. 3.1 were added. After a comparison with published and other assessments, the first draft of the BLWA was finalized.

The first draft of the BLWA was reviewed by experts from the Bosch Production System. After their feedback was included, guideline based interviews were used to have the first draft checked by experts from several organizational levels within Bosch. These experts included representatives from the corporate level, the business unit, warehouse leaders, and shop floor personnel. Experts from the Karlsruhe Institute of Technology were also involved.

A test version of the BLWA was released after the feedback from the interviews was incorporated. The test version was used test wise in three warehouses. The feedback from the test version was used to adjust the BLWA and, after a final review by the corporate Bosch Production System expert team, the BLWA was released. The structure of the BLWA is divided into three segments:

- the Continuous Improvement Process (CIP),
- overall subjects,
- and warehouse processes.

CIP consists of the System-CIP and Point-CIP, which are Bosch specific terms that were developed by Bosch Production System experts. System-CIP pertains to process and value stream design. It aims to capture the current value stream status with standardized diagrams and then develops a future state value stream design. Point-CIP is a method for process stabilization and improvement. It is comprised of five elements: target condition, quick reaction system, regular communication, sustainable problem solving, and process confirmation. This method continues to be used until the stabilization criteria are met permanently.

The roots of System-CIP and Point-CIP are in the Japanese automotive production systems. A lot of the lean systematic mentioned by various authors [3], and in particular, analyzed and summarized (see [4]) is covered by System- and Point-CIP.

The unique strength of this assessment is that each criterion has a concept dimension and an execution dimension that are linked together. This link ensures that the documented standard will be checked to see if it is executed. Figure 1 explains the relationship between topics, components, criteria, and maturity levels within the assessment. The link between concept and execution is explained by the example in figure 2. In this figure, a standard for receiving docks time windows is checked at the conceptual stage. During execution, the adherence to the time window is investigated.

