Proceeding Mercu Buana Conference on Industrial Engineering
Vol. 5 July 2023, 273-280 | e-ISSN 2988-4288

The Effect of Lean Green Management System and Waste Reduction Technique on Lean Green Business Results in the Automotive Manufacturing Industry

Eli Ermawati*, Farida rahma Anggarini, Miranda Khanza, Paran Restiyono, Yandi Umar, Herry Agung Prabowo
Magister Teknik Industri, Universitas Mercu Buana, Jakarta

*Email korespondensi: elieliermawati@gmail.com

Abstrak

Terjadi pertumbuhan pesat dalam industri manufaktur otomotif yang dibuktikan dengan semakin banyaknya variasi kendaraan yang ada di masyarakat saat ini. Kemajuan ini menuntut para pelaku industri untuk bersaing secara efektif dengan mengoptimalkan kinerjanya untuk mencapai kapasitas produksi dan memperoleh pangsa pasar yang memadai. Penelitian ini bertujuan untuk memetakan dan mendeskripsikan kondisi terkini penerapan Lean Green Management System (LGMS) dan Lean Green Waste Reduction Technique (LGWRT) pada industri manufaktur otomotif di Indonesia serta menemukan model terbaik penerapan TPM dan LGMS.Lean Green Management System (LGMS) dan Lean Green Waste Reduction Technique (LGWRT) merupakan konsep yang terkait dengan perampingan aktivitas yang biasa dilakukan oleh perusahaan di sektor manufaktur dan jasa. Oleh karena itu, penelitian ini berfokus pada evaluasi pengaruh penerapan konsep-konsep tersebut terhadap Lean Green Business Results pada industri manufaktur otomotif. Hal ini dicapai melalui analisis statistik multivariat yang diterapkan untuk menjelaskan kesinambungan yang harmonis antara indikator dan variabel laten yang diamati secara langsung menggunakan SEM-PLS. Hasil penelitian menunjukkan bahwa penerapan LGMS dan LGWRT berpengaruh signifikan dan positif terhadap Lean Green Business Results (LGBR) sebesar 97,5% sedangkan sisanya sebesar 2,5% dikaitkan dengan variabel lain. Artinya LGBR telah diterima sepenuhnya

Kata Kunci: Automotive Industry, LGMS, LGWRT, LGBR, SEM-PLS.

Abstract

There was rapid growth in the automotive manufacturing industry as evidenced by the current increasing number of different variations of vehicles in society. This advancement requires industry players to compete effectively by optimizing their performance to achieve production capacity and gain adequate market share. This study aims to map and describe the current conditions of Lean Green Management System (LGMS) and Lean Green Waste Reduction Technique (LGWRT) implementation in the automotive manufacturing industry in Indonesia as well as to find the best model for implementing TPM and LGMS.Lean Green Management System (LGMS) and Lean Green Waste Reduction Technique (LGWRT) are the concepts associated with streamlining the activities usually conducted by companies in the manufacturing and service sectors. Therefore, this research focuses on evaluating the influence of implementing these concepts on the Lean Green Business Results of the automotive manufacturing industry. This was achieved through a multivariate statistical analysis applied to explain the harmonious continuity between the indicator and latent variables directly observed using SEM-PLS. The results showed that the application of LGMS and LGWRT has a significant and positive effect on Lean Green Business Results (LGBR) with 97.5% while the remaining 2,5% was linked to other variables. This means LGBR has been fully accepted

Keywords: Automotive Industry, LGMS, LGWRT, LGBR, SEM-PLS.

1. Intoduction

With the challenges of tight competition worldwide, manufacturing industry is under pressure to provide high levels of performance and commitment. To face the ever-changing customer demands, manufacturing companies opted to adopt strategic changes in management approaches, production process and technologies, supplier attitudes and customer behavior. Lean manufacturing principles have been widely used by manufacturing companies to achieve these changes and gain competitive advantage. The automotive manufacturing industry is experiencing rapid development as indicated by the increasing variety of vehicles in the present society. This is significantly due to the increasing demand for ease of transportation. The industry is highly competitive and this forces the companies to be persistent in ensuring continuous improvement in the design, development, production, marketing, and sales of motor vehicles in a targeted and effective manner. The activities of these companies include the process of converting raw materials into massive finished products to be marketed to the public to obtain profits. The rapid growth of the industry throughout the world has forced industry players to compete effectively by optimizing their performance to increase productivity and gain market share. This can be achieved through the implementation of the Lean Green Management System (LGMS) which is the concept related to streamlining or optimizing the activities of companies in both manufacturing and service sectors.

Some of the efforts include the reduction of non-value-added activities through the concept known as the Lean Green Waste Reduction Technique (LGWRT) (Antony & Laureani, 2011). Observed difficulties in the integration and implantation of these lean and green concepts. In this context, it would be useful to address these challenges by focusing on an indicator that is currently used in lean manufacturing, the Overall Equipment Effectiveness (OEE) (Ioppolo, *et al.2014)*. Based on the phenomenon of the problem, then we need a method for prevent the high impact of pollution industrial environment. The method that can be used is Integration Lean Manufacturing (LM) and Green Manufacturing (GM) (Mao, et al., 2019). Everyone at every level of the business, however, will be accountable and have the authority to make real-time decisions at their own level (Palange & Pankaj, 2021).

The relationship between Total Productive Maintenance (TPM) and Lean Manufacturing (LM) implementation shows the influence of the Lean Green Management System (LGMS) and Lean Green Waste Reduction Technique (LGWRT) on employee performance. It is pertinent to note that the Lean Manufacturing method was established based on the Toyota Production Systems launched in the 1960s with a focus on producing what is needed, to the extent it is required, and within the time allocated. This concept applies to all sectors. LGMS is based on sustainable productivity and quality improvement as well as the elimination of waste or unnecessary activities such as those not adding value to the product/service offered or to the process. The concept usually involves input from the staff.

This research was based on confirmatory data obtained on LGMS or Lean management. It is important to reiterate that lean management is an effort to continuously improve organizational performance. Meanwhile, LGWRT is an environmentally friendly waste reduction technique. Its main priority is to Reduce and this means ensuring a decrease in the waste piles. LGBR is a future-oriented business designed to invest in and focus on the environment in order to increase the competitiveness of companies.

The application of the Green Management approach to reduce environmental waste has been cited in management systems with a focus on pollution control, pollution prevention or cleaner production, and product stewardship. The pollution control aspect emphasizes the storage, treatment, and disposal of pollution after it has been created (Lucila et al., 2017). Lean and Green Management Systems have also been identified as compatible initiatives to jointly reduce waste through efficient usage of resources and meeting customer needs at the lowest possible cost (Duarte and Cruz-Machado, 2013). Environmental management is a scheme designed to make beneficial decisions concerning the environment. Moreover, the green process was triggered by environmental regulations, market demands, or internal company ideas to positively influence the company's economic, social, and environmental performance (Zailani, 2015). The application of the lean system and practices in production involves synergizing environmental processing with a focus on waste reduction and efficiency (Krisnanto, 2017). Manufacturers can adopt and combine Lean and Green Waste Reduction strategies simultaneously to create an environmental attitude to drive cost and risk reduction, revenue enhancement, and better brand image.Method.

2. Method

2.1.Research Materials

This paper identifies 57,570 manufacturing industry automotive companies in Indonesia. The transportation equipment/automotive industry has grown tremendously in 2021, reaching double-digit growth of 17.82 percent. Based on kemenprin, Absorption of labor is also quite high, both directly and indirectly. automotive industry about 3 million people (https://www.gaikindo.or.id). The sampling data used were collected from 10 manufacturing companies with a total of 48 respondents consisting of 3-5 respondents from each company. The process started on November 1, 2022 and ended on December 6, 2022 through the distribution of printed questionnaires to the respondents including division/department heads, assistant supervisors, supervisors, assistant managers, managers, and experienced employees that have worked at the company for at least 3 years. The selection was based on the consideration that they understand the goals, work culture, and green manufacturing systems implemented in their respective companies.