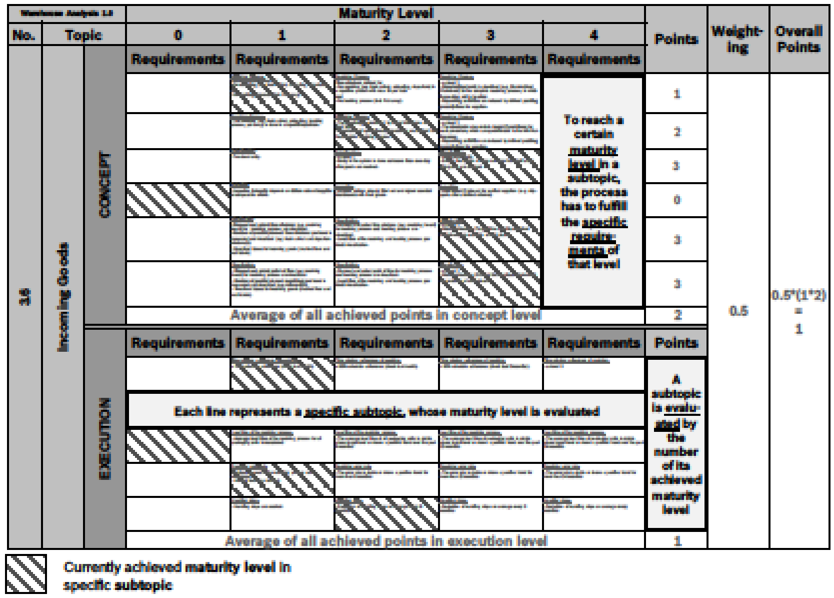


Figure 1: BLWA link between execution and concept

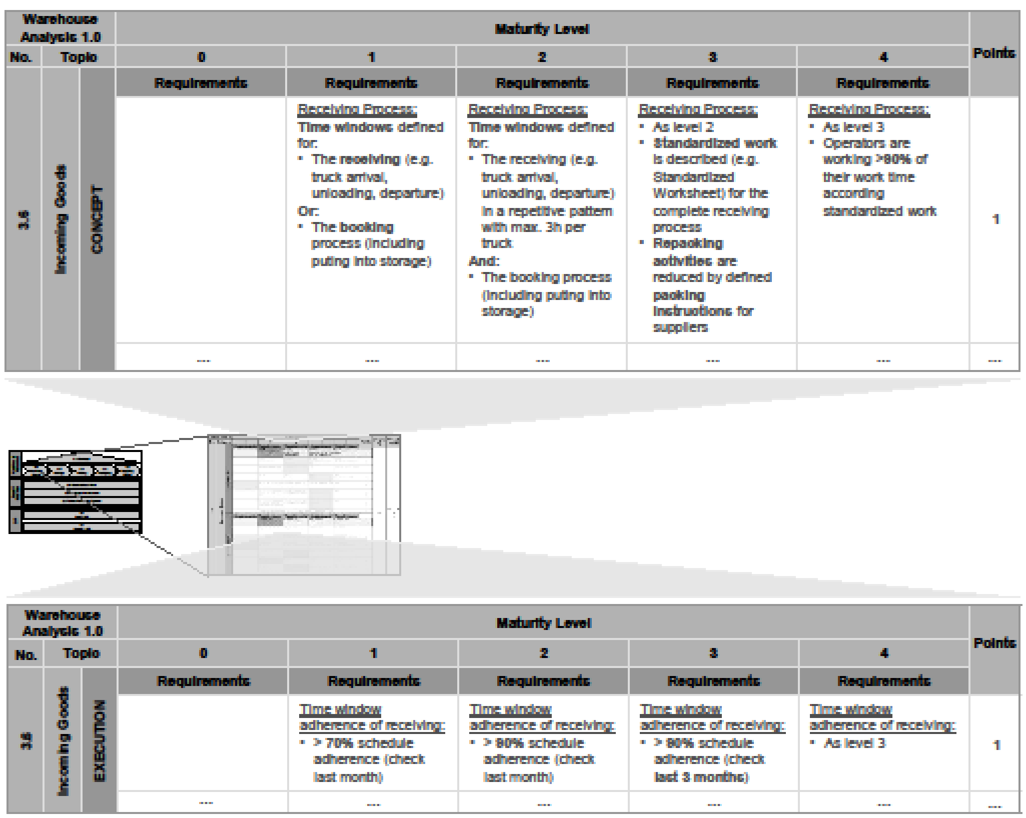


Figure 2: BLWA example for linked criteria

In order to measure the improvement of the lean maturity, two measurements were taken, one before and one after the project. Table 2 provides figures for the assessment results of the observation group over two different years. There is a high level of improvement in the overall average points as well as in the points focusing on the main lean components System-CIP and Point-CIP. These two elements were particularly emphasized by the empowering program within the experiment. Additionally, the coefficient of variation indicates that the spread of the results is reduced. Table 2 shows that the total average accumulated score improves by approximately 23 points. Moreover, the coefficient of variation becomes smaller, which indicates a more aligned group. This means that the improvement of the average score is not just influenced by single warehouses that improved greatly while all other warehouses did not improve. It is more a sign that the maturity of the entire group had a positive development.

Table 2: BLWA results: total points

	WaEx 2010	CoGr 2010	difference 2010	WaEx 2011	CoGr 2011	difference 2011
Average Points in the System- and Piont CIP assessment categories	9,18	8,61	0,57	32,81	12,82	19,99
Variance coefficient in the System- and Point-CIP assessment topics	88,26%	90,85%		28,35%	108,76%	

Table 2 provides the lean assessment results of the control group and compares them with the observation group. Both groups had very similar figures in 2010 but in the year 2011 the observation group displayed a significant improvement. The observation group also improved more uniformly overall in contrast to the control group. In the control group, a few good warehouses moved the average total score up from 8.61 to 12.82. An indication for this is the coefficient of variation for the two groups. The observation group had a smaller spread in 2011 compared to the control group. The spread of the control group in 2011 was higher than in 2010.

These results demonstrate a noticeable improvement in the lean maturity level of the observation group. This indicates that the warehouses did make progress with respect to lean management. The better results in the coefficient of variation could be explained by the usage of milestones, which have to be achieved by the warehouses. Before the project, none of the participating warehouses were mature enough to reach the milestones without an empowerment program. After the empowerment program, all warehouses reached the milestones and did fulfill the minimum requirements. Since the milestones were set as goals and the warehouses achieved them, a slight tendency towards an alignment of the maturity had taken place.