2.2.Research Method

The focus of this research was to examine the influence of Lean Green Management System (LGMS) and Lean Green Waste Reduction Techniques (LGWRT) variables on Lean Green Business Results (LGBR) using questionnaires and SEM-SmartPLS 3.0.
For many years, covariance-based structural equation modeling (CB-SEM) was the dominant method for analyzing complex interrelationships between observed and latent variables. In fact, until around 2010, there were far more articles published in social science journals that used CB-SEM instead of partial least squares structural equation modeling (PLS-SEM). In recent years, the number of published articles using PLS-SEM increased significantly relative to CB-SEM (Hair, et, al., 2017). which is often executed by software packages such as LISREL or AMOS, uses the covariance matrix of the data and estimates the model parameters by only considering common variance. In contrast, PLS-SEM is referred to as variance-based, as it accounts for the total variance and uses the total variance to estimate parameters
Structural Equation Modeling (SEM) is a multivariate statistical analysis technique that combines different multivariate methods to determine the simultaneous relationship between directly and indirectly observed indicator variables. It generally consists of measurement and structural models. The measurement model explains the correlation between independent and dependent latent variables (Ghozali & Imam, 2015). In SEM PLS, these latent variables are usually assessed according to the combination of continuous lines between manifest variables correlated with latent variables and applied to replace manifest variables. SEM PLS is beneficial due to its ability to handle the following two conditions as stated by Ghazali (2006):

1. A difficult situation is when the final data condition of a factor has a different value when calculated from a single-factor model.
2. A solution is accepted because SEM PLS is based on variance and not covariance, thereby, not leading to singular matrix problems.

SEM PLS calculation model aims to prove the validity of the data and determine its acceptability. According to the Outer Model analysis, each indicator is related to its latent variable such that:

1. Loading factor value > 0.7 (Hair, et, al., 2017).

2. Excellent validity value is obtained when the construct correlation with indicators is higher than the correlation with indicators from other constructs.
3. CR value of 0.7 means data acceptance is likely higher.
4. The reliability test is indicated by CA values which are required to be > 0.7 for all constructs used in evaluating the measurement model (outer model).

$$\rho c = \frac{(\Sigma_i)^2}{(\Sigma_i)^2 + Z_i \, var \, s_{(i)}} \quad (1)$$

R^2 values between 0.33 and 0.67 indicate a safe model while values below 0.33 indicate a weak model.

5. Hypotheses can be formulated based on significance tests as follows:
   - H_0: Independent variables do not have a significant effect on the dependent variable.
   - H_1: Independent variables have a significant effect on the dependent variable.

$$T_{statistik} = \frac{b_j}{s(b_j)} \quad (2)$$

Where, bj is the computed value for β_j and $s(b_j)$ indicates the error value for b_j. The testing criteria can be determined based on the significance level such that H_0 is rejected when $|T_{statistic}| > T_\alpha$ and df or p-value < α.

2.3. Research Process

The processes applied are stated as follows:

1. Determine the variables of LGMS, LGWRT, and LGBR
2. Create a questionnaire and distribute it to 10 manufacturing companies.
3. Formulate a model using the SEM method.
4. Collect and organize the data using Smart-PLS 3.0
5. Analyze and draw conclusions.

3. Results and Discussion

3.1. Initial Model (Outer)

The following model and tables were generated using Smart-PLS 3.0 as the data processing tool:

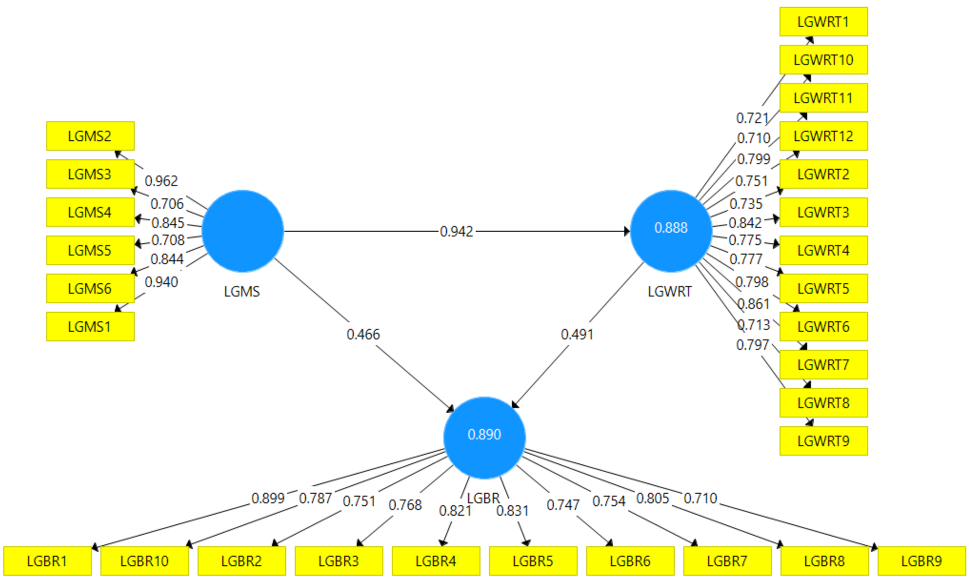

Figure 1. PLS Algorithm Results
Source: Data Processing Results

The results of the PLS model in the figure above, all indicators have a loading factor value above 0.7

so that the model meets the convergent validity.

Table 1. Loading Factor for LGMS Variables

Indicator	Loading Factor	Conclusion
LGMS1	0.940	Valid
LGMS2	0.962	Valid
LGMS3	0.706	Valid
LGMS4	0.845	Valid
LGMS5	0.708	Valid
LGMS6	0.844	Valid

Table 1. shows that all indicators LGMS that were considered valid because their loading factor values are > 0.70.

Table 2. Loading Factor for LGWRT Variables

Indicator	Loading Factor	Conclusion
LGWRT1	0.721	Valid
LGWRT2	0.735	Valid
LGWRT3	0.842	Valid
LGWRT4	0.775	Valid
LGWRT5	0.777	Valid
LGWRT6	0.798	Valid
LGWRT7	0.861	Valid
LGWRT8	0.713	Valid
LGWRT9	0.797	Valid
LGWRT10	0.710	Valid
LGWRT11	0.799	Valid
LGWRT12	0.751	Valid

Table 2. shows that all indicators LGWRT that were considered valid because their loading factor values are > 0.70.

Table 3. Loading Factor for LGBR Variables

Indicator	Loading Factor	Conclusion
LGBR1	0.899	Valid
LGBR2	0.751	Valid
LGBR3	0.768	Valid
LGBR4	0.821	Valid
LGBR5	0.831	Valid
LGBR6	0.747	Valid
LGBR7	0.754	Valid
LGBR8	0.805	Valid
LGBR9	0.710	Valid
LGBR10	0.787	Valid

Table 3. shows that all indicators LGBR that were considered valid because their loading factor values are > 0.70.

Table 4. Validity and Reliability Test

Variable	Cronbach Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)	Conclusion
LGBR	0.932	0.937	0.622	Reliable
LGMS	0.913	0.937	0.706	Reliable
LGWRT	0.939	0.940	0.600	Reliable

Table 4. shows that on indicator is valid to represent LGBR because its loading factor value is > 0.70. Furthermore, the reliability and validity of the variables (constructs) were tested. If the variable (construct) has Cronbach's alpha (CA) value above 0.7, composite reliability (CR) above 0.7, and average variance extracted (AVE) above 0.5, the variable (construct) is said to be reliable and valid (Ermawati, et.al, 2023). The following Table 4 is the value of Cronbach's alpha, composite reliability, and average variance of LGMS, LGWRT, and LGBR.