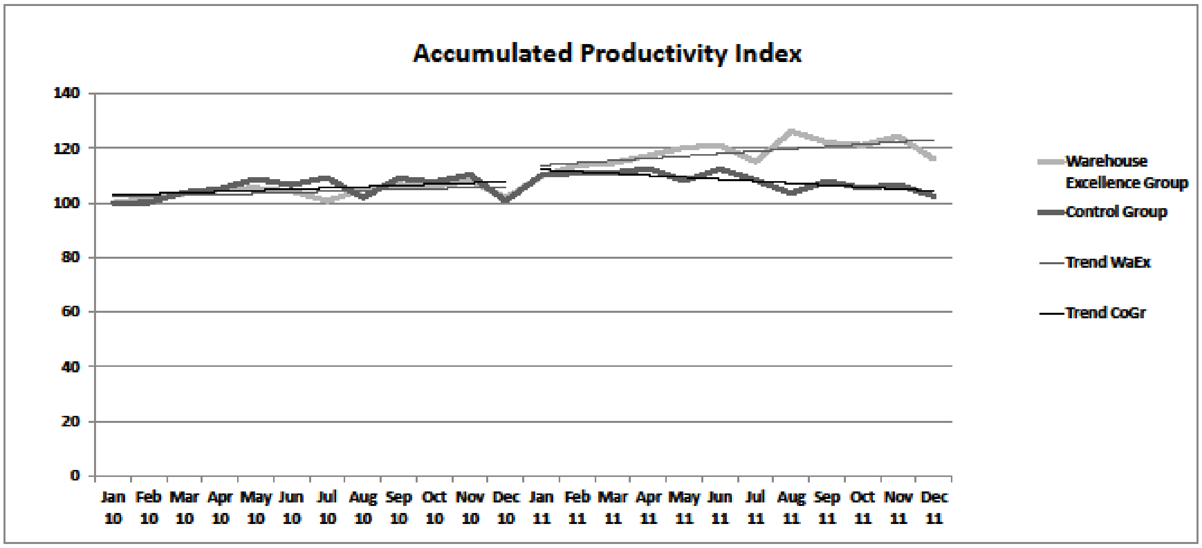
To understand whether the changes in the assessment results were significant, hypothesis tests were used. The result of a Goodness of Fit Test shows with a high significance level, that the distribution of the maturity development of the warehouses is not normally distributed. This means non-parametric hypothesis tests had to be used to determine if the development of the assessment results of each warehouse from 2010 to 2011 is random or not. To know if the results are significant, we can estimate with a higher level of evidence if our results are random or based on the influence of the lean approach.

The results of the hypothesis test for the control group shows that just 37.5% of the warehouses did improve their lean maturity with a minimum low significance level. Compared to the observation group, in which 93.75% of the warehouses showed with a very significant level an improvement. This implies that the control group improved in absolute and relative measures much less than the observation group.

2. Warehouse Performance

From the beginning of the experiment in year 2010, warehouses measured the monthly productivity of the entire warehouse operation. Each warehouse reported the monthly average. These monthly average figures were then normalized. This means that the monthly average of January 2010 was set as the index base 100. All further figures were related to that base and represent the development of the original figure. For example, a warehouse had the monthly average productivity of 20 order lines per man hour in January. This would set the index figure at 100. If the figure had a positive development of 10% to 22 order lines per man hour in February, the index would rise to 110.

The average of the index developments of the warehouses is shown in figure 3. The graph shows a higher productivity development for the observation group in 2011. The positive trend of the graph is characterized by the two Kolmogorov-Smirnov-Z test to show if the result was random or significant. The index graphs from 2010 could be from the same population but in 2011, the graphs show high significance so they are not from the same distribution. In conclusion, the data and development in 2010 are similar for both groups but are significantly different in 2011 which leads us to the assumption that something happened in the observation group that did not happen in the control group and resulted in an improvement of performance. We may suspect that this was the improvement of the lean maturity in the observation group.



	Jan 10	Feb 10	Mar 10	Apr 10	May 10	Jun 10	Jul 10	Aug 10	Sep 10	Oct 10	Nov 10	Dec 10
Warehouse Excellence Group	100.000	101.532	103.385	104.964	105.465	104.254	100.746	104.914	106.728	106.081	108.163	101.743
Control Group	100.000	100.051	103.784	105.211	108.627	106.667	109.244	101.932	108.948	107.633	110.285	100.712

	Jan 11	Feb 11	Mar 11	Apr 11	May 11	Jun 11	Jul 11	Aug 11	Sep 11	Oct 11	Nov 11	Dec 11
Warehouse Excellence Group	109.768	113.668	114.616	117.314	120.246	121.140	115.057	126.208	122.157	121.085	124.397	115.949
Control Group	110.112	110.879	110.935	112.570	108.072	112.334	108.371	103.474	107.923	105.430	106.657	102.408

Figure 3: Productivity performance comparison between the observation group and control group

3 Conclusions

These results help close the gap in the evidence and encourage decision makers to concentrate on lean activities within logistics operations. A major lean maturity development that results in a positive high performance indicator development is possible within the span of a year in the warehouse environment.

Bosch used this empirical evidence as the basis for its decision making to drive lean into their 800 warehouses around the globe. Investments were released to hire enabling experts. In addition, center of competence in the regions were established to enable the warehouse management and employees more locally. Bosch believes in that leading philosophy and will go that hard way with the sureness that this journey will probably never end.

References

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