Table 5. R Square (R2)

Variabel	R Square (R2)	R2 Adjusted
LGWRT	0,890	0,885
LGBR	0,888	0,886

Table 5. shows the possibility of explaining 89% of the variability in LGWRT by the LGMS. Moreover, 88.80% of the variability in LGBR was found to be due to the combination of the LGMS and LGWRT.

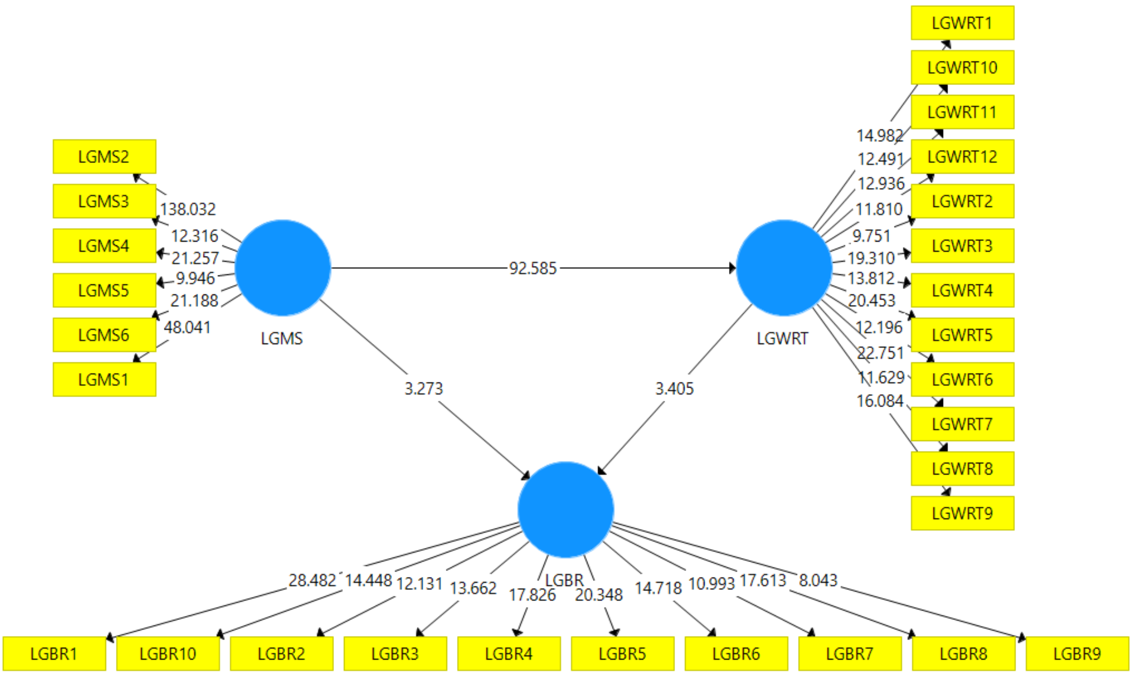

Figure 2. PLS Bootstrapping
Source: Data Processing Results

From Figure 2, Bootstrapping is a process for assessing the level of significance or probability of direct effects, indirect effects and total effects. In addition, bootstrapping can also assess the level of significance of other values, including: r square and adjusted r square, f square, outer loading and outer weight.

Table 6. Significance Test Results

Variable	Standard Deviation	T-Statistic	P-Value
LGMS -> LGBR	0.142	3.273	0.001
LGMS -> LGWRT	0.010	92.585	0.000
LGWRT->LGBR	0.144	3.405	0.001

Table 6. shows that significance Test Results as, LGMS has a positive and significant correlation with LGBR, and LGMS has a significant effect on LGWRT, while LGWRT has a significant effect on LGBR

3.2. Hypothesis Testing

Provide the answers to the hypotheses' tests.

- **H1:** LGMS has a positive and significant correlation with LGBR t-statistic (3.273 > 1.96) or p-value (0.001 < 0.05) every time there is a change in LGMS it will significantly increase LGBR.
- **H2:** LGMS has a positive and significant correlation with LGWRT t-statistic (92.585 > 1.96) or p-value (0.000 < 0.05) every time there is a change in LGMS it will significantly increase LGWRT.
- **H3:** LGWRT has a positive and significant correlation with LGBR t-statistic (3.405 > 1.96) or p-value (0.001 < 0.05) every time there is a change in LGBR it will significantly increase LGBR.

4. Conclusion and Recommendations

This study also proves that almost 97.5% of LGBR variation is significantly influenced by LGMS mediated by LGWRT. This shows the significant role of LGMS in the success of LGBR through the implementation of LGWRT. This means that leadership and empowerment can drive business practices and production processes in the manufacturing system through a vision and strategy in running lean, partnership or collaboration in order to find the best practice in reducing waste, which is supported by all functional units of the organization, and constantly innovating has been able to improve LGBR. This is in line with previous research which says that lean is able to create quality improvement (Samuel, et, al., 2021), productivity improvement (Edwin, et, al., 2016) It is expected that related future research contributes to the improvement of the automotive manufacturing industry in the country.

4.1. Conclusion

Based on the results of the research and the results of data analysis, it can be concluded that the following matters:

1. LGMS has a positive and significant correlation with LGBR
2. LGMS has a positive and significant correlation with LGWRT
3. LGWRT has a positive and significant correlation with LGR

4.2. Recommendations

Based on the results of the above research, the recommendations will be given:

1. Efforts to increase the application of the Lean Green Management System (LGMS) so that it can correlate with Lean Green Waste Reduction (LGWRT and Lean Green Business Result
2. It is recommended for future researchers to conduct research by expanding related variables in order to obtain more accurate research results and this research method can also be carried out in other companies.

References

Antony J., Laureani (2019). Leadership and Lean Six Sigma: a systematic literature review. Total Qual Manag Bus Excell. 30(1):53-81.

Duarte S., Cabrita, R., and Machado, V. C. 2011. Exploring Lean and Green Supply Chain Performance Using Balanced Scorecard Perspective. Ghozali, & Imam. (2015). Partial Least Square, Konsep Teknik dan Aplikasi Menggunakan Program Smart-PLS 3.0: Semarang: Badan Penerbit Universitas Diponegoro.

Ghozali, I. (2012). Aplikasi Analisis Multivariate dengan Program IBM SPSS 20. Semarang: Badan Penerbit – Universitas Diponegoro.

Ghazali, G. (2006). Structural Equation Modeling: Metode Alternatif dengan Partial Least Square. Semarang: Badan Penerbit Universitas Diponegoro.

Hair Jr, J. F., Hult, G. T. M., Ringle, C., & Sarstedt, M. (2019). *A primer on partial least squares structural equation modeling (PLS-SEM)*. Sage Publications.

Https://www.gaikindo.or.id/menperin-tumbuh-1782-persen-industri-otomotif-menyerap-banyak-tenaga-kerja/.

Lucila M. S. Campos Diego A. And Vazquez-Brust. 2016. Lean and Green Synergies in Supply Chain Management. Supply Chain Management: An International Journal, Vol. 21 Iss 5. Emerald Group.

Ioppolo, G.; Cucurachi, S.; Salomone, R.; Saija, G.; Ciraolo, L. Industrial ecology and environmentallean management: Lights and shadows. *Sustainability* **2014**, *6*, 6362–6376.

Krisnanto, A. B. 2017. Green Strategic Management Untuk Keunggulan Bersaing Berkelanjutan.INOBIS: Jurnal Inovasi Bisnis dan Manajemen Indonesia 1 (1), 1-10.

Zainal, Veithzal Rivai S. 2015. Manajemen Sumber Daya Manusia Untuk Perusahaan. Edisike-7.Depok: PT RAJAGRAFINDO.